Investing in the Future: The Economic Case for Natural Infrastructure in Ontario

Anielski Management Inc.

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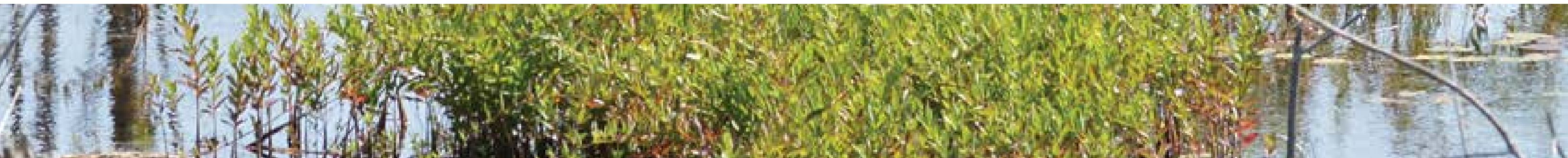

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Executive Summary

The Greenbelt Foundation, in association with the Greenbelt Golden Horseshoe Conservation Authorities Collaborative (GGH CAC), contracted Anielski Management Inc. to develop an economic case for three natural infrastructure projects within the Greenbelt region. The results of the economic case analyses are intended to provide a socio-economic rationale for decision-makers and fundraising efforts for the projects and demonstrate the value of cost-benefit analyses for natural infrastructure projects.

This report has three main purposes:

1. To identify an appropriate methodology for developing business/economic cases that incorporate costs and benefits of ecological restoration projects as investments in natural infrastructure;

2. To apply the selected methodology to three restoration projects in the Greater Golden Horseshoe, and;

3. To document the necessary information required to build business cases for future ecological restoration projects.

Investing in Natural Infrastructure Assets

A critical component of strengthening the region's resilience to the impacts of climate change is the strategic investment in natural assets, like wetlands, lakes and forests, as infrastructure to help manage some of the largest threats including flooding, water quality issues and rising temperatures.

Like all assets, natural infrastructure projects require considerations of the costs to build and maintain the assets in addition to the expected level of service from these natural assets.

Implications for Decision-Makers

This report provides a robust approach to developing a business case for natural infrastructure in southern Ontario that can be provided to decision-makers, particularly in municipal and regional governments.

The cost benefit analyses of the three projects illustrate the range of opportunity and some of the challenges in estimating future benefits resulting from ecological restoration projects. This report can help inform what evidence should be collected by conservation authorities and municipalities through monitoring programs. It can also be a useful guide for conservation authorities and municipalities in determining if there is enough information available to develop an economic case for a specific natural infrastructure project.

Methodologies

This study relies on a natural capital accounting evaluation framework to assess the three restoration projects in the Greenbelt region. The expected future ecosystem service values (ESVs) are estimated using original (primary) valuation analysis in addition to benefit transfer of values from previous Greenbelt and Ontario ecosystem service studies. The ESVs are discounted over a 50-year amortization period using a range of discount rates from 0.5 per cent to two per cent. This discounted or net present value (NPV) of the expected future benefits of each scenario can be compared to the estimated cost of the project. Ideally, to make a strong business case, the total projected ESVs should equal or exceed the total projected costs of the project.

Each case study involved a different combination of valuation approaches, based on the type of project, the geographic and demographic context and the availability of existing baseline data.

The three restoration projects analysed were:

1. Hamilton Conservation Authority's Saltfleet Conservation Area
2. Toronto and Region Conservation Authority's Brock Lands Restoration Project
3. Kawartha Conservation Authority's Lake Scugog Enhancement Project

Findings

This project highlights the diverse benefits that different ecological restoration projects can have in different contexts. Where data were easily available, it was clear that these projects were good investments in natural infrastructure for resilient communities. It also highlights the difficulty encountered in determining ESVs for projects where there is less baseline data available.

One significant lesson learned from all case studies was an identified need for more detailed ecological and social data to support fulsome accounting on the returns of investing in natural infrastructure projects. This finding highlights the importance of monitoring and research initiatives of conservation authorities and municipalities.

The table below summarizes the results of the three case studies. A more detailed summary of each individual case study including methods and findings follows.

Project	Services valued	Value of ecosystem services (million $)[1]	Cost of project (million $)	Net benefit (million $)
Saltfleet Conservation Area	Flood mitigation[2] Recreation[2] Biodiversity[3] Climate regulation[3] Water quality[3] Waste (nutrient) regulation[3]	$24 – 44.2	$15.3[4]	$8.6 – 28.9
Brock Lands Restoration Project	Recreation[2] Air quality[3] Climate regulation[3] Flood mitigation[3] Erosion control[3] Water quality[3] Pollination[3] Biological control[3] Biodiversity[3]	$60.5 – 92.3	$7 – 8.1[5]	$52.4 – 85.3
Lake Scugog Enhancement Project	Reduced phosphorus[6]	$0.72 – 0.94	$3.4[4]	N/A[7]

1 Net present value of 50-year service with 0.5% to 2% discount rates applied
2 Primary valuation
3 Benefit transfer valuation
4 Capital cost only
5 Capital and operating costs
6 Based on the capital cost of tertiary P removal technologies
7 Insufficient baseline data to estimate net benefits

Saltfleet Conservation Area

The Hamilton Conservation Authority (HCA) is creating a new conservation area to be located above the Niagara Escarpment in the Upper Stoney Creek and Upper Battlefield Creek watersheds in the east end of the city. The study area was originally a mix of rural and agricultural land with some historical wetland (marsh and swamp) and low-lying areas that could accommodate new wetlands.

The purpose of the new conservation area is to:

- Reduce downstream flood risk to residential and commercial properties by enhancing and enlarging existing wetland areas, creating new wetland areas and restoring the natural features and functions of watercourses in the area
- Support community well-being by creating new recreational opportunities and linking to the Dofasco Trail
- Support biodiversity by creating new wildlife habitat and connective corridors to other local conservation areas.

A 2018 engineering study by Amec Foster Wheeler (AFW) determined that creek and wetland restoration could help keep water on the landscape to reduce impact of significant storm- and runoff events. This study was used as a baseline for the flood mitigation service estimates.

Recreation and flood mitigation services were valued using a primary valuation method. Climate and population changes were accounted for in this valuation. Annual values associated with recreational trips will increase over time as the population of the City of Hamilton and region increases. Similarly, the value from flood mitigation will likely increase with the changing climate. Due to a lack of established projections on the increased occurrence of flooding events with the changing climate, conservative scenarios of one and two per cent increases in the risk of a severe flood event (a five to 50-year event) were used in this business case.

Primary values could not be determined for all the ESVs from the new conservation area. A benefit-value-transfer approach for benefits including biodiversity, water quality regulation and climate regulation (carbon sequestration) illustrates the services that might be expected. It was assumed that the newly constructed wetland would start with two per cent of its potential ecosystem functions and would increase to 100 per cent over 50 years.

Ecosystem service	Annual value of service ($ CAD/yr in 2018)	50-year net present value (NPV) range[3] of services (million $ CAD)
Flood mitigation[1]	$171,400 - 332,358	$5.5 - 14.8
Recreation[1]	$57,800	$2.4 - 3.5
Biodiversity[2]	$719,507	$9.9 - 15.6
Carbon sequestration[2]	$87,497	$0.95 - 1.8
Water quality provision[2]	$10,119	$0.149 - 0.230
Waste (nutrient) regulation[3]	$376,091	$5.2 – 8.2
Total		**$24 - 44.2 million**

1 Primary valuation. 2 Benefit transfer value. 3 Using 0.5% and 2% discount rates and 1-2% increase in flood incidence

At two per cent discount rates and no increased flood incidence, the 50-year net present value (NPV) of ESVs from this project is $24 million, which as a conservative estimate is still greater than the $15.3 million project capital cost. If flood incidence increases by two per cent and discount rates are set at 0.5 per cent, the NPV of ESVs from this project would be $44.2 million, which is over double the capital cost for the project.

The alternative to investing in this natural infrastructure could be an investment in conventional 'grey' flood attenuation infrastructure. The estimated capital cost of building a grey infrastructure alternative in this locale is $28.5 million. Notably, grey alternatives would not provide the other ESVs associated with the wetland complex's carbon sequestration, biodiversity and recreation benefits.

In conclusion, even by conservative estimates, this natural infrastructure capital investment would pay for itself and would provide additional value beyond grey infrastructure alternatives.

Brock Lands Restoration Project

The Toronto and Region Conservation Authority (TRCA) developed a plan to restore over 400 hectares of land at the former Brock Landfill sites with the intent of improving terrestrial and aquatic habitat, ground water catchments, headwater conditions for fisheries and to promote self-sustaining natural cover.

The recreational draw and capacity of the lands are expected to increase because of this project. Improvements to the site's condition are expected to draw people from other sites. Redistributed recreational trips were estimated using various assumptions about the percentages of trips that could be redistributed from other sites. The travel and time savings associated with these redistributed trips were the basis of the recreational valuation.

Other ESVs, including those from improved air quality, biodiversity (habitat) and carbon storage and sequestration are likely to accrue over the 50-year period. These values were quantified using a benefit transfer approach from previous Greenbelt studies, omitting any recreational values so as not to double-count.

Ecosystem service/habitat type	Annual value of service ($ CAD/yr in 2018)	50-year net present value (NPV) range[3] of services (million $ CAD)
Recreation benefits (primary valuation)[1]	$603,514	$25.0 - 36.1
Forests[2]	$566,503	$7,8 -12.3
Meadows[2]	$268,690	$3.7 -5.8
Wetlands[2]	$1,750,554	$24.1-38.0
Total	**$3,189,261**	**$60.5-92.3 million**

1 Primary valuation
2 Benefit transfer value

After accounting for the estimated capital and operating costs of the project, the estimated net value of recreational benefits of this project range from $18.2 to 28.6 million, around 4 times greater than the NPV of estimated capital and operating costs for the project ($7.0 to 8.1 million, based on early project budget estimates). This suggests that the investment in this natural capital asset by the TRCA would generate a very positive return on investment. Additional investments and benefits of new recreational amenities on the site (e.g. trails), as outlined in TRCA's Greenwood Conservation Area Master Plan were not included in this assessment and could provide additional benefits.

There are other potential well-being values associated with this project to nearby communities that were not included in this assessment. Including these values would require primary research, such as household well-being impact surveys of nearby residents. With expected increased pressure on greenspaces for recreational use from local urban development and with increased need for natural infrastructure to help mitigate climate impacts like flooding and extreme heat, the benefits of this project are likely to increase over time.

Lake Scugog Enhancement Project

The Kawartha Conservation Authority (KCA) is leading this project, intended to support the lake's important local tourism and recreational economy by addressing water quality, nutrient budgets, invasive species, wildlife habitat and recreational amenities in and around the lake.

The Lake Scugog Enhancement Project was proposed to address the issues of high sedimentation, invasive vegetation and eutrophication (increased nutrients) in the lake. It would involve dredging a portion of the lake to increase its depth and using the dredged material to create wetland habitat and new recreational amenity. The dredging will also temporarily reduce the amount of invasive vegetation in the area.

Estimated potential ESVs for this project were limited to the benefit of reduced phosphorus loading to Lake Scugog that may result from development of the wetland complex and installation of oil and grit separators. The NPV of the project's phosphorus loading reduction was estimated to be approximately $716,000 to 936,000. Unfortunately, other potential ESVs, including incremental recreation values, biodiversity, wildlife habitat and water quality could not be estimated due the absence of key baseline data.

If considering only the value of this one service, without any additional information, the shortfall between the cost of the service and its NPV is between $2 and 2.3 million. However, the annual estimated ESVs of the Lake Scugog watershed, which has a total area of about 54,000 hectares, are estimated at $220.9 million per year. These valuable services provided by the greater lake ecosystem are at risk if no investment is made to maintain these services from deteriorating because of human activities.

The continued impact of phosphorus loading on Lake Scugog should be examined in terms of the potential long-term economic costs of lake eutrophication – an overabundance of nutrients in the lake – and algal blooms. A 2019 study of the estimated economic costs associated with harmful and nuisance algal blooms in Lake Erie estimates costs equal to $272 million over a 30-year period if they are left unchecked. This 2019 Lake Erie report was used as a framework in the current report to demonstrate how such an assessment might be done for Lake Scugog, but as it would require additional data, an assessment was not possible.

Maintaining the current service level provided by Lake Scugog requires investments to maintain its function as phosphorus and sedimentation levels continue to rise from continuous new inputs. The Lake Scugog Enhancement Project plays a role in the asset renewal of Lake Scugog. Long-term cost comparison shows that making more frequent renewal investments can lead to significant cost savings over time compared to letting an asset deteriorate so much that it needs to be replaced. The reason Lake Scugog is so valuable to the community is because of its proximity to human activity. This proximity also means that humans are influencing the lake, largely with ecological stressors like phosphorus inputs. If nothing is done until there is such significant ecological decline that the system no longer functions on its own, a higher cost is likely than if timely and continued investments were made.

It is important to note that this ecological restoration project could achieve objectives beyond what can be included in this type of ecosystem service valuation. The Lake Scugog Enhancement Project is supported by many in the community who see it as an important investment in the lake's future. This community support and the local knowledge and understanding of the project's benefits is an important factor. Additionally, this project will include restoring wetland habitat in an area that historically had a greater amount of this type of habitat, which could provide benefit to local biodiversity including targeted habitat improvements for local species at risk.

1

Introduction

The Greenbelt Foundation, in association with the Greenbelt Golden Horseshoe Conservation Authorities Collaborative (GGH CAC), contracted Anielski Management Inc. to develop an economic case for three natural infrastructure projects within the Greenbelt region. The results of the economic case analyses are intended to provide a socio-economic rationale for decision-makers and fundraising efforts for the projects and demonstrate the value of cost-benefit analyses for natural infrastructure projects.

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3. To document the necessary information required to build business cases for future ecological restoration projects.

Investing in Natural Infrastructure Assets

A critical component of strengthening the region's resilience to the impacts of climate change is the strategic investment in natural assets such as wetlands and forests as infrastructure to help manage some of the largest threats including flooding, water quality issues and rising temperatures.

Like all assets, natural infrastructure projects should be planned for and managed with consideration of the costs to build and maintain the assets in addition to the level of service expected from the asset.

Three proposed restoration projects were analysed as case studies:

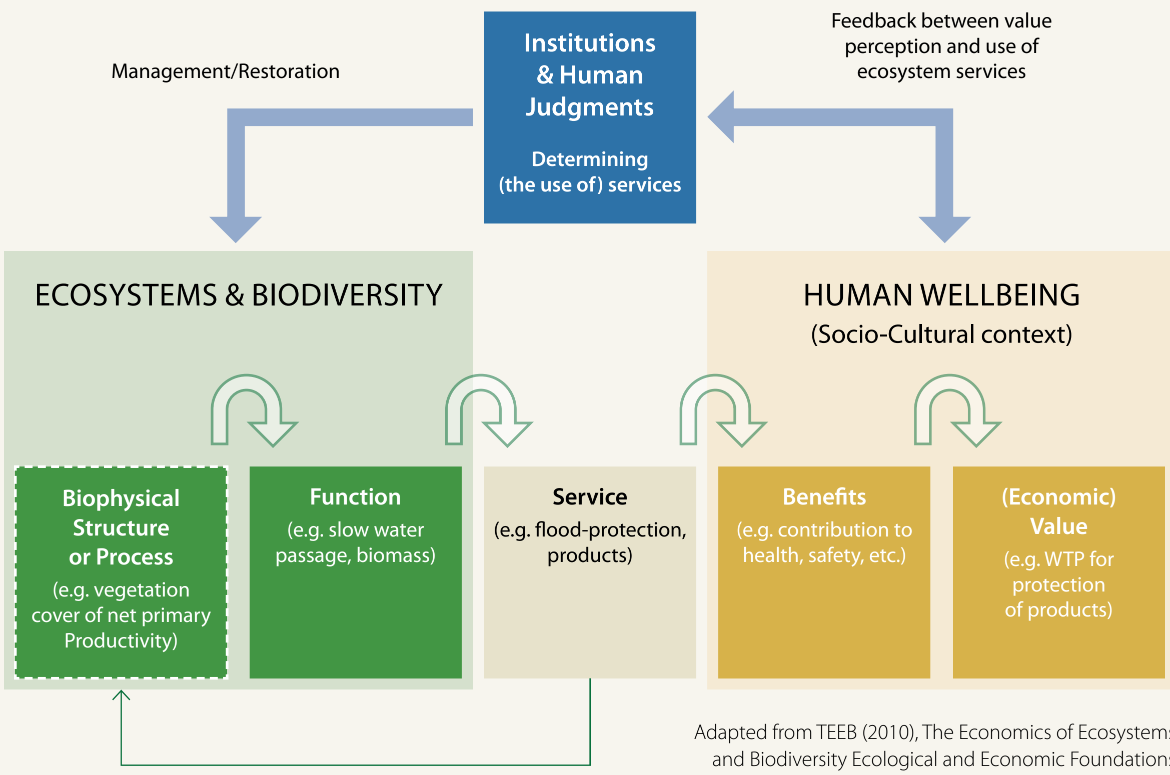
1. Hamilton Conservation Authority's Saltfleet Conservation Area
2. Toronto Region Conservation Authority's Brock Lands restoration
3. Kawartha Conservation Authority's Lake Scugog Enhancement project

Natural capital refers to a region's stock of natural "assets" or infrastructure such as water, forests, wetlands, air or soil. Just like other forms of capital, these stocks produce a flow of goods and services over time. For instance, a wetland purifies water, providing a flow of clean water to people downstream.

The flow of goods and services is often referred to as ***ecosystem services***, which are typically defined as the benefits people obtain from nature. A ***benefit*** is the actual improvement in human well-being provided by the flow of ecosystem services (e.g. cleaner drinking water). An economic (or other) ***value*** can be applied to that service or benefit. The sum of these ecosystem service values (ESVs) can be calculated and compared to the cost of restoring or maintaining the natural assets.

Beneficiaries are a specific group of people who benefit from the flow of ecosystem services (e.g. those people who live downstream of the wetland and as a result, benefit from access to the cleaner drinking water).

The pathway from ecosystem structure and processes to human wellbeing



Adapted from TEEB (2010), The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations

2

Theoretical Framework

A natural capital accounting evaluation framework is the basis for developing the business cases for ecological restoration. The framework will helps discern the relative economic, societal and ecological impacts of restoring ecologically functional landscapes to provide benefits for the well-being of the Greenbelt region.

In order to make a 'business case', a full cost accounting of the suite of ESVs and human beneficiaries associated with the project is needed. The extent to which natural capital is expected to improve through restoration and the number of beneficiaries affected can help provide understanding as to whether an investment is in the economic interests of the community. This holistic approach to ecosystem service valuation has the potential to yield much more efficient decision making than approaches that focus on merely one objective like flood mitigation alone.

2.1 Cost-Benefit Analysis

Conventional cost-benefit analysis (CBA) is a tool traditionally used by economists to evaluate whether a project, program or capital investment is worthwhile. In terms of the "economic value" of a particular natural asset, such as a forest, we are referring to the value provided by the things it does (its function) on the landscape, which is ultimately determined by its physical condition (or structure). For example, the condition of a forest may be changed through management activities like removing invasive plant growth to allow young trees to establish, improving functions like water retention and carbon storage. This improved function also leads to increased monetary value, as we would pay more $ for this increased water and carbon storage. The change in the total ESV of landscapes should be quantified with regard to specific changes in structure/function and associated changes in value.

Historically, most CBA studies and land use decisions have failed to incorporate ESVs. Natural features provide a wide variety of ecosystem services or functions, many of which have no monetary market value, yet contribute to the welfare of communities.

The inclusion of ESVs in CBA can be a valuable tool in assessing the non-market return on investment from environmental restoration or other "green investments." This allows for quantifications of a full spectrum of economic and social benefits that can be compared to the cost of restoring natural systems, to determine if a restoration project is justified. It can also be used to compare the benefits derived from acquisition of different land parcels.

Figure 1 *Cost-benefit analysis (CBA)*

2.2 Natural Capital Framework

Figure 2 shows the natural capital accounting evaluation framework used as the basis for determining the ESVs provided by the restoration projects. The idealised framework can be used to help decision-makers determine the relative economic, societal and ecological impacts of restoring ecologically functional landscapes to provide benefits for the well-being of people in and around the Greenbelt.

In order to make a business case, a full cost accounting of the suite of ESVs and human beneficiaries associated with the project is needed. The extent to which a natural asset/capital is expected to improve through restoration and the number of beneficiaries affected can help understand if the investment is in the best interests of the human community.

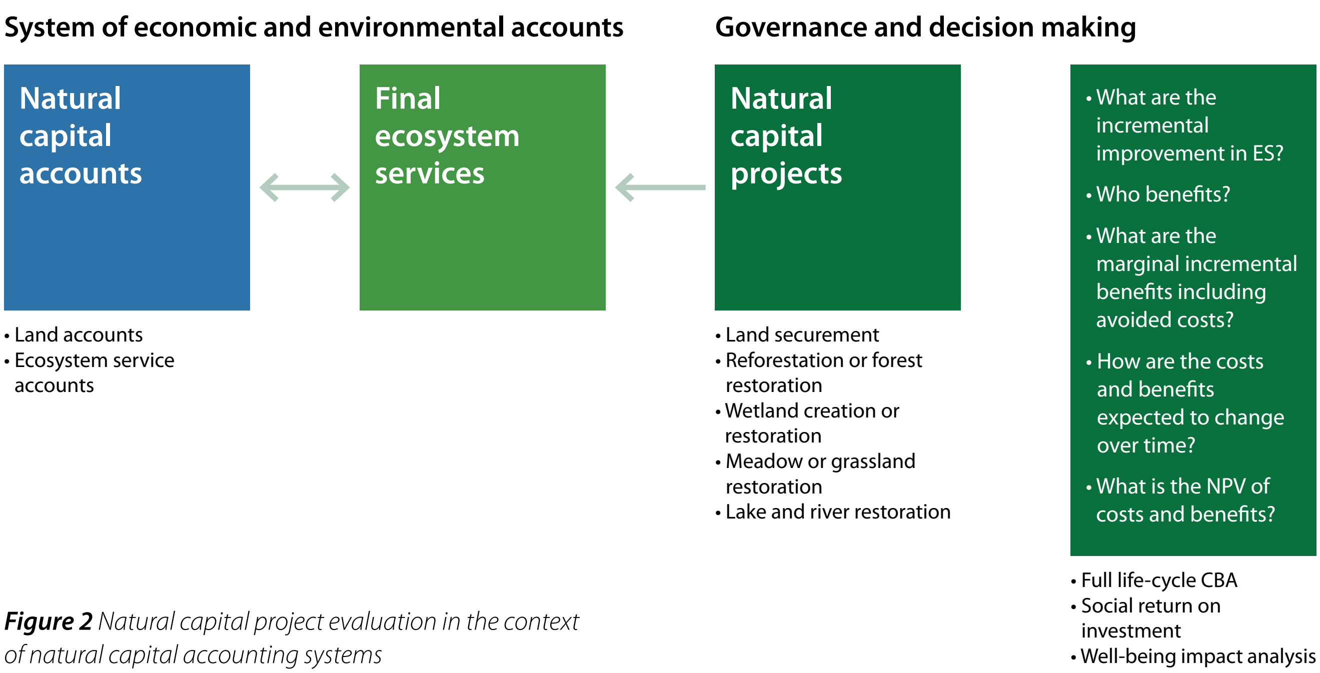


Figure 2 *Natural capital project evaluation in the context of natural capital accounting systems*

2.3 Final Cost-Benefit Natural Capital Framework

By combining CBA and the natural capital framework, a business case for restoration projects can be developed (Figure 3). The analysis begins with a biophysical assessment of the baseline ecological conditions of the proposed project site and estimated ecological impacts of restoration activities on a wide range of ecosystem functions and the services that flow from these functions.

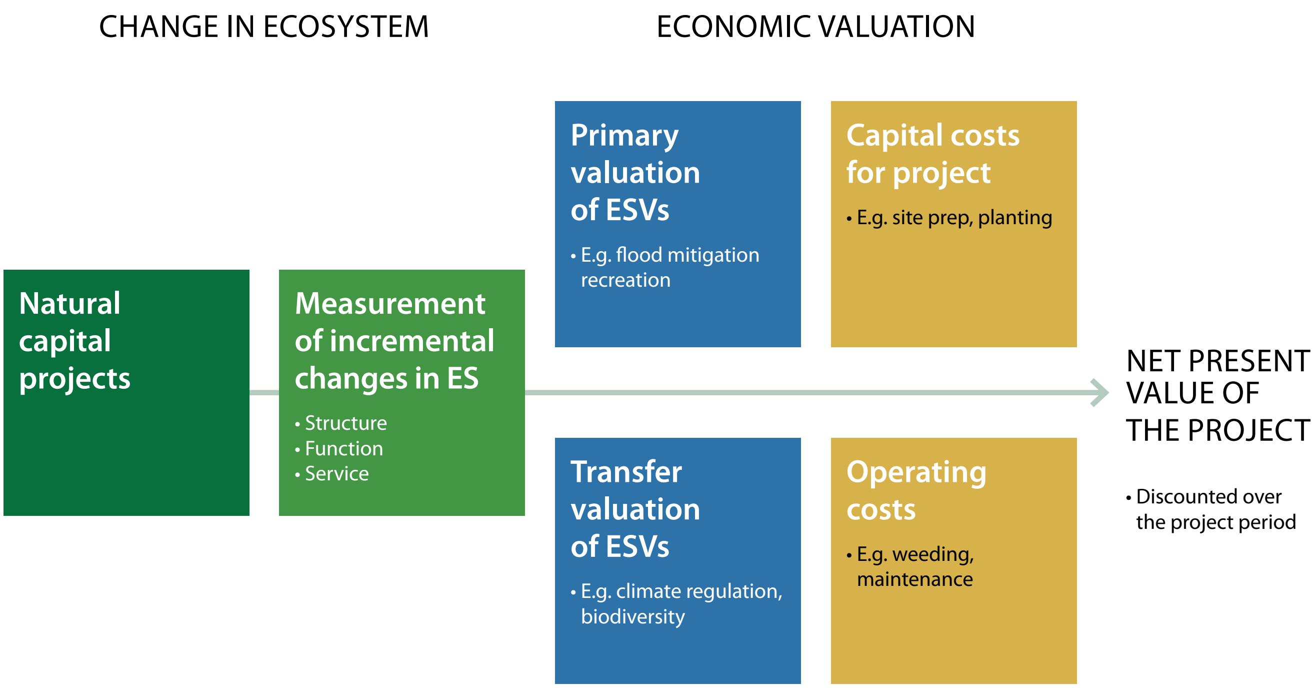
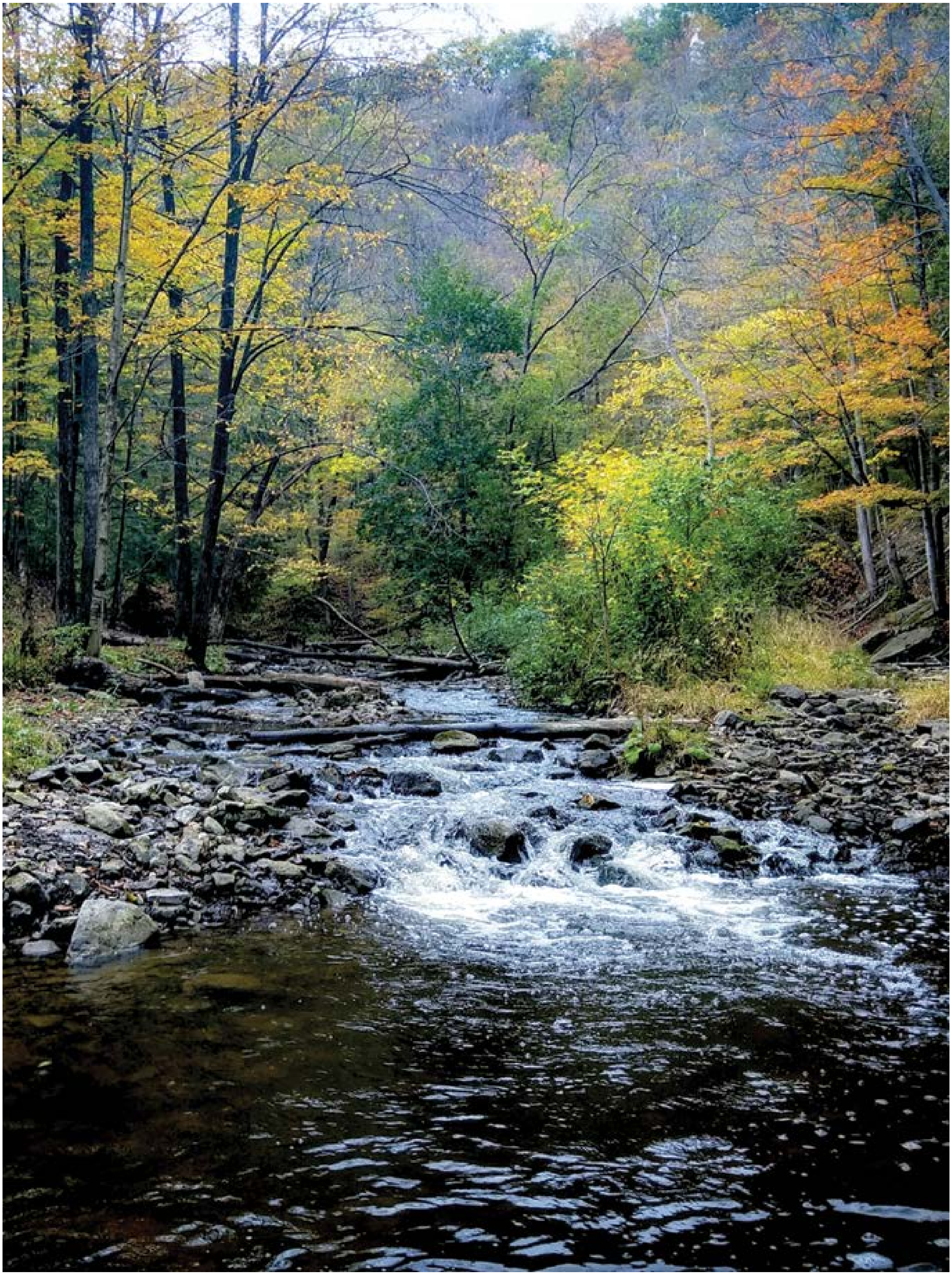


Figure 3 *Conservation project evaluation framework*



3

Methodological Approach

The CBA natural capital framework was applied to the three restoration projects. The degree to which this framework was applicable, and the opportunities and weaknesses of using this approach varied among the projects. For each project, additional data needs to make a stronger future business case were identified.

The results of each cost-benefit analysis were then assessed based on three scenarios:

a. Restore: cost of undertaking the proposed restoration works

b. Do nothing: potential outcomes if no additional work is done to prevent deterioration in the physical environment, resulting in lower ecological function and reduced ecosystem services

c. Maintain current state: potential outcomes of intervening to maintain the current ecological functions as they are without improving function (e.g. maintain vacant fields as fields and do not restore to wetland)

3.1 Valuation of Ecosystem Services

Each of the three projects highlights a different primary ecosystem service objective: flood prevention (Hamilton), waste treatment or phosphorus removal (Scugog) and terrestrial habitat and recreation (Brock Lands).

There are many ESVs (see Table 1) associated with natural areas like forests, wetlands and lakes. Each ecological function and derivative services and values requires its own valuation method. For detailed description on how the value of specific services were estimated, see Appendix A.

***Table 1** Ecosystem services and functions*

Ecosystem service	Ecosystem functions	Examples
Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO_2/O_2 balance, ozone layer)	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels
Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favourable climate, carbon regulation, cloud formation
Disturbance (flood) prevention	Influence of ecosystem structure on environmental disturbances	Storm protection, flood control, drought recovery
Water regulation	Role of land cover in regulating runoff and river discharge	Drainage, natural irrigation, transportation
Water supply	Filtering, retention and storage of fresh water	Provision of water by watersheds, reservoirs and aquifers
Soil retention	Role of the vegetation root matrix and soil biota in soil retention	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands
Soil formation	Weathering of rock, accumulation of organic matter	Maintenance of productivity on arable land; maintenance of natural productive soils
Nutrient cycling	Role of biota in storage and re-cycling of nutrient (e.g. nitrogen)	Maintenance of healthy soils and productive ecosystems, nNitrogen fixation, N, P and other elemental or nutrient cycles
Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds	Pollution control/detoxification, filtering of dust particles, abatement of noise pollution
Pollination	Role of biota in the movement of floral gametes	Pollination of wild plant species and crops
Biological control	Population and pest control	Control of pests and diseases, reduction of herbivory (crop damage)
Biodiversity (Habitat)	Role of biodiversity to provide suitable living and reproductive space	Biological and genetic diversity, nurseries, refugia, habitat for migratory species
Food production	Conversion of solar energy, and nutrient and water support for food	Provision of food (agriculture, range), harvest of wild species (e.g. berries, fish, mushrooms
Raw materials	Conversion of solar energy, nutrient and water support for natural resources	Lumber, fuels, fodder, fertilizer, ornamental resources
Genetic resources	Genetic materials and evolution in wild plants and animals	Improve crop resistance to pathogens and crop pests
Medicinal resources	Biochemical substances in and other medicinal uses of biota	Drugs and pharmaceuticals, indigenous traditional plants and medicines, chemical models and tools
Recreation	Providing opportunities for recreational activities	Eco-tourism, sport fishing and other outdoor recreational activities
Education, Culture and Spirituality	Providing opportunities for noncommercial uses	Aesthetic, artistic, educational, spiritual and/or scientific values of ecosystems

Source: Adapted from: De Groot, R.S. 2002. "A typology for the classification, description and valuation of ecosystem functions, goods and services." Ecological Economics. 41: 393-408

Quantifying many of the services listed in Table 1 requires baseline ecological data or additional research resources that were not available for this analysis. Where primary valuation could not be undertaken, a benefit (or value) transfer method was used to estimate the value of services provided based on the percentage of each habitat (e.g. wetland, forest) that was associated with the project. The correct inflators were used to convert values from previous studies to current dollars.

Two studies of the ESVs in the Greenbelt were used in this report for the benefit transfer method. The first, "Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services", completed in 2008, estimated the total ESVs in the Greenbelt by classifying the area into land cover types (forest, wetlands, agriculture, waterbodies, grasslands, etc.) and then applying estimates of ESVs per hectare taken from other studies. ESVs in the Greenbelt were estimated to have a value of $2.65 billion, or $3,487 per hectare (see Table 2).

Table 2 *Greenbelt region land cover types, area and ESVs in 2008*

Land cover type	Area (ha)	Total value ($ millions)	Average value ($/hectare/yr)
Agriculture/Cropland	384,378	$183	$477
Forest	182,594	$989	$5,414
Wetlands	94,014	$1,331	$14,153
Rivers	7,821	$2.6	$335
Hedgerows	7,039	$11.8	$1,678
Orchards	5,202	$2.6	$494
Grasslands	441	$0.714	$1,618
Other	42	$0	$0
Idle land	78,889	$132	$1,667
Total	**760,420**	**$2,652**	**$3,487**

Source: Ontario's Wealth, Canada's Future: Appreciating the Value of Greenbelt's Eco-Services (2008).

The second report, "Ontario's Good Fortune: Appreciating the Greenbelt's Natural Capital" (2016), estimated a total value of final ecosystem services that were worth $3.2 billion, or $3,997 per hectare per year. This 2016 study used a different approach than the 2008 study by measuring total ESVs in terms of "final ecosystem goods and services" or FEGS. This is a new standardization system developed by the U.S. Environmental Protection Agency that identifies and refers to the components of nature, directly enjoyed, consumed, or used to yield human well-being. The 2016 study also excluded some ecosystem goods and services due to lack of available information.

Table 3 *Summary of the value of ecosystem services for Ontario's Greenbelt (2016)*

Final ecosystem services	Aquatic ecosystems $ millions	Terrestrial ecosystems $ millions	Atmosphere $ millions	Total $ millions
Recreation/Tourism	$383.2	$1,722.2		$2,105.4
Protection of human property	$224.5			$224.5
Existence, bequest and aesthetics	$124.2	$301.0		$425.1
Plant cultivation pollination		$48.1		$48.1
Extractive uses	$367.2	$9.2		$376.4
Clean air			$18.4	$18.4
Total	**$1,098.9**	**$2,080.5**	**$18.4**	**$3,197.8**

Source: Ontario's Good Fortune: Appreciating the Greenbelt's Natural Capital, 2016.

Following a restoration project, the ecological function of the landscape does not start at 100 per cent of its potential, but gradually increases over time as the habitat matures and becomes more functional. In this assessment, it is assumed ecological functionality will progress, beginning with two per cent functionality in the year following ecological restoration to 100 per cent ecological functionality or maturity 50 years in the future.

3.2 Costs

The estimated capital and (where available) annual operating costs were provided by conservation authority staff as appropriate for each project. Estimates of project costs were provided at the initial phase of this research. These values may vary from actual or currently anticipated costs associated with these projects.

3.3 Discount Rates

The choice of a discount rate in cost-benefit analysis is an important consideration. A discount rate is used to reflect the future value of the purchasing power of money. Due to inflation, the future value of money will be less than today. Typically, market discount rates in the range of five to 10 per cent are used to calculate the NPV of conventional projects and capital investments.

Natural capital assets should have a lower discount rate than standard capital investments to reflect the scarcity of integral ecological assets. This is because as human populations increase, conversion of natural lands to built-form (residential, commercial and other real estate development) occurs, resulting in increased scarcity of natural lands that makes them more valuable to future generations measured in monetary terms than they are today. Additionally, lower discount rates reflect the degree of risk or uncertainty associated with climate change impacts.

In this study, a lower bound discount rate of 0.5 % to an upper bound of two per cent was chosen based on the above rationale that lower discount rates reflect the importance of these ecological projects to future generational well-being.

Discount rates are applied to any costs and benefits associated with the project in the future beyond the capital investment.

4

Saltfleet Conservation Area

4.1 Introduction

The Hamilton Conservation Authority (HCA) is creating Saltfleet Conservation Area (CA) in the east end of the city of Hamilton, specifically in the Upper Stoney Creek and Upper Battlefield Creek watersheds above the Niagara Escarpment. This is to reduce natural hazards, enhance natural heritage and create recreation opportunities.

This assessment compares the potential costs and benefits associated with establishing this new CA. The resulting analysis can guide decision-makers as to some of the returns on investment for these new natural assets and provide more evidence on how they can contribute to human well-being.

4.2 Biophysical Setting

The Battlefield Creek and Stoney Creek watersheds together are approximately 3,089 hectares in area and drain into to Lake Ontario. About 76 per cent of the two watersheds (2,360 hectares) are located above the Niagara Escarpment and are used primarily for rural and agricultural purposes.

The 729 hectares of watershed area below the Escarpment is used primarily for residential purposes, with some commercial, institutional and open space development. This development has typically occurred without adequate stormwater management and watercourses in the lower part of the watersheds have been straightened or modified. This has resulted in increased flow rates in watercourses during storm events. Additionally, in some cases land development has occurred in the riparian zone in the regulatory floodplain (a one-in-500-year flood event). There is a history of flooding and erosion issues in the urban area of Stoney Creek.

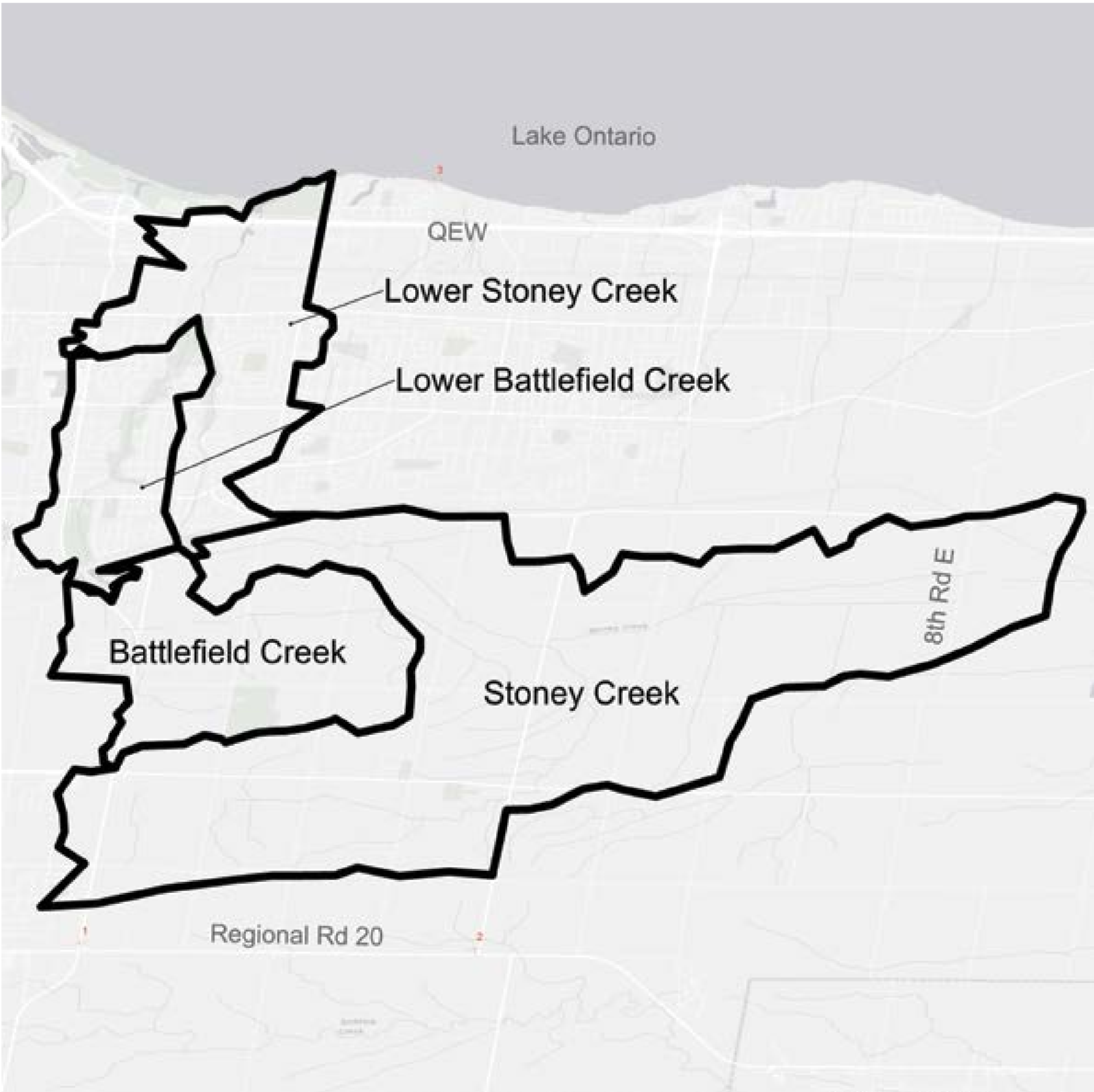


Figure 4 *Location of Battlefield and Stoney Creek drainages*

4.3 Local Demographics

In 2016, the overall watershed had a population of about 22,100 people, representing four per cent of the City of Hamilton's population of 536,917. While the population numbers are nearly equally split between the Stoney and Battlefield Creek watersheds, 13 per cent of the population live in the upper basins (above the Niagara Escarpment) and 87 per cent live in the lower parts of the basin (below the Escarpment).

Population change from 2011 to 2016 in the upper and lower parts of the watersheds was quite different. While the overall population of the City of Hamilton increased by 3.3 per cent during that time, population in the watersheds as a whole decreased by 1.1 per cent. However, the upper parts of both watersheds had population increases (+16.2 per cent) while the population in the lower watershed declined by 3.2 per cent. This population growth in the upper watersheds is worth noting because it is where the new CA will be located.

4.4 Conservation Project Description

The objectives of this conservation project are to:

- Use the floodplain areas of Upper Battlefield Creek and Upper Stoney Creek to hold water to reduce flooding both above and below the Niagara Escarpment in these watershed areas
- Enhance and enlarge existing wetland areas and create new wetland areas to provide enhanced wetland hydrologic function to reduce the impacts of high-water events and provide water to area watercourses during low flow periods
- Restore the natural features and functions of the watercourses in the area
- Restore, enhance and enlarge the natural heritage features associated with the floodplains, wetlands and watercourses of the area
- Provide linkages in and between conservation area lands by using the DoFasco Trail
- Enhance and create passive recreational opportunities along the DoFasco Trail

Our analysis relied on a February 2018 engineering study completed by the firm Amec Foster Wheeler (AFW), which determined how natural hazards (e.g. flooding, erosion) could be addressed through creek/wetland restoration and keeping water on the landscape during storm and runoff events.[1] AFW developed detailed engineered and restored wetland designs for the lands secured by HCA. The work includes creation of engineered wetlands, excavation of pond complexes, restoration of historical wetland ecosystems, creek restoration and revegetation or reforestation in four distinct parcels of land covering a total area of 109.2 hectares with an originally estimated capital cost of $15.35 million.

According to the 2018 AFW report, flooding and erosion conditions along the lower Stoney Creek and Battlefield Creek have affected private property and municipal infrastructure. The report identified limited historical application of stormwater management and erosion mitigation works since 1989, as well as private property encroachment of floodplains.[2]

The project has three stages.

Stage 1 – Consolidation of Core Conservation Area

This first stage involves securing lands immediately adjacent and contiguous to the existing Devil's Punch Bowl Conservation Area. This will provide for a larger, five-core conservation area with lands containing both Stoney Creek and Battlefield Creek. The core area provides HCA opportunities for initial restoration work and passive recreation opportunities.

Funding for land acquisition has been secured in the amount of $4.75 million over a five-year period beginning in 2015. Land acquisition will always be on a willing buyer/willing seller basis. To date, $2.38 million has been spent on securing 99 hectares, much of which may have been part of a historic wetland complex.

1 Amec Foster Wheeler. 2018. Flood Erosion Control Project for Upper Battlefield Creek and Upper Stoney Creek Community of Stoney Creek, City of Hamilton. Prepared for the Hamilton Conservation Authority.
2 Amec Foster Wheeler. 2018. Flood Erosion Control Project for Upper Battlefield Creek and Upper Stoney Creek Community of Stoney Creek, City of Hamilton. Prepared for the Hamilton Conservation Authority.

Stage 2 – Natural Hazard Attenuation

The second stage involved the 2018 AFW studies to determine how natural hazards (e.g. flooding, erosion) can be addressed through creek/wetland restoration and through holding water on the landscape during storm and runoff events.

Stage 3 – Natural Heritage Conservation and Restoration

This stage involved continued land securement as required and the completion of a detailed engineering study by AFW. The AFW studies proposed the development of engineered and restored wetland complexes along with additional revegetation on four distinct parcels of land (see Table 4) covering a total area of 109.2 hectares at a capital cost estimate of $15.35 million. The resulting wetland complexes including storage ponds would have a flood water storage capacity of 619,800 m^3.

Table 4 *HCA Wetland Projects: Area, water storage capacity and project costs*

Project	Area coverage (ha)	Available storage (m^3)	Estimated costs ($ millions)
BC-1	25.65	221,400	4.4
SC-5	23.11	204,000	8.8
SC-7	45.09	146,000	1.8
SC-8	15.33	48,400	0.33
Total	**109.18**	**619,800**	**15.3**

The key difference among the four wetland complex projects is that three of the complexes (SC-5, SC-7 and SC-8) are engineered wetlands requiring significant soil excavation and export costs, with average costs per hectare ranging from $116,511 to $196,336 (see Table 5).

Wetland complex BC-1 requires less engineering costs as it is a former wetland area that is expected to return to a functional wetland over time with minor restoration efforts. Costs per hectare are significantly lower: less than eight per cent of the average costs of the other three engineered wetlands.

Table 5 *HCA Wetland engineering and restoration cost estimates*

Total cost estimates	SC-5 ($ millions)	SC-7 ($ millions)	SC-8 ($ millions)	BC-1 ($ millions)	Total ($ millions)
Soil excavation and export	$3.6	$7.8	$1.4	$0	$12.8
Berm construction	$0.07	$0.07	$0.02	$0	$0.17
Road reconstruction*	$0.16	$0.10	$0.03	$0.07	$0.37
Plantings	$0.53	$0.88	$0.30	$0.26	$2.0
Total	**$4.4**	**$8.8**	**$1.8**	**$0.33**	**$15.3**

$/hectare	SC5-2	SC7-2	SC8-1	BC-1	Average
Soil excavation and export	$0.16	$0.17	$0.09	$0	$0.12
Berm construction	$0.003	$0.001	$0.001	$0	$0.001
Road reconstruction*	$0.007	$0.002	$0.002	$0.003	$0.003
Plantings	$0.023	$0.20	$0.019	$0.001	$0.018
Total	**$189,699**	**$196,336**	**$116,511**	**$12,833**	**$140,612**

Source: HCA revised cost estimates (reduced planting cost estimates) based on the original estimates by Amec Foster Wheeler. 2018. Flood Erosion Control Project for Upper Battlefield Creek and Upper Stoney Creek Community of Stoney Creek, City of Hamilton. Prepared for the Hamilton Conservation Authority. *Note that road reconstruction is not yet a confirmed necessary cost of the project.

4.5 Ecosystem Service Valuation

The HCA identified a number of potential future ecosystem services. The primary benefits will be flood control and recreation benefits, which should provide direct benefits to residents in the Hamilton region. These ecosystem services were quantified using primary research and analysis protocols. There are a number of other ESVs normally associated with wetlands which were not valued using primary valuation. Some of these other ESVs, including values for climate regulation, biodiversity and waste treatment, are estimated using a benefit transfer value approach.

4.5.1 Flood Control Benefits

According to HCA staff, residential and other developments in the downstream reaches of Battlefield Creek and Stoney Creek periodically flood during and following high rainfall events. Without measured data on depth of flooding associated with various flood events, some assumptions were used to estimate the potential economic benefits of wetland construction.


Photo courtesy of https://en.wikipedia.org/wiki/List_of_tallest_buildings_in_Hamilton,_Ontario#/media/File:HamiltonOntarioSkylineC.JPG

Current Conditions

The 2018 AFW study estimates the number and types of buildings and properties that would be affected by floods of various frequencies without the proposed wetlands. These data are summarized in Table 6. The majority (73 per cent) of the total properties or buildings would be affected by a regional flood (a 500-year event). The majority of the properties and buildings that would be flooded are located in sub-basin 4 of Battlefield Creek and sub-basin 6 of Stoney Creek.

Table 6 *Number and types of buildings and properties in Lower Stoney Creek and Battlefield Creek potentially affected by flooding under current conditions*

Flood frequency (return period in years)		2	5	10	25	50	100	Regional
Property type	Residential	0	11	31	50	69	83	151
	Commercial	0	2	3	6	6	11	12
	Industrial	0	1	1	1	1	1	21
	Institutional	0	0	1	2	2	2	2
	Public/open space	1	3	4	5	5	6	7
	Utility/hydro	0	0	0	0	0	0	1
	Total	**1**	**17**	**40**	**64**	**83**	**103**	**194**
Building type	Residential	0	1	2	7	20	39	88
	Commercial	0	1	1	1	1	3	8
	Industrial	0	0	0	0	0	0	15
	Utility/hydro	0	0	0	0	0	0	1
	Total	**0**	**2**	**3**	**8**	**21**	**44**	**112**
Roadway	Local	0	0	0	3	4	6	10
	Collector	0	0	0	0	0	1	2
	Arterial	0	0	0	0	0	1	4
	Freeway	0	0	0	0	0	0	1
Railway	CNR	0	0	0	0	0	0	1

Residential Buildings

For this analysis it was assumed that no buildings would flood in events with return frequencies of less than one-in 10-year event. For the one- in 10-year flood, it is assumed that basement flooding would occur to a depth of 0.3 metres (2.4 metres below main floor). For the one-in-25-year flood, it is assumed that basement flooding would occur to a depth of 1.2 metres. The one-in-50-year event would result in full basement flooding and some main floor damage. For the one-in-100-year flood, it is assumed that the main floor would be flooded to a depth of 0.3 metres. For the regional flood, a flood depth of 1.5 metres above the main floor is assumed.

Reports by Moudrak et al. (2017) and Natural Resources Canada (2017) estimate flood damages per square metre and depth of flooding for different types and classes of residential housing. Satellite imagery from Google Earth was used to determine the types of housing in the study. The subsequent damage estimates include both damages to contents (which range from about 44 per cent of total costs for two-story housing to 55 per cent of total costs for one-story housing) as well as structural damages.

Table 7 summarizes cost data, corrected for differences in the costs of housing and personal effects costs between Alberta and Ontario, as well as the effects of inflation between 2014 and 2017. Corrections relative to changes in the value of personal effects followed the procedure used by Moudrak et al. (2017) which were based on comparing the 2014 and 2017 surveys of household spending in Alberta and Ontario (Statistics Canada 2018) for the categories of furnishings and equipment, clothing and accessories and recreation. Changes in the costs of structural damages were based on new housing construction costs reported for Calgary and the Greater Toronto Area for 2014 and 2017 (Altus Group 2014; 2017).

Table 7 *Average damage costs per square metre relative to depth of flood for Alberta (2014) and Ontario (2017)*

Depth of flood relative main floor (metres)	2014 Alberta damages per square metre			2017 Ontario damages per square metre		
	One-story	Split-level	Two-story	One-story	Split-level	Two-story
-2.4	$621	0	$586	$637	0	$605
-1.5	$732	0	$735	$751	0	$759
0	$877	$698	$917	$899	$720	$946
0.3	$1,668	$892	$1,795	$1,713	$915	$1,855
1.5	$1,949	$1,453	$2,217	$2,004	$1,495	$2,292

An estimate for the total damages to residential properties in Stoney Creek and Battlefield Creek that would occur under floods of different magnitudes was produced by combining information on dwelling type and floor space area with the damage cost data in Table 7 and the number of residential buildings that would be flooded under current conditions.[3] The resulting calculations are shown in Table 8. Costs range from $0.1 million as a result of 0.3 metres of water entering the basements of two houses because of a 10-year flood to $7.1 million for a one-in-100-year flood. For a regional flood, the total damage to residential property is estimated to be $19.6 million. This represents an average annual risk of $230,000 when accounting for the likelihood and cost spread out over a 40 year period.

Table 8 *Estimated damages to residential properties from floods of various magnitudes under current conditions*

Flood magnitude (return period)		10	25	50	100	Regional
Assumed depth of flooding (metres relative to floor level relative		**-2.4**	**-1.5**	**0**	**0.3**	**1.5**
One-story houses	Number	2	5	15	28	64
	Floor space (m²)	235	599	1,711	3337	7,530
	Damage per m²	$637	$751	$899	$1,713	$2,004
	Total damages	**$145,600**	**$499,600**	**$1,537,800**	**$5,717,900**	**$15,093,700**
Split-level houses	Number	0	1	3	6	13
	Floor space (m²)	0	119	348	679	1,533
	Damage per m²	$0	$0	$720	$915	$1,495
	Total damages	**$0**	**$0**	**$250,700**	**$621,800**	**$2,291,100**
Two-story houses	Number	0	1	2	5	11
	Floor space (m²)	0	88	177	431	973
	Damage per m²	$605	$759	$946	$1,855	$2,292
	Total damages	**$0**	**$67,100**	**$167,300**	**$799,900**	**$2,229,900**
Total houses	Number	2	7	20	39	88
	Floor space (m²)	235	807	2,237	4,448	10,036
	Damage per m²	$637	$640	$874	$1,605	$1,955
	Total damages	**$149,600**	**$516,700**	**$1,955,800**	**$7,139,500**	**$19,614,700**

3 Google Earth was used to identify the most likely buildings within each sub-basin, immediately adjacent to Stoney Creek and Battlefield Creek, and type of commercial use, and to determine building type and main floor foot print. Visual examination of 48 houses on these three avenues showed that 73 per cent were single story buildings, 15per cent were split-levels, and 13 per cent were two-story buildings. Estimates of the ground floor area were developed using the ruler tool on Google Earth by measuring the length and width of each house.

Commercial Buildings

Estimates of the potential damages to commercial buildings were developed using the same method used for residential properties. Estimates of structural and content damage based on depth of flooding were taken from the report by Natural Resources Canada (2017, Appendix E – Non-Residential Damage Curves and Values). These values were updated to 2017 dollars in Ontario using the same adjustment methods described for inflation and changes in building costs.

The published damage curves for commercial buildings assume that they have no basements, with $0 damage to structure or contents for floods at zero metres above floor level. However, three of the commercial buildings in the flood plain are converted houses, so the estimates of structural damage for these three buildings were estimated using the damage curves for residential buildings. Estimates of damages to contents relative to flood depth are provided in Table 9 for the types of commercial uses found in potentially affected areas. It shows very high damages for medical buildings (Class B-1 as per the classifications in Natural Resources Canada, 2017) and retail buildings (Class C-6).

Table 9 *Average damage costs of contents for commercial buildings per square metre relative to depth of flood*

Depth of flood relative main floor (metres)	Office (A-1)	Medical (B-1)	Retail (C-6)	Drugstores (F-1)	Restaurant (I-1)	Personal services (J-1)
0	0	0	0	0	0	0
0.3	$127	$450	$408	$350	$257	$74
1.5	$380	$1,425	$1,072	$820	$452	$408

According to the assessment using Google Earth, there were two medical buildings, one office building, one retail store, one drug store, one restaurant and one personal services building located in the floodplain. The main floors of these structures ranged from about 76 m^2 for the personal services buildings to 935 m^2 for the retail building, with a total floor space of 7,748 m^2.

The estimated damages to commercial buildings are shown in Table 10. Though some commercial buildings are located in areas that might be flood in events up to the 50-year flood, no damages are assumed because the depth of flooding in these events is assumed to be less than or equal to the height of the main floor. The analysis shows that flood damages to commercial properties are only likely to occur in extreme flood events (one-in-100-year flood events or greater). For a regional flood, the total damage to commercial buildings/property is estimated to be $2.22 million or an average annual risk of $26,000 per year.

Table 10 *Estimated damages to commercial buildings from floods of various magnitudes under current conditions*

Commercial buildings	Flood frequency (return period - years)				
	10	25	50	100	Regional
Assumed depth of flooding (metres relative to floor level)	-2.4	-1.5	0	0.3	1.5
Number of properties	1	1	1	3	8
Assumed damages	0	0	0	$653,900	$2,217,500

Industrial Buildings

The same procedures were used to estimate the potential damages to industrial buildings that might be affected by floods of different frequencies. There are an estimated 15 industrial buildings located in the flood plain, with all but one of these industrial buildings located in the Stoney Creek Sub-basin 2. These buildings are only expected to be affected by the most significant type of flood event (regional flood). Estimates of structural and contents damage based on depth of flooding were also taken from the report by Natural Resources Canada (2017, Appendix E).

The published damage curves for industrial buildings assume $0 damage to structure or contents for floods at 0 metres above floor level. Table 11 summarizes the damage curve information for industrial buildings for flooding above floor level. The damage tables do not differentiate among types of industrial uses.

Table 11 *Average damage costs for contents for industrial buildings per square metre relative to depth of flood*

Depth of flood relative main floor (metres)	Structural damages	Damages to contents	Total damages
0	0	0	0
0.3	$21	$433	$454
1.5	$30	$1,184	$1,214

In total, it is estimated that the industrial buildings located in the flood plain have a combined footprint of about 38,785 m^2. As shown in Table 12, a regional flood event would result in an estimated $47.1 million in damages or $552,108 on an annualized basis.

Table 12 *Estimated damages to industrial buildings from floods of various magnitudes under current conditions*

Industrial buildings	Flood frequency (return period - years)				
	10	25	50	100	Regional
Assumed depth of flooding (metres relative to floor level)	-2.4	-1.5	0	0.3	1.5
Number of properties	0	0	0	0	15
Assumed damages	0	0	0	0	$47,084,500

Photo courtesy of https://commons.wikimedia.org/wiki/File:Flooding_in_Dufferin_Street_underpass_beneath_railway_tracks,_2013-07-08.JPG

Infrastructure Damages

Floods of different magnitudes would result in other types of damages in terms of flooding of properties, damages to utilities and disruption of highways and even rail service. The 2017 Natural Resources Canada report notes that while it is possible to use various methods to calculate these types of damages, this requires considerable detailed information about what actually happened following a specific flood event like the 2011 Calgary flood. Alternatively, the report suggests using information from other studies that suggest that direct damages to infrastructure make up of 10 to 25 per cent of the damages to residential, commercial and industrial buildings. Considering the relatively low number of roads and other infrastructure that would be affected by flooding in the Stoney Creek and Battlefield Creek basins, it is assumed that direct damages to infrastructure would be 15 per cent of the estimated damages to buildings associated with each magnitude of flood event. With this assumption, the cost of potential damages to infrastructure would range from $22,400 for a one-in-10- year flood to $10.3 million for a regional flood event.

Indirect Damages

Flooding can also result in indirect costs, which include the costs of evacuation and clean-up and loss of production revenue and wages. The 2017 Natural Resources Canada report states that while there are methods for determining these costs through interviews with people following actual flood events, common practice involves estimating indirect costs as a percentage of direct costs. One approach, used by the Canada-Saskatchewan Flood Damage Reduction Program, estimated indirect costs as being 20 per cent of direct costs. Another approach, from U.S. Soil Conservation Services, calculated indirect damages as being 10 to 15 per cent of direct residential damages, 15 to 20 per cent of direct commercial and industrial damages and 15 to 20 per cent of direct damages to highways, bridges, railroads and utilities. For this analysis, it is assumed that indirect damages would be equal to 20 per cent of direct damages. With this assumption, the cost of potential indirect damages would range from $34,400 for a one-in-10-year flood to $15.9 million for a regional flood event.

Total Damages without the Project

A summary of the estimated direct and indirect financial costs associated with floods of different magnitudes is provided in Table 13. It shows that financial costs would be quite low under a one-in-10-year flood event, but would increase substantially with flood events that are greater in magnitude although less frequent. The estimated damages associated with a regional flood event are estimated to be $95.1 million. The estimates show that damages to residential properties account for the majority of damages under most flood events, except for a regional flood event where the largest damages would be expected for industrial properties.

Table 13 *Estimated direct and indirect damages from floods of various magnitudes under existing conditions*

Type of flood damage	Flood frequency (return period - years)					
	5	10	25	50	100	Regional
Residential	0	$149,600	$516,700	$1,955,800	$7,139,500	$19,614,700
Commercial	0	0	0	0	$653,900	$2,217,500
Industrial	0	0	0	0	0	$47,084,500
Buildings sub-total	0	$149,600	$516,700	$1,955,800	$7,793,400	$68,916,700
Infrastructure	0	$22,400	$77,500	$293,400	$1,169,000	$10,337,500
Total direct costs	0	$172,000	$594,200	$2,249,2000	$8,962,400	$79,254,200
Indirect costs	0	$34,400	$118,800	$449,800	$1,792,500	$15,850,800
Total	**0**	**$206,400**	**$713,100**	**$2,699,000**	**$10,754,900**	**$95,105,000**

Given that there is uncertainty about the probability that a flood event of any given magnitude could occur in any particular year, it is standard practice to estimate an annualized probability that represents a weighted average of the damages and probabilities for each type of flood event. This reflects the idea that, in any given year, there is a 10 per cent probability of a one-in-10-year flood, a four per cent probability of a one-in-25-year flood event, a two per cent probability of a one-in-50-year flood event, a one per cent probability of a one-in100-year flood event and a less than one per cent probability of a regional flood. Although flood damages in any year could range from $0 to $95.1 million, the annualized cost based on weighted average probabilities is $668,600 per year without the wetland project. A high percentage of this amount (79 per cent) is due to the low probability but very high costs associated with a regional flood event.

Future Conditions with the Project

AFW (2018) used hydrologic modelling to estimate the effects that the proposed wetland storage would have on downstream flows under events of various magnitudes. What the modelling shows (see Table 14) is that for flood events of up to and including one-in-100-year flood events, the addition of wetland storage would result in very large reductions in flows (30 to 50 per cent) in the sub-basins where most damages would occur under current conditions. The proposed wetlands would have a relatively minor effect in terms of changes flows during regional flood events.

Table 14 *Percent differences in estimated peak flows direct with and without proposed storage*

Locations	Flood frequency (return period - years)						
	2	5	10	25	50	100	Regional
King Street	-69.9%	-35.7%	-32.0%	-29.2%	-39.2%	-45.4%	+1.9%
Battlefield/Stoney Creek confluence	-52.3%	-38.6%	-35.0%	-31.6%	-39.3%	-45.4%	-2.9%

Reduction of flows during most flood events would have two effects.

First, the number of buildings and properties at risk from flooding would be reduced. The number and types of buildings and properties that would be flooded with wetland storage in place was estimated using sub-basin information from the AFW (2018) report. These data are summarized in Table 15.

Table 15 *Number and types of buildings and properties in the Lower Stoney Creek and Battlefield Creek potentially affected by flooding under conditions with wetland storage*

Flood frequency (return period - years)		2	5	10	25	50	100	Regional
Property type	Residential	0	7	17	31	37	42	151
	Commercial	0	1	3	3	3	5	12
	Industrial	0	1	1	1	1	1	21
	Institutional	0	0	1	1	1	1	2
	Public/open space	0	3	4	4	4	4	7
	Utility/hydro	0	0	0	0	0	0	1
	Total	**0**	**12**	**26**	**40**	**46**	**53**	**194**
Building type	Residential	0	1	2	2	2	7	88
	Commercial	0	0	0	0	0	3	8
	Industrial	0	0	0	0	0	0	15
	Utility/hydro	0	0	0	0	0	0	1
	Total	**0**	**1**	**2**	**2**	**2**	**10**	**112**

Second, the depth of flooding for affected buildings would be reduced. As noted previously, there is no information on depth of flooding either with or without the wetland storage in place. Consequently, it has been assumed that based on the change in peak flows, the depth of flooding would shift so that depth of flooding under a one-in-50-year event with storage would be the same as that of a one-in-25-year flood without storage. With storage, there would be no damages for a one-in-10-year event. Damages for the regional flood would remain the same with or without storage.

The assumptions for changes in depth of flooding are summarized in Table 16. These assumptions are consistent with the reach-specific peak flow reduction target set out in Tables 3.9 and 3.10 of the AFW (2018) report.

Table 16 *Estimated depths of flooding from floods of various magnitudes with and without wetland storage*

Assumed depth of flooding (metres relative to floor level)	Flood magnitude (return period)				
	10	25	50	100	Regional
Without wetland storage	-2.4	-1.5	0	0.3	1.5
With wetland storage		-2.4	-1.5	0	1.5

Residential Building Benefits with the Project

Table 17 summarizes the estimated damages to residential properties under various flood conditions with wetland storage. Flood damages would only be expected with a one-in-25-year flood event and only two residential properties would be affected. The number of affected residential properties would increase to seven under a one-in-100-year flood event. Flood damages under the regional flood would be the same with and without storage.

Table 17 *Estimated damages to residential properties from floods of various magnitudes with wetland storage*

Flood magnitude (return period)		10	25	50	100	Regional
Assumed depth of flooding (metres relative to floor level relative			**-2.4**	**-1.5**	**0.0**	**1.5**
One-story houses	Number	2	2	2	5	64
	Floor space (m^2)	235	235	235	599	7,530
	Damage per m^2	$0	$637	$751	$899	$2,004
	Total damages	**$0**	**$149,600**	**$176,200**	**$538,200**	**$15,093,700**
Split-level houses	Number	0	0	0	1	13
	Floor space (m^2)	0	0	0	119	1,533
	Damage per m^2	$0	$0	$0	$720	$1,495
	Total damages	**$0**	**$0**	**$0**	**$86,000**	**$2,291,100**
Two-story houses	Number	0	0	0	1	11
	Floor space (m^2)	0	0	0	88	973
	Damage per m^2	$0	$0	$759	$946	$2,292
	Total damages	**$0**	**$0**	**$0**	**$83,600**	**$2,229,900**
Total houses	Number	2	2	2	7	88
	Floor space (m^2)	235	235	235	807	10,036
	Damage per m^2	$0	$637	$751	$877	$1,955
	Total damages	**$0**	**$149,600**	**$176,200**	**$707,800**	**$19,614,700**

Commercial Building Benefits with the Project

Table 18 summarizes potential damages to commercial properties under various flood conditions with wetland storage. With the benefits of storage, no damages to commercial property would be expected to occur as a result of most flood events, although the value of damages under the regional flood is expected to remain the same as under current conditions.

Table 18 *Estimated damages to commercial buildings from floods of various magnitudes with wetland storage*

Commercial buildings	Flood frequency (return period - years)				
	10	25	50	100	Regional
Assumed depth of flooding (metres relative to floor level)		-2.4	-1.5	0.0	1.5
Number of properties	0	0	1	3	8
Assumed damages	0	0	0	0	$2,217,500

Industrial Building Benefits with the Project

Potential flood damages to industrial buildings in the flood plain with wetland storage (see Table 19) would not change because flooding would occur only under the regional flood event and the extent of damages would not change.

Table 19 *Estimated damages to industrial buildings from floods of various magnitudes with wetland storage*

Industrial buildings	Flood frequency (return period - years)				
	10	25	50	100	Regional
Assumed depth of flooding (metres relative to floor level)		-2.4	-1.5	0.0	1.5
Number of properties	0	0	0	0	15
Assumed damages	0	0	0	0	$47,084,500

Infrastructure Damages with the Project

It is assumed that direct damages to infrastructure would be 15 per cent of the estimated damages to buildings associated with each magnitude of flood event. This percentage reflects the relatively low number of roads and other infrastructure that would be affected. With this assumption, the cost of potential damages to infrastructure would range from $0 for a one-in-10-year flood to $10.3 million for a regional flood event.

Indirect Damages with the Project

It is also assumed that indirect damages under floods with wetland storage in place would be equal to 20 per cent of direct damages. With this assumption, the cost of potential indirect damages would range from $0 for a one-in-10-year flood to $15.9 million for a regional flood event.

Total Damages with the Project

A summary of the estimated direct and indirect financial costs with the wetland project is provided in Table 20. It shows that there would be no financial costs associated with a one-in-10-year flood event and would be only slightly larger for a one-in-50-year flood because very few residential properties would remain in the floodplain. The estimated damages associated with a regional flood event are again estimated to be $95.1 million because wetland storage would not cause a significant reduction in peak flows.

***Table 20** Estimated direct and indirect damages from floods of various magnitudes with wetland storage*

Type of flood damage	Flood frequency (return period - years)					
	5	10	25	50	100	Regional
Residential	$0	$0	$149,600	$176,200	$707,800	$19,614,700
Commercial	$0	$0	$0	$0	$0	$2,217,500
Industrial	$0	$0	$0	$0	$0	$47,084,500
Buildings sub-total	$0	$0	$149,600	$176,200	$707,800	$68,916,700
Infrastructure	$0	$0	$22,400	$26,400	$106,200	$10,337,500
Total direct costs	$0	$0	$172,000	$202,600	$814,000	$79,254,200
Indirect costs	$0	$0	$34,400	$40,500	$162,800	$15,850,800
Total	**$0**	**$0**	**$206,400**	**$243,100**	**$976,800**	**$95,105,000**

Although flood damages in any year could range from $0 to $95.1 million, the annualized cost based on weighted average probabilities with wetland storage is $497,200 per year, compared to $668,597 per year in flood damage costs without the project. Almost the entire amount (97 per cent) is associated with the low probability (based on current assessments) of a regional flood event.

4.5.1.1 Incremental Flood Control Benefits of the Project

Estimates of the potential annual benefits were calculated by comparing the potential damages under current conditions with potential damages with wetland storage (Table 21). It shows that under either scenario, there would be no flood damages expected for one-in-five--year flood events. For one-in-10-year events, there would be no damages if wetland storage were in place, compared to $206,400 in damages under current conditions. For one-in-50-year flood events, wetland storage would provide a benefit of $506,600 compared to damages under current conditions. Similarly, flood damages for onein-100-year events would be reduced by $2.5 million if wetland storage was created. However, for a regional flood, wetland storage would do little to reduce peak flows, so the extent of damages would be expected to be the same in each case.

Table 21 *Summary of direct and indirect damages from floods of various magnitudes with and without wetland storage*

		Flood frequency (return period - years)					
		5	10	25	50	100	Regional
Building damages	Current conditions	$0	$149,600	$516,700	$1,955,800	$7,793,400	$68,916,700
	With wetland storage	$0	$0	$149,600	$176,200	$707,800	$68,916,700
	Net benefit of storage	$0	$149,600	$367,100	$1,779,600	$7,085,600	$0
Infrastructure damages	Current conditions	$0	$22,400	$77,500	$293,400	$1,169,000	$10,337,500
	With wetland storage	$0	$0	$22,400	$26,400	$106,200	$10,337,500
	Net benefit of storage	$0	$22,400	$55,100	$266,900	$1,062,800	$0
Indirect costs	Current conditions	$0	$34,400	$118,800	$449,800	$1,792,500	$15,850,900
	With wetland storage	$0	$0	$34,400	$40,500	$162,800	$15,850,900
	Net benefit of storage	$0	$34,400	$84,400	$409,300	$1,629,700	$0
Total costs	Current conditions	$0	$206,400	$713,100	$2,699,000	$10,754,900	$95,105,000
	With wetland storage	$0	$0	$206,400	$243,100	$976,800	$95,105,000
	Net benefit of storage	$0	$206,400	$506,600	$2,455,800	$9,778,100	$0

Reflecting the probabilities and costs of floods of different sizes occurring in any given year, the creation of wetland storage is expected to provide net benefits of $171,400 per year on an annualized basis (see Table 22). This is the difference between annualized costs under current conditions ($668,600) and the annualized costs with wetland storage ($497,200).

Table 22 *Annual flooding costs and net annual benefits of the wetland storage project: base case, one per cent and two per cent increase in flood incidence*

	Annual costs of flooding		
Flood frequency period	**Base case (AFW)**	**1% increase in flood incidence**	**2% increase in flood incidence**
1	0	0	0
2	0	0	0
5	0	0	0
10	$6,193	$12,140	$8,258
25	$4,496	$13,219	$8,991
50	$6,100	$26,903	$18,299
100	$480,409	$706,293	$480,409
Annual flooding costs with the wetland	$497,197	$758,556	$515,957
Annual flooding costs without the wetland	$668,597	$506,577	$848,515
Net annual benefits (avoided costs) with the wetland	**$171,400**	**$251,979**	**$332,558**

One per cent Increase in Flood Frequency Risk

When the flood frequency is increased by one per cent for the five to 50-year flood frequencies, the flood mitigation benefits nearly double from $171,400 per year to $251,979 per year (see Table 22). The analysis assumes that the change in frequencies starts immediately and continues for 50 years, which is probably a very liberal assumption.

Two per cent Increase in Flood Frequency

If flood frequency increased by two per cent for the five to 50 year flood frequencies, the incremental increase in annual flood mitigation net benefits would rise to $332,558 per year (see Table 22), nearly double the baseline of $171,400 per year.

With flood risk scenario modeling, it would be possible to conduct flood event risk analysis to predict flood costs and thus incremental benefits of the wetland projects. The strength of this kind of scenario analysis, if supported by flood-climate change modeling, is that it allows decision-makers to conduct what-if risk analysis in a dynamic model for future risk management.

4.5.2 Recreation Benefits

The new conservation area will provide new recreational opportunities through a trail system and by connecting to two key recreational trails that run through this area: the Dofasco 2000 Trail and the Bruce Trail.

Current Conditions

There is currently no recreational opportunity at the study sites so the new conservation area will be creating a new amenity. The Canadian Nature Study showed that adults who participated in nature-based activities spent an average of 111 days per year engaged, with 81 of these days (73 per cent) of activity occurring within 20 km of their homes.

Based on these findings, it is assumed that the primary market for recreation in the study area will be residents of the City of Hamilton, which is located within 20 km of the proposed wetland areas. It is estimated that as many as 323,900 adults in Hamilton participated in nature-based activities (70 per cent of the total adult population in the 2016 census, 418,843 from the Hamilton Census Metropolitan Area (CMA)). It is estimated that this is equivalent to 161,900 Hamilton households, including 6,300 in the watershed, assuming an average of two adults per household. While the census showed there were actually 2.39 adults per household, the lower number was used to reflect the higher likelihood of single adult households. Based on the average of 81 days of nature-based recreation per year within 20 km of home, it is estimated that the total demand for nature-based recreation by Hamilton households amounts to about 13.1 million days per year.

4.5.2.1 Recreation ESV Methodology

Previous studies used recreation values for wetlands in Ontario that ranged from $135 per hectare per year (David Suzuki Foundation, 2008) to $3,351 per hectare per year in non-urban southern Ontario and as high as $9,900 per hectare per year in southern Ontario urban settings (Troy and Bagstad, 2009).

As outlined in Appendix A, there are numerous methodologies that can be used to measure the economic benefits associated with recreational resources. Ideally, surveys of existing users of the Dofasco and Bruce trails and a sample of regional households would be completed to determine current levels of recreational activity in the area and their potential levels of use once the wetlands are established. This stated preference approach would focus on the incremental values associated with wetland creation, not total value, and would be focused on learning how their expenditures on recreation activities and willingness to pay (non-market benefits) would change as a result of the new wetlands. These estimates would then be correlated with reported attendance at key and representative recreational sites in the region. Undertaking a survey to collect primary data is beyond the scope of the current study, but this information may prove valuable to decision-makers and stakeholders involved in this project and would help quantify benefits and values of future projects.

A study assessing the potential recreational value of a new wetland from Little Bow Project/Highwood Diversion Project provides some useful information (Alberta Environment et al., 1994). This study used a revealed preference approach in the greater Calgary area to determine how the creation of a new site and improved recreational quality at some existing sites (based on increased river flows) would affect recreation patterns in the region. The restoration projects in this Calgary study are not analogous to those in the Stoney and Battlefield watersheds and recreational patterns and choices of residents of Calgary likely differ from residents of the Hamilton region. However, the Little Bow/Highwood study clearly shows how recreational patterns in a region can shift as a result of changing the supply of recreational opportunities. It provides some insights into what percentage of households chose to change their travel patterns and the distance and travel time they saved by having access to the new and improved sites. The methodologies from the Calgary study could be of use if Hamilton Conservation Authority or the City of Hamilton are interested in doing a similar study locally.

Although there is limited current recreational data in the area, some assumptions about potential changes in visitation and their associated economic value can be made. Based on current levels of nature-based recreation by residents of Hamilton, it is assumed that 0.1 per cent of their activities will shift as a result of developing new sites and improving other sites as a result of project development. Estimation of the economic value associated with redistribution was done using the information from the study of the recreational impacts of the Little Bow Project/Highwood Diversion Plan in Calgary, which showed a reduction of 4.5 km in average travel distance and a travel time reduction of five minutes. Average travel costs associated with car travel were assumed to be $0.52 per kilometre (CRA 2019) and an average hourly wage rate of $27.36 (Statistics Canada 2019) was used to calculate the travel time savings associated with these redistributed trips.

Our analysis assumed that the annual benefits associated with redistributed trips associated with the wetland projects will increase as the population of the Hamilton CMA increases. Population forecasts (Ontario Ministry of Finance 2018) indicate that the population of Hamilton is expected to increase by 1.4 per cent per year to 2021, 1.2per cent per year to 2026, 1.1 per cent per year to 2036, and one per cent per year to 2041. These population growth forecasts were used to estimate the incremental recreational values over a 50-year discount period.

Note that health system savings associated with increased recreational use were not included in this valuation.

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4.5.2.2 Incremental Recreational ESVs of the Project

An anticipated 13,889 redistributed trips are expected in the year following project completion. This is slightly higher than paid visitation at the parking lot at the Devil's Punch Bowl. Given that the precise recreational amenities at the new conservation area is unknown, it is difficult to determine the accuracy of this estimate.

Travel cost saving in year one was valued at $2.33 per trip or $32,361 for all redistributed trips. Travel time saving was valued at $2.08 per trip or $28,889 for all redistributed trip. The total anticipated value of time and travel costs savings in year one associated with recreational use of the new conservation area is $61,250 (Table 23).

Table 23 *Initial (year one) recreation ESV estimates for HCA Wetland Project*

Please confirm header titles	???
Population (18 years and older), Hamilton CMA	598,347
Participated in hiking, climbing or horse riding	70%
Estimated participants	418,843
Persons per household	2.44
Estimated households	171,468
Days per year of participation in nature-based recreation within 20 km of home	81
Estimated days per year	13,888,921
Redistributed trips as a result of new and improved sites	0.1%
Redistributed site trips	**13,889**
Average cost per km of driving	$2.33
Total travel cost savings	**$32,361**
Average value of time per trip	$2.08
Total time of travel saving	**$28,889**
Total travel cost and time savings	**$61,250**

In year two (e.g. beginning in 2021), the recreational benefits would increase to $583 per hectare per year or $63,696 in travel cost and time savings for all redistributed trips. The total NPV of recreational ESVs ranges from $2.55 million (using a two per cent discount rate) to $3.67 million (based on a 0.5 per cent discount rate).

In comparison with previous recreational benefit estimates for the Greenbelt region and Ontario, our estimate of $583 per hectare per year is conservative. Estimates of recreation ESVs for wetlands in Ontario have ranged from $399 per hectare per year for the entire Greenbelt (David Suzuki Foundation, 2008), $3,351 per hectare per year for non-urban southern Ontario wetlands (Troy and Bagstad, 2009) and $9,900 per hectare per year for southern Ontario urban wetlands. The City of Hamilton and the HMA are located within the Greater Golden Horseshoe, Canada's most densely populated region. While national numbers were used to calculate the recreational value of the new conservation area, it is likely that these areas will have greater visitation than other parts of the country, particularly as population grows. This is another highlight of why local recreational use data is invaluable to understanding the value of natural infrastructure projects.

4.5.3 Other ESVs of Wetlands

Other ESVs normally associated with wetlands may be expected from the HCA wetland project, including but not limited to the following:

- **Carbon storage and sequestration** are generally significant services in wetland complexes given the significant amounts of carbon wetlands can store; however, the ecological function behind this service can take a long time to return to the landscape and can fluctuate through wetland development.
- **Water supply/regulation** are services normally considered an important and significant value associated with wetlands.
- **Waste (nutrient) regulation** are normally associated with wetlands, depending on their ecological function, location and disturbance regime.
- **Biodiversity/habitat/refugia** values from protection of habitat for plants, mammals, birds and amphibians. Biodiversity values can be significant; the 2008 Greenbelt study of ESVs estimates average biodiversity values of $5,831 per hectare per year for wetlands, equivalent to $6,590 per hectare per year in 2018 dollars.
- **Erosion control** services provided by wetlands have not previously been estimated in natural capital accounting studies, including previous Greenbelt studies. These benefits have been identified by the HCA as potential benefits. Current capital and operational costs associated with erosion control expenditures by the City of Hamilton may be used in future as a proxy for the value of the wetlands projects with respect to potentially offsetting these grey infrastructure costs. HCA does have cost estimates from the 2011 Environmental Assessment to do the restoration work related to downstream erosion, but not the ongoing maintenance challenges on Stoney Creek. Using annual municipal expenditures related to erosion control would help, in future, in a full cost benefit accounting for the East Escarpment wetland projects. Construction of the wetland complexes may result in future reduction in the frequency for erosion-related repairs and thus future cost savings to the City of Hamilton. However, without the necessary detailed information, it is difficult to verify such a prospective value.

Estimating the potential future ESV (in the absence of primary value analysis) entails using benefit transfer protocols of previous ESV estimates (using meta-analysis) for the Greenbelt region. Values from the 2008 Greenbelt study for wetlands were applied to the total area of the project (109.2 hectares). As noted in the methodology section of this report, we assume that these ecological functions and services would be restored over 50-years beginning with an assumed two per cent rate of service functionality at the completion of the project and reaching 100 per cent or optimum ecological conditions 50 years later.

If these other ESV are realized in future, they would contribute significant societal benefits ($1.2 million per year or $11,000 per hectare of wetland per year) to both the Hamilton region and to the Greenbelt region as a whole (Table 24). These additional ESVs would add considerably more value to the estimated $2,145 per hectare per year in combined flood mitigation and recreational benefits. The key, however, will be verifying in future that these benefits were realized in both ecological terms and economic value terms.

Table 24 *Estimated potential future ESVs of the HCA wetland project*

	Climate regulation (carbon sequestration and storage)	Water supply/ regulatory	Waste (nutrient) regulation	Biodiversity	Subtotal
ESVs per ha per yr.	$800	$90	$3,000	$7,000	$11,000
Total annual ESVs	$87,500	$10,000	$376,000	$719,500	$1,193,000
NPV (0.5% discount rate)	$1,823,000	$230,000	$8,200,000	$16,000,000	$26,000,000
NPV (2.0% discount rate)	$947,500	$149,000	$5,170,000	$9,900,000	$16,100,000

4.6 Cost-Benefit Analysis

4.6.1 Project Costs

The total cost of constructing the four wetland projects is estimated to be $15.35 million with the costliest projects being SC-7, SC-5 and SC-8 (see Table 25). For this study, total spending was assumed to occur in 2020. These costs may prove to be conservative because of unaccounted additional land acquisition, engineering design or any ongoing maintenance costs. To date, 245 acres (99.2 hectares) of agricultural land has been acquired by HCA at a cost of approximately $2.4 million or $24,000 per hectare. These land acquisition costs are treated as sunk costs and do not factor into the cost benefit analysis, which only considers future benefits and costs. An additional $2.4 million (or approximately another 245 acres) is the assumed budget for future land acquisition needed for project construction.

Table 25 *HCA wetland project cost estimates*

Total cost estimates	SC-5	SC-7	SC-8	BC-1	Total
Soil excavation and export	$3,614,040	$7,792,411	$1,431,706	$0	$12,838,157
Berm construction	$71,434	$71,892	$23,742	$0	$167,068
Road reconstruction	$163,696	$105,479	$26,571	$72,675	$368,421
Plantings	$534,781	$883,010	$304,096	$256,485	$1,978,372
Total	**$4,383,951**	**$8,852,792**	**$1,786,115**	**$329,160**	**$15,352,018**

$/hectare	SC-5	SC-7	SC-8	BC-1	Average
Soil excavation and export	$156,384	$172,819	$93,392	$0	$117,587
Berm construction	$3,091	$1,594	$1,549	$0	$1,530
Road reconstruction	$7,083	$2,339	$1,733	$2,833	$3,374
Plantings	$23,141	$19,583	$19,837	$9,999	$18,120
Total	**$189,699**	**$196,336**	**$116,511**	**$12,833**	**$140,612**

4.6.2 Project Benefits and NPV

The analysis of project incremental ESVs, both primary value estimates and benefit-transfer function estimates, are summarized in Table 26. The NPV of the ESVs are calculated using a 50 -year discount period and 0.5 per cent and two per cent discount rate.

Table 26 *Summary of HCA wetland project estimated ESVs vs. costs*

Ecosystem services	$/annum	$/ha/yr.	NPV (@2.0%)	NPV (@0.5%)
Primary valuation				
Flood mitigation (AFW baseline, no increase in flood frequency)	$171,400	$1,562	$5,322,295	$7,432,461
Recreation	$63,696	$583	$2,410,818	$3,467,635
Subtotal	**$235,096**	**$2,121**	**$7,731,488**	**$10,900,096**
Benefit transfer values				
Climate regulation (carbon storage)	$87,497	$801	$947,500	$1,823,211
Water supply/regulatory	$10,121	$93	$139,115	$219,673
Waste (nutrient) regulation	$376,091	$3,444	$5,169,447	$8,162,973
Biodiversity	$719,507	$6,950	$9,889,767	$15,616,737
Subtotal	**$1,193,216**	**$10,928**	**$16,145,829**	**$25,822,594**
Total ESVs	**$1,428,312**	**$13,049**	**$23,877,317**	**$36,722,690**
Project capital costs			$15,300,000	$15,300,000
Net benefits (ESVs less costs)			**$8,577,317**	**$21,422,690**

If not accounting for potential increases in flood frequency, the estimated NPV of flood control benefits ranges from $5.3 million (based on a two per cent discount rate) to $7.4 million (based on a 0.5 per cent discount rate). Table 27 compares the flood mitigation benefits of the AFW baseline study and one and two per cent flood incidence increases. If flooding frequency increased by one per cent, the per hectare value of the wetland would rise to $2,307per year. With a two per cent increase, value would increase to $3,045 per hectare per year. The flood benefits alone for this project have a higher NPV than the project capital costs.

Table 27 *Flood mitigation ESV estimates from AFW baseline to one and two per cent flood frequency increase and total net benefit of all ESVs with adjusted flood mitigation values*

	AFW baseline (million $)	1% flood incidence increase (million $)	2% flood incidence increase (million $)
Flood mitigation	$5.3 - 7.4	$8 - 11.2	$10.7 - 14.80
Total benefit (All services)	$24 - 36.9	$26.7 - 40.7	$29.3 - 44.2

4.7 Alternative Scenarios

Do Nothing

The option of doing nothing and foregoing the HCA wetland project has significant associated risks and potential costs associated with future flooding in the City of Hamilton. While the wetland complex would not mitigate the damages that could occur with a one-in-100-year catastrophic regional flood event, the wetland complex would mitigate property damages under lesser flood event scenarios. As analyzed, any increase in the frequency of five to 50-year flood-events would quickly reveal the wisdom of investing in the wetland as a natural asset. The values associated with the recreational and other benefits of the project would also be unrealized and residents will continue to pay more in travel costs and time to visit other recreational amenities, which may become increasingly stressed by increased visitation as the population in the region grows.

Maintain the Current State

The other option would be to maintain the current state of the proposed wetland development as it is (rural and farmland). The values associated with communal use (e.g. recreational values) would be lost in this option and flooding and erosion issues would not be mitigated.

Invest in Grey Infrastructure Solutions

The alternative to investing in green infrastructure such as the proposed engineered wetlands is a conventional 'grey' flood attenuation infrastructure capital investment. Engineering solutions to provide built infrastructure with similar flood mitigation benefits could cost at least $28.5 million, considerably more than the estimated $15.3 million in green infrastructure.[4] Using the same full cost capital accounting and CBA analytic perspective for either grey or green infrastructure capital investment options, it seems logical that an investment in the green infrastructure alternative would be more cost-effective, more economical and provide higher net societal benefits from a public sector investment perspective.

Photo courtesy of Toronto and Region Conservation Authority

4 Cost estimate provided by Scott Peck of the HCA in consultation with one or more engineering firms.

4.8 Conclusions

It is evident that there is a strong business case for this project. It is expected that this project will achieve its goal of creating a new conservation area in the Upper Stoney Creek and Upper Battlefield Creek to provide natural hazard attenuation, natural heritage enhancements and recreation opportunities. Even without being able to fully account for the potential erosion control benefits of the project, the flood mitigation benefits alone are worth more than the capital cost of the project.

The use of flood frequency risk scenario analysis to model some of the uncertainty related to climate change is instructive, showing that a wetland natural capital investment can quickly become even more economically viable with increasing flood events. More robust climate change impact modeling and flood frequency what-if scenarios would be required to assess the economics of flooding and the merits of these kinds of natural asset investments.

Recreational information is necessary in helping understand the needs and values of natural asset projects like the new conservation area. Local data on recreational preferences and use would be beneficial in tracking the success of the recreational objectives of this project as well as determining baselines for future restoration projects.

The alternatives of doing nothing or keeping the land use as it exists today are not likely to result in the benefits that the new wetlands could provide. The grey infrastructure alternative in this locale is greater than the capital cost of the new conservation area and would not provide the co-benefits of recreational amenity, habitat and air quality that the new wetlands could provide.

This cost-benefit analysis does not account for additional services that the project might provide to human health and well-being which could translate to health care system savings and generally improved standards of living for beneficiaries of the project. This valuation also does not account for the complex and important role that increased development, population growth and the impact of climate change will have on all the functions and services explored in this valuation.

In addition to flooding, climate change impacts may lead to increased drought, human heat stress and less available habitat for biodiversity, increasing the incremental value that this project may provide. Similarly, development in the region is likely to make natural assets rarer. This has potential to increase the value of the new conservation area. Population growth has been accounted for in the recreational valuation, but it will have far-reaching implications on the per capita share of services of all kinds including water provision and access to greenspace. These are complicating factors not easily incorporated into economic models, but it is likely that if the current trajectory is maintained, ecologically functioning natural spaces will become rarer and therefore more valuable in the Hamilton region.

In conclusion, Hamilton Conservation Authority's Saltfleet Conservation Area and the associated wetland restoration has a strong business case and the benefits this project will provide to the community are likely to extend long beyond the 50-year return period used in this analysis. Additional local information on the recreational impacts of this project could help further this case.

Photo courtesy of Toronto and Region Conservation Authority

5

Brock Lands Restoration Project

5.1 Introduction

The former Brock North and Brock South landfill sites were acquired by the Toronto and Region Conservation Authority (TRCA) from the City of Toronto in 2011. These sites are located south of Highway 407 and east of Brock Road. Brock North is situated north of Concession Road Five in the City of Pickering, while Brock South site is located on the south side of the road in the Town of Ajax (see Figure 5). As part of the acquisition agreement, the City of Toronto stated its preference that the lands be used for open space and park purposes, including paths, trails and other recreational uses.

Following acquisition of the lands, the TRCA has worked with the Town of Ajax and the City of Pickering to develop a Restoration Plan for the two properties (Figure 6). The properties offer critical wildlife habitat and connectivity to other important habitats in the Duffins Creek watershed.

The purpose of this assessment is to compare the potential costs of restoring the Brock Lands area with the range of ESVs that these areas would generate in order to determine whether benefits would exceed costs.

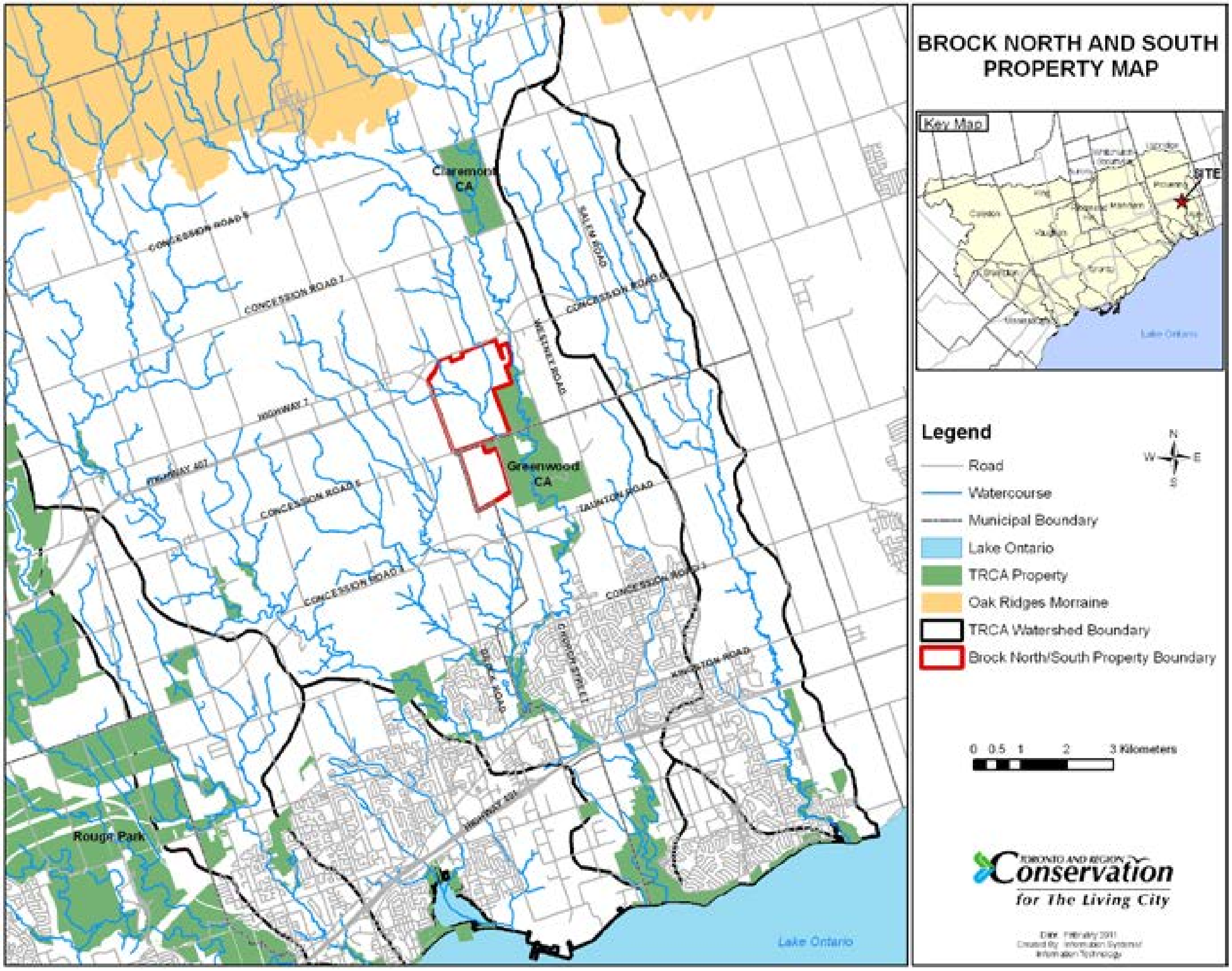


__Figure 5__ Location of Brock North and Brock South Properties highlighted in red, other TRCA property in green and Ajax/Pickering boundary in yellow. Map courtesy of TRCA.

5.2 Biophysical Setting

The Brock properties are located in the Duffins Creek watershed (TRCA 2011). The soils in the area are permeable and sandy. The aggregate in the area was extracted from 1954 to 1969, resulting in the creation of large depressions, redirection of surface flows and watercourses and exposure of groundwater and low permeability soils. The areas within and adjacent to the Brock Lands serve as a combination of groundwater recharge and discharge. The ditches, sumps and pits associated with past land uses have resulted in wetlands, channels, seeps and discharge points that have changed the groundwater-surface water relationship in the Duffins Creek watershed, which is primarily dependant on groundwater sources. Water quality in the creek is good and does not appear to have been compromised by past landfill operations.

The Brock North property is an area of roughly 319 hectares comprised of a mosaic of forests (76.7 hectares), semi-wooded areas (32.0 hectares), meadows (114.0 hectares) and wetlands (87.9 hectares comprised of swamp (53 hectares), marsh (14.9 hectares) and fern-complexes (20.0 hectares). There are also nine hectares of sand barren areas (four per cent of the area) that are remnants of aggregate extraction.

The Brock South area is roughly 92 hectares with a similar mix of habitats, small areas of mature forests, young meadows, sand and barren land and a variety of plant species. This area has not been completely inventoried. A total of 94 flora species of regional concern were identified in the Brock North property and 29 species of concern in Brock South. Studies in Brock North found 25 species of birds, one mammal species and seven reptiles and amphibians that were of regional concern. Two species are protected under the Ontario Endangered Species Act, the common snapping turtle and the Bobolink. Similar species were observed in Brock South.

In terms of aquatic habitats and species, the Brock North property contains the confluence of Brougham Creek, a cold-water stream, and Spring Creek, a cool-water stream. Brougham Creek is of particular importance because the cold water supports species like Brook Trout as well as Redside Dace, a nationally and provincially endangered species. Since 2006, Atlantic Salmon have been stocked in Duffins Creek in the adjacent Greenwood Conservation Area. While less is known about the fisheries potential of the Brock South property, there are concerns that changes to surface drainage may be limiting fish passage.

5.3 Local Demographics

The two Brock properties are currently surrounded by agricultural lands to the west and north and the Greenwood Conservation Area to the east. While there are expectations for more urban development in the general area both in Pickering and Ajax, the current land use plans call for minimal development immediately adjacent to the properties.

The demographic characteristics of the population in the surrounding region were estimated using census tract information from the 2016 Census and weighting this information according to the percentage of each census tract that lies within specific distances from the Brock Lands site, using the intersection of Church Street and Concession road 5 as the centre point. Selected demographic characteristics for the populations near the Brock Lands site are summarized in Table 28.

In 2016, about 1.12 million people lived within 20 km of the Brock Lands. Compared to 2011, there was a very large increase in the population (21.1 per cent) that lived within five km of the site. This compares to population growth rates of 6.1 per cent for the larger region living within 20 km of the site.

Table 28 *Selected demographics of residents living adjacent to the Brock Lands site, 2016*

	Distance from Brock Lands (kilometres)		
	5	10	20
Population			
2016	45,500	215,770	1,124,550
2011	34,500	200,670	1,059,600
Growth rate 2011 to 2016	21.1%	7.5%	6.1%
Age			
0 to 14 years	22.2%	19.0%	16.6%
15 to 64 years	69.6%	68.8%	68.6%
65 to 84 years	8.2%	12.2%	14.8%

Sources: Interpolated from Statistics Canada 2017 based on the percentage of each census tract falls within given distance from the centre point of the Brock Lands site.

5.4 Conservation Project Description

The objective of the project is to protect and restore ecological function and resilience for both aquatic and terrestrial ecosystems in the area (TRCA, no date). The objectives include:

- Restoring and enhancing altered hydrology and sensitive groundwater zones;
- Enhancing landform and soil conditions to promote self-sustaining natural communities;
- Restoring natural cover and providing connectivity at both the local and regional scale; and
- Creating and enhancing optimal fish and wildlife habitat.

The following deliverables are expected from the project:

- 139 hectares of improved terrestrial habitat;
- 6 hectares of created or enhanced wetland habitat;
- 14 sub-catchments restored to capture flow of water generated by 1,035 hectares of land;
- 142 hectares of improved stream edge habitat;
- 14.7 km of improved headwater streams that support cold-water fisheries;
- 143 hectares of improved landform and soil conditions that protect groundwater, support natural site drainage and promote self-sustaining natural cover; and
- Installation of essential structures such as nest boxes and log tangles to promote creation of wildlife habitat.

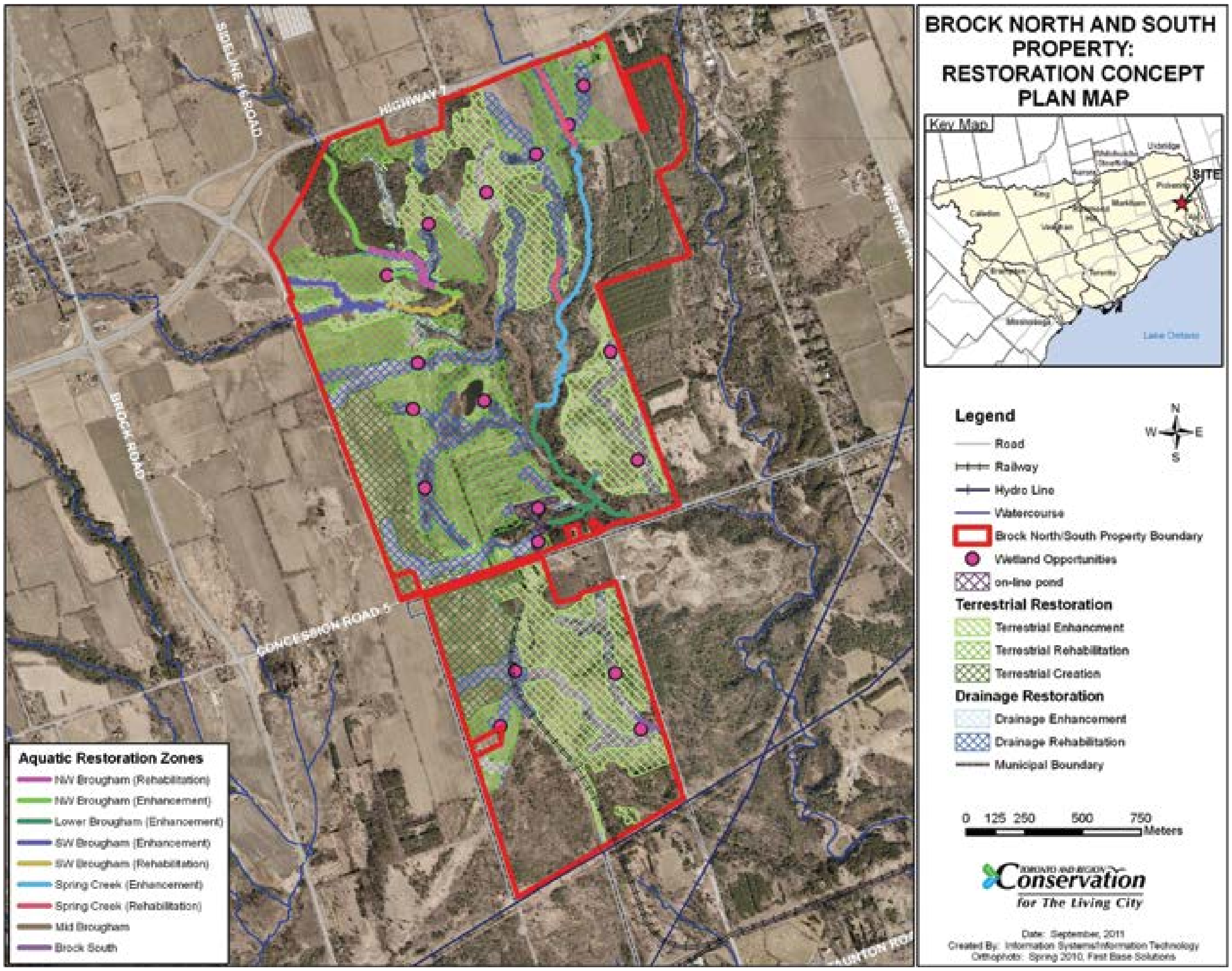


Figure 6 *Brock North and South Lands priority restoration map*

5.5 Ecosystem Service Valuation

Recreation is the key ecosystem service considered in this analysis using primary research. A number of other ESVs normally associated with wetlands, forest land and meadows which make up the Brock Lands site are estimated as potential future benefits as the site is restored ecologically over the next 50 years.

5.5.1 Recreation Benefits

Recreational values associated with creating new recreational opportunities in the Brock Lands area have been estimated using the same approach that was used to estimate the recreational effects associated with the proposed wetlands project in the Battlefield and Stoney Creek watersheds (described above and in Appendix A).

Current Conditions

Estimates of total recreation demand and use by the adult population (people aged 18 years and older) living within 20 km of the Brock Lands were made using the methods and estimates contained in the 2012 Canadian Nature Survey (federal, provincial and territorial governments of Canada, 2014) (see Table 28).

Table 29 *Regional and local participation in nature-based recreation*

	Distance from Brock Lands (kilometres)		
	20	10	5
Number of adult residents	965,500	58,750	18,200
Participants in nature-based recreation	675,850	60,025	12,750
Participating households	337,900	230,000	6,400
Days of nature-based recreation per year	27,340,900	2,431,000	516,200

While there is no detailed data on the extent of recreational activities that currently occur on the site, TRCA staff have documented various types of activities including off-leash dog walking, trail hiking, all-terrain vehicle (ATV) and snowmobiling and mountain biking.

5.5.2 Incremental Recreation ESVs of the Project

Table 30 shows how very small changes in the percentage of trips being redistributed to the Brock Lands could result in very large increases in the number of sites visits. A 0.1 per cent change in visitation could result in about 23,370 visits to the area; this is slightly less than current levels of use of the GCA. If improvements to the area resulted in redistribution of 0.5 per cent of trips, this could result in about 136,860 visits per year or 3.4 times the extent of existing trail use. Redistribution of one per cent of regional recreational use could result in 273,800 user-days of recreation and this would be nearly seven times the current levels of trail use in the GCA.

Table 30 *Regional and local participation in nature-based recreation*

	Distance from Brock Lands (kilometres)		
	20	10	5
Days of nature-based recreation per year	27,340,900	2,431,000	516,200
Possible increased use of Brock Lands due to redistribution of trips from other sites			
0.1% redistribution	23,370	2,430	520
0.5% redistribution	136,860	12,200	2,600
1.0% redistribution	273,800	24,300	5,160
1.5% redistribution	410,600	36,500	7,750

From the perspective of local demand, a 1.5 per cent increase in use of the Brock Lands following redevelopment by people living within 10 km of the site would be nearly equivalent to current levels of trail use in the GCA.

The analysis shows that, because of the very large and growing population near the Brock Lands site, even very small changes in recreation patterns could result in a considerable increase in recreational use of the site.

5.5.3 Other ESVs

Other ESVs normally associated with forests, wetlands and meadows are estimated by applying values from the 2008 Greenbelt study, inflated to 2018 dollar values to the future area of forest (98.7 hectares), wetlands (113.2 hectares) and meadows (146.9 hectares) expected in Brock Lands. Ecological functions are assumed to start at two per cent of their full potential to 100 per cent within 50 years. These ecosystem services (in addition to the recreational benefits already estimated) were evaluated over the 50-year period (Table 31).

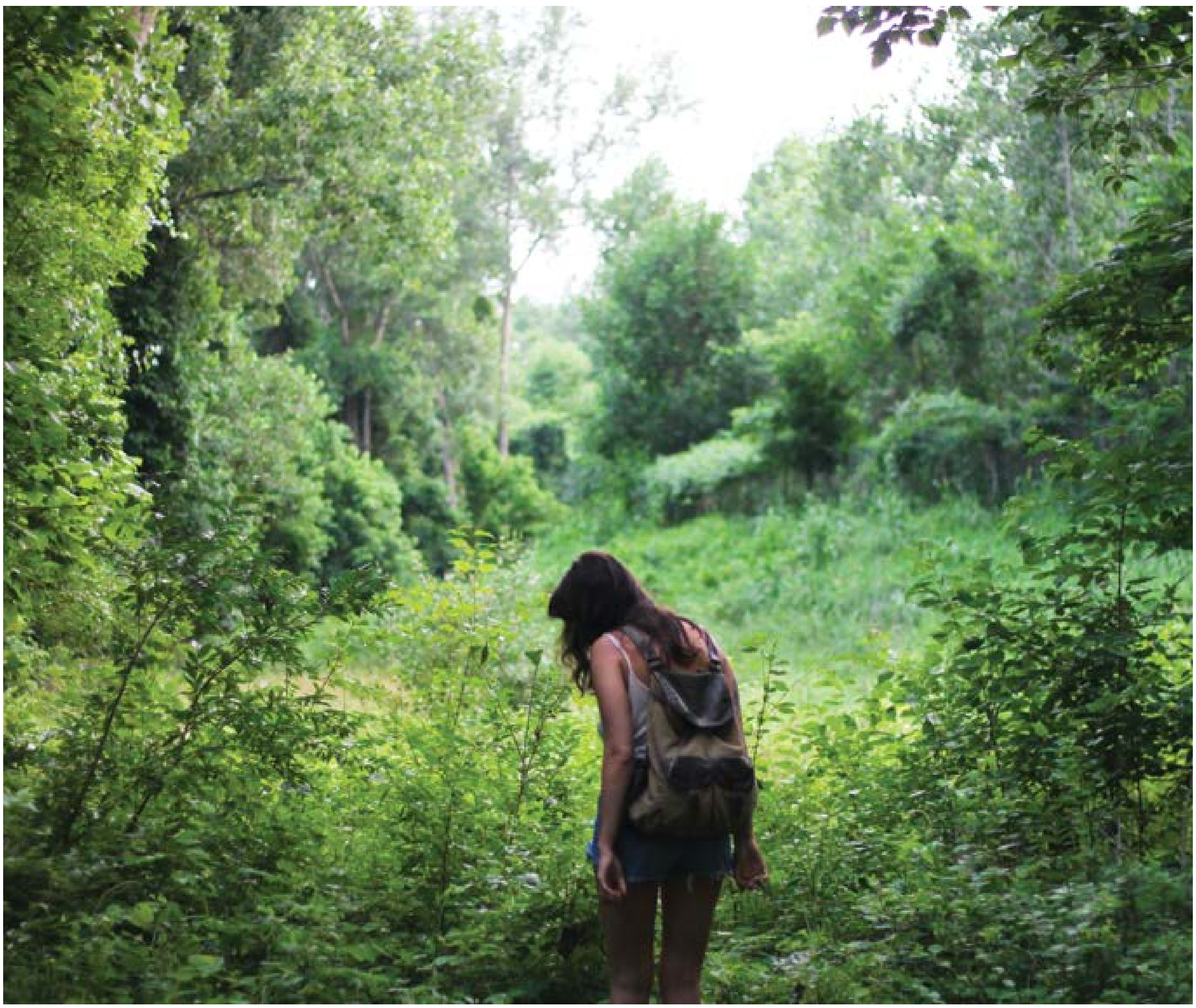


Table 31 *Estimated future ESV of Brock Lands Conservation Area ($/ha/yr and total ESVs)*

	Annual ESV by Area ($/ha/yr, 2018 dollars)		
	Wetlands	Forests	Meadows*
Gas regulation/Air quality		426	14
Climate regulation (carbon stored)	796	1,039	241
Climate regulation (annual carbon uptake)	6	44	33
Flood control	4,564		8
Erosion control		19	57
Water regulation	59	1,721	11
Water filtration	34	536	
Waste treatment (removal of excess N and P runoff)	3,410	66	165
Pollination (agriculture)		1,253	1,253
Pollination (trees)		607	
Biological control		29	45
Biodiversity/habitat/refugia	6,590		3
Total per ha $/ha/yr	**15,458**	**5,741**	**1,829**
Area (hectares)	**113.2**	**98.7**	**146.9**

	Total Annual ESV estimates ($/yr, 2018 dollars)			
	Wetlands	Forests	Meadows*	Total
Gas regulation/Air quality		42,064	1,992	44,055
Climate regulation (carbon stored)	90,086	102,500	35,350	227,935
Climate regulation (annual carbon uptake)	666	4,362	4,813	9,841
Flood control	516,878		1,162	518,040
Erosion control		1,896	8,298	10,194
Water regulation	6,630	169,866	1,660	178,156
Water filtration	3,865	52,865		56,730
Waste treatment (removal of excess N and P runoff)	386,149	6,469	24,230	416,848
Pollination (agriculture)		123,691	184,050	307,741
Pollination (trees)		59,894		59,894
Biological control		2,897	6,638	9,535
Biodiversity/habitat/refugia	746,280		498	746,777
Total annual ESVs	**1,750,554**	**566,503**	**268,690**	**2,585,747**

* Using grassland ESVs as proxy

Source: Toronto Region Conservation Authority; Derived from David Suzuki Foundation, S.J. 2008. Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services. Greenbelt Foundation and David Suzuki Foundation. Toronto, Canada

5.5.4 Recommendations for Future Valuations

Several opportunities for future data collection were identified to track the success of the Brock Lands restoration efforts and to make the case for future projects. Some of these data are describe by service below:

Carbon storage and sequestration services are generally significant in the case of forested lands and wetlands. A biomass assessment using non-destructive measurements like lidar and wetland/soil coring would be beneficial in tracking the success of this objective. The additional local information it could provide could also be used to help build the case for future restoration projects. The new forest and wetland areas in particular offer an opportunity for valuable long-term monitoring.

Recreation value estimates would benefit from local preference and use data. Primary data on attendance for recreational sites in the region and local survey data would be beneficial for increasing the accuracy of the recreational benefit estimates, and to track the success of the project in meeting its recreational amenity objectives.

Property values of nearby residential and commercial lands could increase because of the restored natural assets of Brock Lands. Willingness to pay surveys and reviews of land premiums could be used to help build the case for these project values.

5.6 Cost-Benefit Analysis

A cost-benefit analysis can be a useful tool in making the case for a project. By assessing the future ESVs of a natural infrastructure project like Brock Lands restoration and comparing it to the cost over a given period, decision-makers can evaluate the potential impact of the project in monetary terms. Discount rates are applied to future benefits and costs to adjust for the higher worth of cash flow today compared to its worth in the future.

5.6.1 Project Cost

The total cost of restoring the Brock Lands sites is estimated at $4.3 million with an additional estimated annual operating costs of $88,000. It is assumed that total spending would occur in 2020 or 2021. Discounted annual operating costs over 50 years range from $2.7 million (two per cent discount rate) to $3.8 million (0.5 per cent discount rate).

5.6.2 Project Benefits

The estimated ESV from recreation benefits are $603,514 per year or a 50-year NPV of between $25.0 million (two per cent discount rate) to $36.1 million (0.5 per cent discount rate). Therefore, the value of recreational benefits alone are 3.6 to 4.5 times greater than the NPV project costs, suggesting a net positive economic return on investment even by just considering the primary service of recreation.

The additional ESVs add an extra value of $2.58 million per year with an NPV of $35.5 million (two per cent discount rate) to $56.1 million (0.5 per cent discount rate) (Table 32). When these other ESVs are added to the estimated recreation benefits, the Brock Lands project could generate an NPV of between $60.5 million and $92.3 million.

Table 32 *NPV of Brock Lands ESVs: Recreation and Other Services*

Ecosystem services	Annual value $/yr (2018$)	Total value range ($ over 50 years)
Recreation benefits (primary valuation)	$603,514	$25.0 million to $36.1 million
Potential future ESVs of within 50 years (benefit-transfer valuation)		
Forests	$566,503	$7,8 million to $12,3 million
Meadows	$268,690	$3.7 million to $5.8 million
Wetlands	$1,750,554	$24.1 million to $38.0 million
Subtotal	**$2,585,747**	**$35.5 million to $56.1 million**
Human well-being impacts	Estimates not available	
Total ESVs		**$60.5 million to $92.3 million**

5.7 Alternative Scenarios

Do nothing

The alternative of leaving the former landfill and aggregate site to languish unrestored is a least desired alternative. Restoring the land to a higher state of ecological functionality is in the interests of society as a whole as healthier and flourishing natural landscapes will ultimately contribute to a broad spectrum of ecosystem services that will benefit both local residents and Ontarians.

Maintain the Current State

Many challenges associated with the Brock Lands site have been identified, including presence of invasive species. Without continued monitoring, intervention and control, invasive plants could spread across the sites. Maintaining the current state of the site would likely involve operating costs to stop invasive species from dominating the site. The site preparation and restoration outlined in the Brock Lands restoration plan can help reduce the population of invasive species and increase the vigor of native vegetation in the area. As shown in the cost-benefit analysis, the benefits of implementing the restoration plan for Brock Lands outweighs the costs and considering there would be costs to even maintain the current state of the property, investment in this restoration project has evident benefits.

Invest in Grey Infrastructure Solutions

There is no known grey or engineered solution to replace the recreational value that greenspace like the restored Brock Lands site can provide. Engineered solutions to replace the climate regulation and air quality services are likely to be far more expensive than the costs associated with the Brock Lands restoration.

Photo courtesy of https://commons.wikimedia.org/wiki/File:Soil_Erosion_at_its_worst-2%2B_(2146223172).jpg

5.8 Conclusions

The significant NPV from future ESVs for the Brock Lands project suggests there is a very strong economic argument for the project. The recreational value of these restored lands is enough to make the case that this natural infrastructure investment is worthwhile.

With increased uncertainty associated with a changing climate and increased pressure and demand for natural areas from a growing population, it is possible that the valuation reported here significantly underestimates the potential value of this project.

The incremental cost benefit analysis of the Brock Lands projects demonstrates a very favourable business case for investing an estimated $4.3 million in the restoration of once industrial lands to an ecologically functional forest and wetland complex. The expected incremental recreational benefits are estimated at between $25.0 to $35.1 million in terms of NPV, based on project rates of 0.5 and two per cent respectively. The addition of other potential ESVs would add an additional $35.5 million to $56.1 million in NPV of benefits to the project economics. This would suggest that the investment in this natural capital asset by the TRCA would generate societal benefits that greatly exceed the costs of this project.

Photo: © Hark Nijjar Photography

6

Lake Scugog Enhancement Project

6.1 Introduction

Lake Scugog is a shallow lake located in the southwest portion of the Kawartha watershed (Figure 7). Historically, Lake Scugog consisted largely of wetlands with river channels flowing through it. Damming of the river in the 1830s raised the lake level by 10 feet, allowing it to be used for transportation as part of the Trent Severn waterway that links Georgian Bay with Lake Ontario. The lake is important for recreation and tourism. Port Perry, a community of about 9,500 people, is located on the southwest corner of the lake.

Lake Scugog has become increasingly eutrophic, resulting in significant aquatic vegetation that limits boat traffic and has adversely affected water quality and fish habitat. Concerns about the growth of aquatic vegetation, including invasive species (Eurasian Milfoil and Starry Stonewort) and toxic bluegreen algae led to the development of the Lake Scugog Environmental Management Plan (Kawartha Conservation 2010).

The purpose of this assessment is to compare the potential costs of enhancing Lake Scugog with the range of ESVs that could result in order to determine whether benefits would exceed costs.

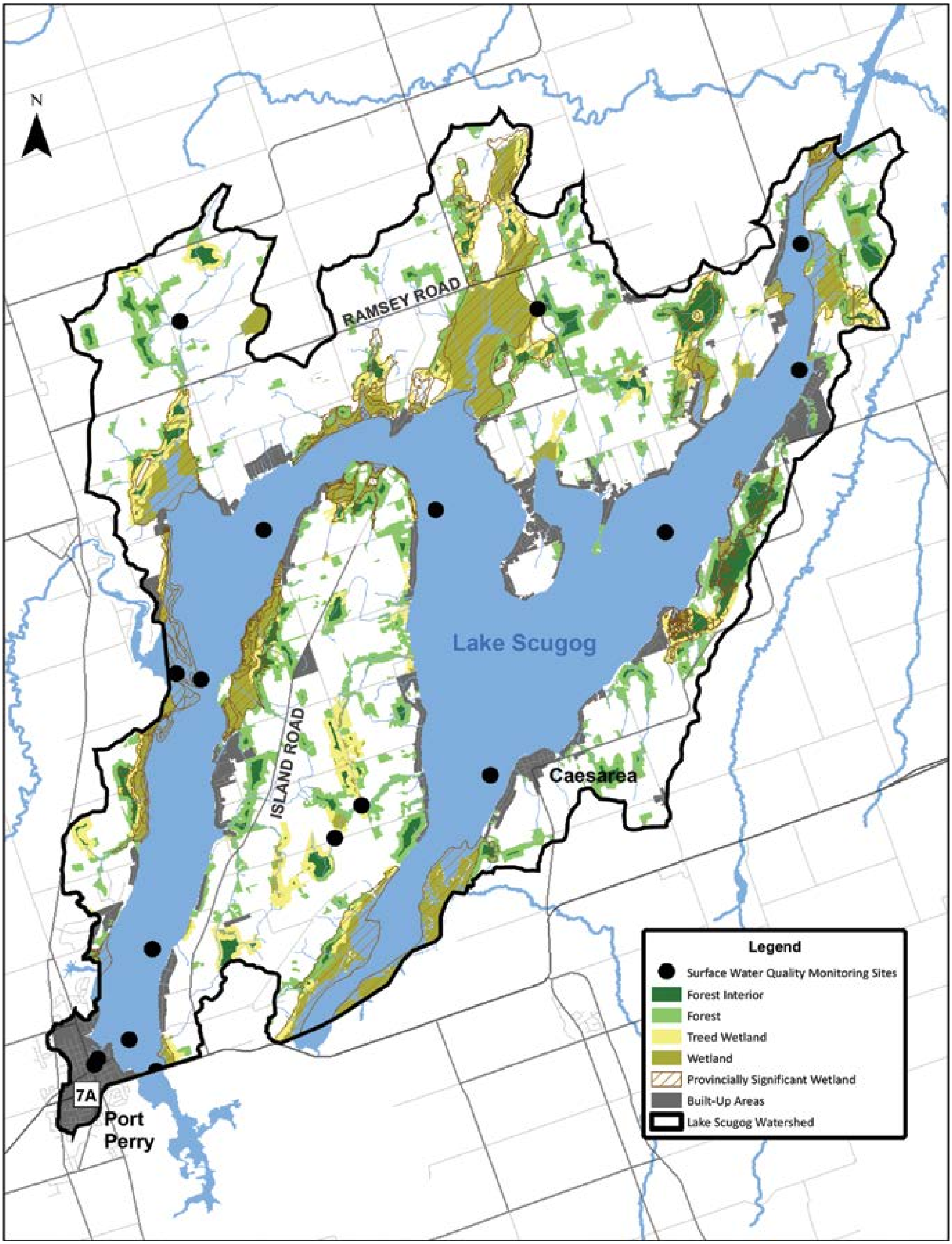


Figure 7 *Lake Scugog watershed and features*

6.2 Introduction

Lake Scugog is situated between the communities of Port Perry and Lindsay in central Ontario, in the Great Lakes Basin and forms part of the Trent–Severn Waterway.

Lake Scugog sits in a sub-watershed of 14,061 hectares and has a surface area of 68 km^2 (6,800 hectares) and shoreline length of 172 km. Technically not considered one of the Kawartha lakes because of its shallow depth, Lake Scugog is often linked to them and is among the largest by surface area. The lake has been raised and lowered several times over its history. Agricultural land is the biggest component of the lake watershed at 45.6 per cent, followed by forest and wetlands.

Originally, Lake Scugog was essentially two lakes connected via a broad channel flowing through a marshy area along the north end. Prior to the construction of a dam in 1834 and flooding events, much of area was forest and swamp land. The marshes of the lake prior to flooding were filled with wild rice stands and cranberries harvested by First Nations. The flooding of the lakes contributed greatly to their destruction.

The lake also supports abundant fish stocks and is one of the most renowned fishing locations in southern Ontario for its bass, walleye, crappie, musky, perch, carp, catfish, and minnows. Lake Scugog is also a tourist area, forming the southern boundary to "Cottage Country". The towns of Port Perry and Lindsay benefit from the recreational boating through the Trent-Severn Waterway.

Lake Scugog has become increasingly eutrophic, with inflows of untreated sewage resulting in significant aquatic vegetation that limits boat traffic and has adversely affected water quality and fish habitat. The Port Perry urban area has a significant impact on water quality, largely attributed to stormwater discharge in Williams Creek and Cawkers Creek, which flow through the urban area and several stormwater culverts that outlet directly into the lake. Eutrophication has caused rapid sedimentation and excessive vegetation growth, aquatic habitat degradation and loss and the proliferation of invasive aquatic species. The western basin of the lake, immediately offshore from the community of Port Perry and north to the Nonquon River mouth, was identified as requiring significant remedial action.[5]

Phosphorus and nitrogen loading into the lake's ecosystem is contributing to the eutrophication of the lake biology. An estimated 9,100 to 9,600 tonnes of phosphorus enter the lake every year from sources that include:

- 24% from agriculture
- 18% from urban run-off
- 10% from private septic systems
- 6% from rural road run-off
- 2% from the Port Perry Sewage Treatment Plant
- 21% from natural sources
- 19% from precipitation

5 GHD. 2018. Lake Scugog Enhancement Design Brief. Prepared for the Town of Scugog. December 2018

6.3 Local Demographics

The Mississaugas of Scugog Island First Nation reside on Scugog Island in the centre of the lake, occupying about 2.58 square kilometres (2,580 hectares) of land area. There are also many seasonal cottagers on the island and around the lake.

Lake Scugog is situated in the Scugog Township Census Subdivision in the Regional Municipality of Durham (census division). A second census subdivision, the Mississaugas of Scugog Island Indian Reserve, is also located nearby. As of 2016, an estimated 21,748 people lived near Lake Scugog. As shown in Table 33, less than half of the regional population lives in Port Perry (44 per cent) with most of the population living in rural areas outside Port Perry. While there has been a small overall increase in the regional population since 2011 of 0.4 per cent, the population of Port Perry actually decreased by 2.7 per cent while the rural population increased by 2.6 per cent and the reserve population increased by 40.9 per cent.

Table 33 *Demographic characteristics of the regional population*

	Port Perry	Rural Scugog Township	Mississaugas of Scugog Island	Total
Population 2016	9,453	12,164	131	**21,748**
Percent of total	43.5%	55.9%	0.1%	**100%**
Population 2011	9,717	11,852	93	**21,664**
Percent change	-2.7%	+2.6%	+40.9%	**+0.4%**
Age: 0 to 14 years	14.5%	14.5%	16.0%	**14.5%**
Age: 15 to 64 years	58.4%	69.1%	80.0%	**64.5%**
Age: 65 to 84 years	22.3%	15.1%	4.0%	**18.1%**
Age: 85 years and over	4.9%	1.3%	0.0%	**2.8%**

Aside from the differences in population growth rates, the demographic characteristics of Port Perry and the surrounding rural areas are quite similar. Lake Scugog is also very attractive to tourists and cottagers for angling, boating and other recreational uses.

6.4 Conservation Project Description

The Working Group for a Healthy Lake Scugog (WGHLS) was formed in 2013 with a mandate to identify and examine alternatives for addressing issues of eutrophication, sedimentation and weed growth in order to improve the environmental, financial and social economies of the area. It proposed the Lake Scugog Enhancement Project as an environmental improvement and dredging project that would benefit the entire lake. This would involve dredging part of the lake near Port Perry Bay to address shallow water issues and using the dredged material to create a large engineered wetland that would be used to treat stormwater. The preferred alternative was selected because it would alleviate problems with sediment and organic matter accumulation, mitigate stormwater impacts, improve recreational use and aquatic and wetland habitat and avoid provincially-significant wetlands and spawning areas (Township of Scugog 2017).

The plan concluded that, in order to improve water quality, inflows of total phosphorus loads into the lake had to be reduced. The plan identified a number of strategies designed to increase awareness of land use and other practices that adversely affect water quality that would encourage urban and agricultural landowners and others to find ways of reducing nutrient loading.

There are increasing concerns about the growth of aquatic vegetation, including invasive species and toxic blue-green algae that would detract from the lake's recreational fishery image and recreational lake boating tourism. With the pressures of phosphorus and nitrogen loading in the lake from various point sources, there is a sense of urgency to improve water quality and reduce these inflows.

Another key issue is the sediment accumulation in the Port Perry Bay area, which identified the need for dredging part of the lake to address shallow water issues. The demand for dredging may in part be driven by recreational lake (boating) users who are finding accessibility increasingly constrained. The dredged material would be used to create a large engineered wetland to treat stormwater.

In 2004 the Lake Scugog Environmental Management Plan was established. The primary goal of the LSEMP is to ensure the long-term environmental and social sustainability of Lake Scugog and its resources by achieving the following objectives:

1. Protect and improve water quality in the lake and its tributaries
2. Maintain healthy aquatic and terrestrial ecosystems within the watershed
3. Improve the aesthetic values of the lake and enhance opportunities for public enjoyment of the lake's natural surroundings
4. Foster community understanding of the lake and an appreciation of the lake's natural and historic heritage
5. Promote environmentally sustainable use of the lake
6. Maintain ongoing monitoring and research

The LSEMP is not a fisheries management plan. The primary goal of plan is to encourage a greater understanding of the true nature of this lake and its watershed and an appreciation of its assets. The LSEMP attempts to balance the goals of maintaining the integrity of natural features and addressing the human-caused factors that are accelerating the lake's aging process. The LSEMP does not deal with aquatic habitats in any significant way. However, Lake Scugog is a significant fishing destination with important angling and other aquatic recreational and tourism benefits. The shorelines and many wetlands abutting the lake provide significant habitat for a wide variety of birds and wildlife. The naturally abundant aquatic vegetation and productive nature of the lake and landscape are the primary cause of this rich resource.

The Lake Scugog Enhancement Project involves the following components:

- Sediment and invasive aquatic plant (temporary) removal by dredging
- Placement and confinement of dredged material along shoreline
- The creation of stormwater management and constructed wetlands
- Shoreline extensions and naturalization for habitat enhancement and recreational use

The objectives of this project are to enhance Port Perry Bay and restore natural features by:

- Removing excessive invasive aquatic vegetation
- Removing excess sediment
- Improving of future water quality
- Increasing fish spawning and winter and summer foraging habitat
- increasing waterfowl habitat
- Increasing boating access
- Promoting excellent angling
- Educating wetland visitors through interpretative signage
- Increasing trail walking opportunities over lake via the berm
- Increasing accessible trails
- Promoting tourism to the Bay and the surrounding communities

A key part of this project is removing the dredged sediment material and reusing it to create an enhanced fringe wetland. This option was selected because it is expected to alleviate problems with sediment and organic matter accumulation, contribute to the lake's nutrient budget by potentially absorbing phosphorus and nitrogen loads, mitigate local stormwater impacts, improve recreational use and aquatic and wetland habitat, and avoid provincially-significant wetlands and spawning areas. The project footprint is 5.8 hectares while the area to be dredged is roughly 4.1 hectares, representing only 0.1 per cent of the lake's entire area. It is somewhat uncertain whether this level of effort over a relatively small area of the lake will have an incrementally beneficial impact on water quality in the short- or long-term. The dredging of phosphorus-containing sediment is expected to result in a onetime removal of 948 kg of phosphorus from the lake system. The sediment is to be reused in the wetland.

One of the reasons for the Lake Scugog natural capital investment initiative is to address lake's eutrophication risk, reduced water quality and proliferation of aquatic vegetation, which have resulted in losses in boating, fishing and other recreational use values. With 24 per cent of nutrient loading coming from agricultural land owners (estimated at 2.18 million to -2.30 million kg per year), it was determined that the best investment of funds and effort would be in working with agricultural land owners to adopt best management practices through a program of education of best management activities to reduce phosphorus. The other focus will be on shoreline residents, septic use and shoreline restoration efforts. In the urban communities, the Conservation Authority looked at bio swales and stormwater controls and bylaws that promote Low Impact Development (LID); these are long-term solutions. At present, Port Perry as a community has no immediate plans or solutions for their contribution to the nutrient loading issue.

In addition to the potential losses in the lake's aesthetic and perceptional value from continued eutrophication and ongoing risks of harmful algal blooms (HABs), there is also the potential loss of tourism benefits and social (reputational) capital resulting from lake ecosystem degradation. This includes the loss of a larger transient boater population venturing into Port Perry from the Trent Severn waterway by way of the Lindsay lock.

The majority of the capital investment anticipated for the project will be dredging of lake sediment and moving that material in the construction of wetland a berm to deal with stormwater issues and potential nutrient-loading capture. Since there are many catch basins in to the lake, a wetland complex and adjacent oil and grit separators will help resolve some of the sedimentation issues (Kawartha Conservation, GHD and the Township of Scugog). Moreover, dredging of the lake and construction of a berm and wetland complex with the dredged material located in a less populated area of Lake Scugog away from the Port Perry Bay is seen as one of the few viable options for dealing with the sediment and vegetation loading challenges.

6.5 Ecosystem Service Valuation

A number of key final ecosystem services along with beneficiaries are expected from the Lake Scugog projects. The key ecosystem services impacts and benefits include:

- Biological control:
  - removing excessive invasive aquatic vegetation
- Waste treatment and water purification:
  - removing excess sediment
  - mitigation of phosphorus and nitrogen loading
- Water quality:
  - improvement of future water quality
- Biodiversity, habitat/refugia:
  - increasing fish spawning and winter and summer foraging habitat
  - increasing waterfowl habitat
- Climate regulation:
  - increase in forested land
- Recreation and tourism opportunities:
  - increasing boating access
  - promoting excellent angling
  - promoting tourism to the Bay and the surrounding community
- Aesthetic, cultural and spiritual benefits:
  - enhanced perceptions of environmental quality and well-being

While these ESVs are typical of s watershed like Lake Scugog, the challenge with analyzing the merits of the Lake Scugog projects is to what degree there will be expected incremental improvements in ecological function and incremental ESV. This would require a baseline of information that should include physical or biological conditions (current and historical) of the watershed ecosystem, lake nutrient budget and changes in water quality conditions, as well as trends in recreation and tourism use data. Without a baseline of a healthy or sustainable Lake Scugog ecosystem and a nutrient budget, it is difficult to determine how the proposed green capital investments might contribute to a net positive improvement or benefit in future ecosystem services.

Our estimates of potential future ESVs was limited to estimating the benefit of reduced phosphorus loading to Lake Scugog that may result from development of the wetland complex and installation of oil and grit separators (OGS). Unfortunately, other potential ESVs, including incremental recreation values, biodiversity, wildlife habitat and water quality could not be estimated due the absence of key baseline data. However, it was possible to estimate the annual total estimated ESVs of the Lake Scugog watershed, based on the application of previous Greenbelt ESV for forests, open water (lake), wetlands and grasslands (meadows) to the Lake Scugog watershed. This use of benefit transfer protocols provides a second-best estimate of the ESVs which currently exist and which may ultimately be at risk due to potential losses in ecological integrity and ecological functionality due to ongoing lake eutrophication and impacts of human development.

6.5.1 Phosphorus Removal Benefits

The most tangible and verifiable incremental benefit expected is the reduction of phosphorus loading into the Lake Scugog ecosystem. The expected phosphorus removal efficiency of the OGS separators is roughly 30 per cent phosphorus removal efficiency and 77 per cent removal efficiency by the wetland complex[6]. The total estimated total phosphorus (TP) reduction is 32.26 kg of phosphorus per year (including reductions from both the Casmir and Baagwating outlets). In addition, the dredging of lake sediment and establishment of the wetland is expected result in a one-time removal of 948 kg of phosphorus from the lake ecosystem. However, as this one-time removal is likely negligible and the total lake phosphorus budget is unknown, it is not included in the overall value.

The estimated opportunity cost of removing phosphorus in the lake sediment can be evaluated based on the capital cost of tertiary phosphorus removal technologies now in use in Canada, which can have unit costs above $1,000 per kilogram per year.[7] In comparison, the phosphorus offset program now operational in the Lake Simcoe watershed uses a $35,000 per kilogram for phosphorus offset charge.[8] In a recent 2018 economic analysis of phosphorus removal strategies for Pelly's Lake, Manitoba[9] used an estimate of $60 per kilogram for the value of phosphorus removed from Pelly's Lake associated with a wetland complex investment (see text box). For purposes of the Lake Scugog analysis, we have used the $1,000 per kilogram per year opportunity cost of phosphorus applied to the estimated annual phosphorus removed by the wetland complex and the Casimir and Baagwating outlets. The phosphorus reduction services of this project are estimated to have an annual value of $32,260.

6 Based on estimated by Hutchinson Environmental using their P Loading Tool for Phosphorus Sensitive watersheds (2014). Estimates conducted July 3, 2019 by Debbie Balika, Water Quality Specialist with the Kawartha Conservation

7 XCG Consultants Ltd. 2010. Review of Phosphorus Removal at Municipal Sewage Treatment Plants Discharging to the Lake Simcoe Watershed. Kingston, Ontario: Water Environment Association of Ontario

8 Walter, M. 2018. Lake Simcoe Phosphorus Offset Program. Presented at the National Nutrient Recovery and Reuse Forum, Toronto, Ontario, March 8, 2018

9 Insurance Bureau of Canada. 2018. Combatting Canada's Rising Food Costs: Natural Infrastructure is an underutilized option. September 2018. Co-authored with the University of Waterloo, Intact Centre on Climate Adaptation, and the International Institute for Sustainable Development. P. 19-22.

6.5.1.1 The Economic Costs of Harmful and Nuisance Algal Blooms

The continued impact of phosphorus loading on Lake Scugog must be examined in terms of the potential long-term economic costs of lake eutrophication and algal blooms. A recent report (2019) of the estimated economic costs associated with HNABs in Lake Erie provides an important benchmark for similar analysis for HNABs risks in Lake Scugog (Smith et al. 2019). The costs associated to HNABs for the Canadian portion of the Lake Erie basin were estimated at an annual cost of $272 million in 2015 prices over a 30-year period if left unchecked (Environment Canada, 2015). The largest market costs would be imposed on the tourism industry ($110 million in equivalent annual costs) and the largest non-market costs would be borne by recreational users and those who place inherent value on the lake's quality ($115 million in equivalent annual costs).

This 2019 report (based on the 2015 study) provides a useful analytic framework for evaluating impacts of future phosphorus management actions for Lake Scugog by examining three management scenarios:

a. **Stable lake:** HNABs are stable at their baseline levels for the 30-year modelling horizon

b. **Business-as-usual:** HNABs continue to worsen until 2030 when the lake stabilizes at a significantly degraded state

c. **Policy intervention:** HNABs continue to worsen until 2020 when actions are taken to reduce phosphorus loading and the lake gradually improves to reach a stable and substantially improved state by 2025 for cyanobacterial blooms and 2030 for Cladophora.

The cost categories Smith modeled for each scenario were:

Cost category	Nature of costs imposed
Commercial fishing	Reduced value added due to reduced flows or quality of freshwater fish and/or increased costs to harvest fish
Water users: industries (including municipal drinking water treatment plants) that use water from the lake for various purposes	Increased capital and operating costs due to reduced raw water quality
Recreational users: individuals that participate in lake-based recreation	Reduced utility due to reduced enjoyment from beach activities, fishing, boating, birdwatching and hunting
Non-users: individuals that do not make direct use of the lake but that are concerned about its quality	Reduced utility due to reduced well-being associated with knowledge of the lake's condition
Tourism: businesses operating in the "tourism industry"	Reduced value added due to lost business as a result of reduced numbers of visitors to the lake
Lake shore property owners	Reduced wealth due to reduced value of lakefront property
Human health: individuals exposed to increased disease threat	Reduced utility and increased health care costs due to increased individual morbidity/mortality

The other important benefit of the 2015 analysis for Lake Erie is the demonstration of what NPV of management actions are justified based on the welfare economic grounds. The study uses the WQL (Water Quality Ladder), a measure or scale of water quality (1-10) that was developed by Resources for the Future (Washington) as a measure of the incremental changes in water quality associated with algal blooms (Figure 8).[10] The WQL serves as a scaler to assess the incremental cost and losses in economic benefits associated with algal blooms driven by phosphorus and nitrogen loading in the lake's ecosystem.

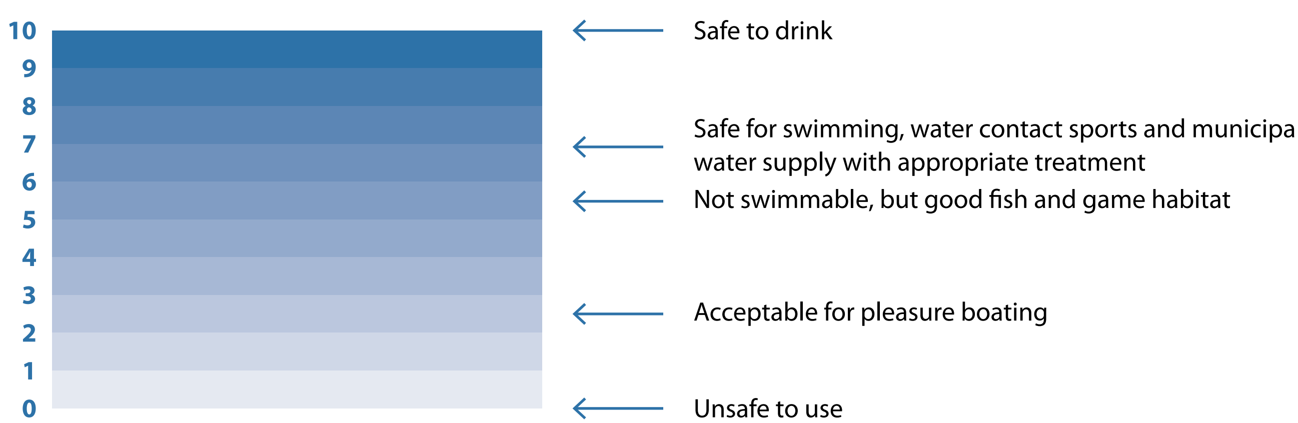


Figure 8 *Water Quality Index (WQL) Scale*

Source: Adapted from Vaughan, W. J., 1986, "The RFF Water Quality Ladder", Appendix B in Mitchell, R. and R. Carson, The Use of Contingent Valuation Data for Benefit/Cost Analysis in Water Pollution Control, Final Report, Washington, D.C.: Resources for the Future

10 The RFF Water Quality Ladder is a 10-point scale commonly used in studies of willingness-to-pay for water quality improvements. The scale provides a common point of reference for researchers to use in querying individuals about their willingness-to-pay for different kinds of improvements in water quality.

If Lake Scugog had the equivalent of a WQL index (a measure of lake water quality) for the lake ecosystem, that would be a useful tool for monitoring changes in future recreational, tourism, nonuser and property values to assess losses in economic benefits to these beneficiaries and compare them to the full costs of policy actions. In addition, monitoring the successes of phosphorus management protocols for Lake Simcoe should prove instructive for future management actions.

Adopting a similar analytic framework to the Lake Erie assessment of economic costs of algal blooms in Lake Scugog would be beneficial to decision-makers. The range of economic costs and beneficiaries associated with algal blooms in Lake Erie are similar to Lake Simcoe. However, the utility of this economic analysis framework is dependent on ongoing monitoring of recreational and tourism user statistics, lake water quality (perhaps using a WQL scale) and the relationship between phosphorus loading and algal blooms.

6.5.2 Recreation and Tourism Benefits

While the estimated incremental value to future recreational beneficiaries could not be estimated, previous estimates in the 2016 Greenbelt study may provide relevant contextual information about the potential aquatic use and benefits from the Lake Scugog. Using the 2016 total ESVs for non-motorized water and beach aquatic use, angling and bird watching for the entire Greenbelt region, ESVs can be expressed on a per household basis (households both within the Greenbelt region and extending in a 20+ km buffer around the region). These per household ESVs can then be applied to the estimated 21,748 residents or 8,700 households that live in the Port Perry, rural Scugog township and Scugog Island communities to derive an annual estimated ESV of Lake Scugog to the local communities. Table 34 shows that the estimated annual value of only three aquatic-related recreational activities applied to only 21,748 residents of the Lake Scugog geography is estimated to contribute between $4.4 million to $25.5 million annually. Comparatively, the 2013 Port Perry Stormwater Management Plan estimated that municipalities in the Scugog watershed receive approximately $10 million to $15 million dollars annually from tourism and recreational activities concentrated around the lake (Kawartha Conservation Authority, 2013).

The most recent tourism and recreational user data for Durham Region (which includes Lake Scugog) reveals the importance of Lake Scugog as a recreational and tourism asset for the region and Port Perry. The economic value of Lake Scugog as a recreational asset is evidenced by the estimated 5.2 million visitors in 2018 to Durham County and their $309 million in spending. As noted, a majority of visitors identified Lake Scugog itself as the primary reason to visit. A variety of recreational benefits, including angling, lake-shore recreational enjoyment, walking, bird watching and boating can be evaluated in terms of the current economic value that stems from the current Lake Scugog ecosystem and its ecological conditions.

Table 34 *Greenbelt ESVs associated with Lake Scugog on a per household basis (Greenbelt region, Greenbelt + 20 km buffer zone) and estimated value to Lake Scugog communities.*

	Aquatic recreation uses values for Greenbelt Region		Estimated value attribute to Lake Scugog communities	
Aquatic recreation use values within Greenbelt	Per household within Greenbelt	Per household of Greenbelt +20 km buffer	Estimated value using per household within Greenbelt	Estimated value using per household Greenbelt region + 20 km buffer
Non-motorized water and beach	$391.34	$67.46	$3,404,303	$586,818
Angling	$432.81	$74.61	$3,765,079	$649,007
Bird watching	$2,103.76	$362.64	$18,301,012	$3,154,646
Subtotal	**$2,927.90**	**$504.70**	**$25,470,394**	**$4,390,471**

Source: Ontario's Good Fortune: Appreciating the Greenbelt's Natural Capital. 2016

These estimates of the value of the Lake Scugog watershed should be used with the caveat that they may not reflect the actual ESVs associated with the unique ecosystem functions and conditions of the Lake Scugog watershed. Nevertheless, they provide an important case for maintaining or improving the condition of Lake Scugog.

Without more detailed information, the impact the proposed Lake Scugog enhancement project will have as an incremental increase in recreational values to current and future visitors and users cannot be estimated.

6.5.3 Biodiversity and Habitat Incremental Benefits

Habitat enhancement benefits from the construction of the wetland complex have been identified by the Kawartha Conservation Authority. The economic value of the biodiversity benefits has not been evaluated for the Lake Scugog enhancement project primarily because there are no benchmark studies from the literature that could be used to make such estimates on projects of this nature.

6.5.4 Recommendations for Future Valuations

Plans for monitoring the progress of this project have been made. This additional information will help to validate the success of the interventions, and if undertaken in a comprehensive manner, data collected through these initiatives could be used to demonstrate the actual value of the project and provide evidence for similar projects in the future.

The expected measurement of the effectiveness of project in meeting management priorities are:

- existing and enhanced a water quality monitoring program (total phosphorus (TP), total nitrogen (TN), nitrate (NO_3), nitrogen dioxide (NO_2), ammonia (NH_3), total suspended solids (TSS), conductivity, pH, temperature, dissolved oxygen)
- annual algae survey (native and invasive) (annually for five years)
- annual wetland vegetation survey (annually for five years)
- annual species at risk survey (annually for five years)

This and future valuation projects would benefit from more detailed information about the recreational use of the project area as it exists now (as a baseline) and the recreational preferences of lake users, both residents and tourists. A baseline survey of tourist numbers and recreational users is recommended. Understanding how future degradation of the lake and eutrophication events impact its values may become more important if the issue worsens.

6.5.5 The Lake Scugog Subwatershed and Natural Asset Management

The broadest suite of estimated ecosystem services attributed to the Lake Scugog subwatershed can be valued to provide decision-makers with an appreciation of the current potential ESV the forests, wetlands, meadows and lakes provide annually. Using the ESVs from the 2008 Greenbelt study and applying these values on a per hectare per year basis, we can estimate the current annual ESVs from natural areas in the watershed. Table 35 summarizes the ESV estimates that include $38.8 million per yr for Lake Scugog (6,800 hectares in size), $110.5 million per year for the wetlands (7,084 hectares), $55.2 million per year for forest(9,019 hectares) and $16.5 million per year for meadow lands (1,916 hectares). The total combined ESVs would amount to $220.9 million per year. Other land categories including agricultural land and urban areas were not valued in terms of ESVs.

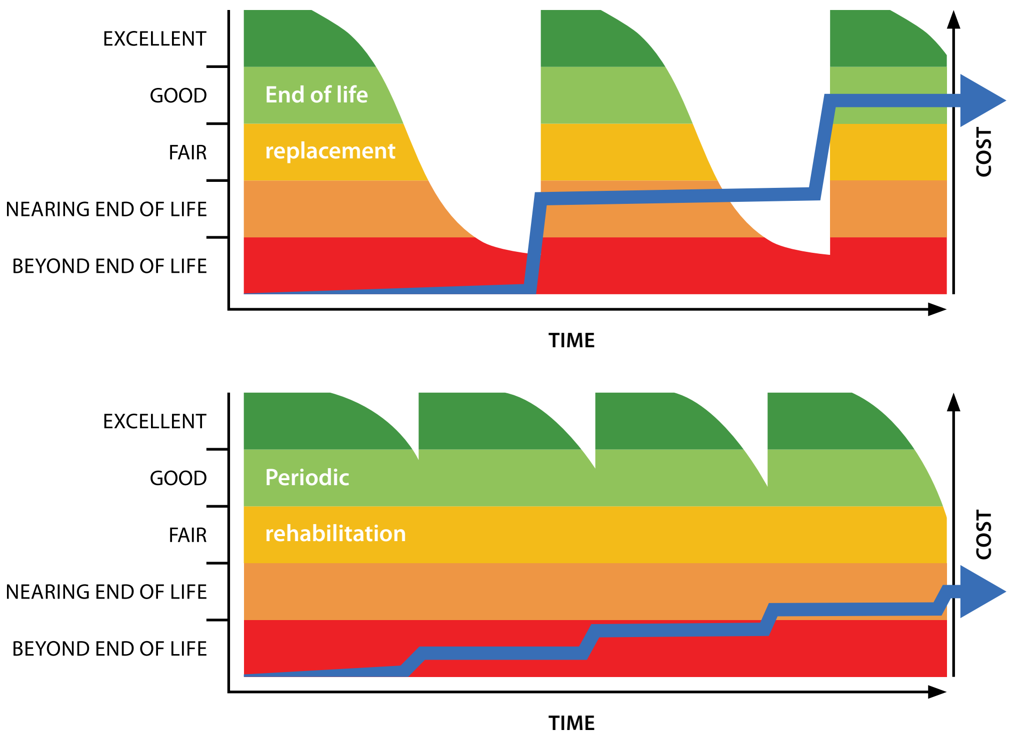
Table 35 *Lake Scugog watershed ESV estimates*

Expected benefits from Lake Scugog watershed	Lake Scugog (Inner Lake)	Wetlands	Forests	Meadows (using grassland values)
Area (hectares)	6,800	7,084	9,019	1,916
Annual ESVs ($/ha/yr (2018$)				
Gas regulation/Air quality			426	14
Climate regulation (carbon stored)		796	1,039	241
Climate regulation (annual carbon uptake)	692	6	44	33
Flood control		4,564		8
Erosion control			19	57
Water regulation		59	1,721	11
Water filtration		34	536	
Waste treatment (removal of excess N and P runoff)		3,410	66	165
Pollination			1,860	1,253
Biological control			29	45
Biodiversity/habitat/refugia		6,590		3
Recreation and aesthetics	5,016	135	378	
Total per ha $/ha/yr	**5,708**	**15,593**	**6,119**	**1,829**
Total annual ESVs	**$38,811,269**	**$110,462,764**	**$55,184,794**	**$16,499,642**

Source: Estimated by Anielski Management derived from Greenbelt 2008 ESV by, inflated to 2018 dollars.

While these figures are not compared directly to the costs of the project in this assessment, they represent estimates of the societal value that the watershed currently provides to the region and the province, which can be used to help build a case for the importance of investing into natural asset management.

Like all assets, managing natural infrastructure requires strategic planning and investment. For example, consider two strategies of managing road asset quality. First, consider that the road is allowed to deteriorate until it is no longer usable and needs to be completely replaced. This may look good on a budget sheet for the first cycle of replacement, but a long-term cost comparison shows that making more frequent investments (e.g. re-paving the top layer only) leads to significant cost savings over time. Natural infrastructure management works similarly. The reason Lake Scugog provides services to the community is because of its proximity to human activity. This proximity also means that humans are influencing the lake, largely with ecological stressors like phosphorus inputs. If nothing is done until there is such significant ecological decline that the system no longer functions on its own, a higher cost is incurred than if continual investments were made (see Figure 9).



Eg. Periodic, planned rehabilitation of roadway asphalt has lower total lifecycle costs than rebuilding the road on a less frequent basis. Rehabilitation has higher costs at first, but becomes less expensive over the long term.

Figure 9 *Long-term maintenance investments in assets compared to replacement costs. Adapted from Figure 42 of Richmond Hill's 2016 Asset Management Plan*

6.6 Cost-Benefit Analysis

The original cost estimate for the entire Scugog project was $2,838,700, with an estimated 10-15 year project period. Revised estimates suggest total costs could be $3,023,850 (including 15 per cent contingency) for the dredging and construction of a berm structure and wetland complex broken down as follows (Table 36):

Table 36 *Lake Scugog dredging, wetland and berm construction project estimates*

1: Construction inspection/contract administration	$96,000
2: Mobilization/access/road/layout/bond	$30,000
3: Berm construction	$979,795
4: Suction dredging	$834,940
5: Wetland features	$150,700
6: Oil and grit separators	$538,000
15% contingency	$394,415
Total (excluding HST)	**$3,023,850**

A range of discount rates from 0.5 per cent to two per cent over a 50-year discount period were applied to the incremental benefits of phosphorus removal anticipated by the project. The estimated capital cost of $3.02 million can be compared with the ESV of phosphorus removal from the lake ecosystem range which is estimated between $716,000 (two per cent discount rate) to $936,000 (0.5 per cent discount rate).

Unfortunately, other potential ESVs, including incremental recreation values, biodiversity, wildlife habitat and water quality could not be estimated due the absence of key baseline data. If only this one service was valued without additional information, the cost would be an estimated $2 to 2.3 million more than its NPV. However, the annual ESVs of the Lake Scugog watershed, with a total area of 53,876 hectares, are estimated at $220.9 million per year. Some of these ESVs are at risk to losses due decline in ecological function due to the human activities that are affecting the lake and restoration efforts are needed to protect these values.

The NPV of the Lake Scugog enhancement project if counting only the phosphorus loading reduction benefits would result in a $2.1 million to $2.3 million shortfall relative to the estimated $3.0 million capital investment. Unfortunately, other potential ESVs, including incremental recreation values, biodiversity, wildlife habitat and water quality could not be estimated due the absence of key baseline data.

In order for the benefits of the Scugog project to equal or exceed the costs, incremental recreation benefits would have to range in value from $47,000 (at 0.5 per cent discount rate) to $72,000 per year (at two per cent discount rate) for a 50–year project discount period. Expressed another way, approximately $2.0 million in total recreation value or NPV over the next 50 years would have to be realized for the project to break even. As shown in the TRCA Brock Land project, recreational values of natural asset investments can be much higher than this. Furthermore, the project is taking place in a larger subwatershed that has an estimated value of $220.9 million per year. Whether other incremental ESVs will be achieved by this project can ultimately only be verified using primary data collection including annual recreation/tourism user surveys.

Based on the subwatershed analysis, the current economic value of aquatic-related recreational activities (non-motorized water and beach use, angling, bird watching) associated with Lake Scugog may range from $4.39 million (lower bound) to $25.47 million (upper bound) per year. These recreation values do not include the value of motorized boating (estimates are not available), hiking ($854,000 per year, lower bound), cycling ($741,000 per year, lower bound), cross country skiing ($1,179,000 per year, lower bound) and other activities that may be associated with the use of the Lake Scugog area.

What is unknown without primary data collection is how much of the estimated $4.39 to $25.47 million per year in recreation value associated with a healthy Lake Scugog ecosystem is being protected, at risk or being improved as a result of the current investment.

6.7 Alternative Scenarios

Do Nothing

The alternative of doing nothing or continuing business as usual – leaving the lake ecosystem to be negatively impacted by nutrient loading and risking ongoing future algal blooms – will undoubtedly pose a growing risk to the future economic well-being of the lake's ecosystem, the watershed and communities like Port Perry and others. As in the case of both Lake Erie and Lake Simcoe, the economic costs of business-as-usual can be estimated and are significant enough to justify and warrant policy interventions and management plans to reduce phosphorus loadings in the hope that these lakes gradually improve to reach a substantially improved, stable state.

Therefore, any attempts to restore the Lake Scugog watershed to a higher state of ecological functionality is in the interest of society as a whole, as healthier and flourishing aquatic and terrestrial natural landscapes will ultimately contribute to a broad spectrum of ecosystem services that will benefit both local citizens and Ontarians as a whole. That said, the proposed Lake Scugog projects will likely do very little to achieve this desired future even though the projects may help secure and maintain recreational and tourism values while also educating the public about the lake ecosystem's conditions and challenges.

Maintain the Current State

Maintaining the current ecological conditions of Lake Scugog would require investments to maintain its current phosphorus and sedimentation levels, as there are new inputs annually. The Lake Scugog Restoration Project may actually represent this scenario of maintaining the current state of the lake. Significantly lowering phosphorus levels would require other initiatives, including some ongoing and proposed programs of Kawartha Conservation Authority as described below.

Stream Restoration Program

A stream restoration program will prioritize sites and provide resources to plan and implement restoration activity to enhance in-stream riparian habitat conditions. As determined in the Kawartha Conservation Oak Ridges Moraine Watershed Plans, issues that will be addressed include:

- fragmentation of aquatic habitat caused by instream barriers (e.g. perched culverts)
- organic pollution; the quality of aquatic insect (benthic macroinvertebrate) communities suggests several parts of these watersheds suffer from elevated organic pollution

Generally, the watercourses in the program area watersheds do not meet the minimum recommended natural coverage length of 75 per cent.

Project component	Estimated cost
Inventory the location of critical aquatic habitats (e.g., spawning sites for Brook Trout and Muskellunge)	$25,000 +
Landowner outreach	$25,000 +
Development of restoration plans	$100,000 +
Implementation of restoration plans	$500,000 +

Stewardship Programs

This short-term program would provide incentive for agricultural landowners in the Lake Scugog region to practice best management practices (BMPs) that prevent soil loss and nutrient loading into waterbodies. The program costs are estimated at $298,000. BMPs promoted will include the following:

- managing manure and other sources of contamination (e.g. manure storage, fuel storage)
- fencing livestock to restrict access to waterbodies and riparian areas
- well decommissioning
- agricultural soil erosion control structures
- drainage stewardship (e.g. naturalization of open drains)

Expected ecological impacts:

- improved ground water quality
- improved surface water quality, including benefiting downstream communities like Lindsay in terms of reduced water treatment costs
- Reduce phosphorus and nitrogen loading

6.8 Conclusions

The proposed enhancement projects for Lake Scugog appear to have strong local support based on surveys of residents and businesses. A lack of robust information on both historical and current ecological and recreational data limited the potential to undertake a complete cost-benefit analysis.

The objective of this analysis was to determine whether the estimated $3.0 million natural infrastructure capital investment would result in measurable incremental improvements or benefits in key final ESVs. While this objective was not met, useful information for decision-makers did come from this analysis.

The proposed enhancement projects are only expected to remove about 940 kg of phosphorus from lake sediment and reduce annual phosphorus loading (now between 9,100 to 9,600 kilograms per year) by 32 kg annually. Ongoing nutrient loading from residents, agricultural land owners and municipalities makes it difficult to know what impact this reduction alone could have. A nutrient budget for the lake and tributaries is now being conducted to assess and verify whether the enhancement projects will have any real incremental impacts on the lake's ecosystem. Changes in ecosystem functions would have to be carefully monitored and evaluated over the life of the project to verify that incremental benefits have resulted.

These are common analytic challenges in many ecological asset enhancement projects of this nature. Notwithstanding, it is clear from evidence that does exist, including recreational use statistics, tourism spending, boating, angling and other recreation values, that Lake Scugog constitutes an important natural capital asset to the Durham Region and Port Perry community that would be important to protect and enhance in terms of improving key ecological functions of the watershed. A robust suite of final ESVs has not been identified.

The most important value of Lake Scugog comes from recreational values. At the very least it could be argued that the $3.0 million capital investment in the enhancement projects serves as "periodic rehabilitation", a notion from asset management that considers the long-term benefit of periodic investments in infrastructure instead of allowing them to become so degraded they must be replaced. The ecological function of Lake Scugog can be thought of in similar ways to any other asset, and this investment is extending the usefulness of the lake to beneficiaries.

Another important consideration in determining the societal value of the Lake Scugog initiatives is apparently strong support from local residents for all aspects of the Lake Scugog enhancement project. This suggests high levels of social capital value for the project and a strong expression of interest that something should be done, and investments made to improve the ecological conditions of the lake. Strong public opinion may be evaluated in future in terms of a willingness-to-pay or invest in the project. The estimated $3.0 million capital investment in lake enhancement would amount to an average one-time $347.60 investment per household in Port Perry/rural Scugog communities (n=8,700 households) or $12.93 per household in the Durham Region (n=233,936 households). The expected benefit would be to maintain or enhance the estimated $309+ million in recreation-tourism spending in region in 2018, with Lake Scugog as a major source of recreational activity and value. The value of this recreational-tourism spending to local households would equate to $35,523 per Port Perry/rural Scugog household per year or $1,321 per Durham Region household per year Our estimated aquatic recreation values of Lake Scugog to Port Perry/rural Scugog households (using the Greenbelt 2016 study) suggests recreational values of between $4.39 million to $25.47 million per year. Aquatic recreational values of the Greenbelt region range from $504.70 per household (households inside and in a 20+km buffer surrounding the Greenbelt) to $2,927.90 per household in the Greenbelt region.

Other benefits including biodiversity and wildlife habitat values, reduction in human health-related costs and other utilities, as well as other intangible aesthetic, well-being and perceptional values would need to be included in future analysis.

The effects on the lake's ecological conditions even with a seven per cent reduction in annual phosphorus loading may be difficult to see, hidden within the background noise on the whole lake ecosystem.[11] Because the lake is so shallow, there may be considerable return of phosphorus from lake sediments. Without sufficient levels of iron in the lake system, phosphorus is very mobile and recycles efficiently between water and sediment. This is a problem with similar shallow lakes in Alberta, further highlighting how local information and long-term monitoring of Lake Scugog is so important to evaluate the success of this project and to inform future management decisions.

Kawartha Conservation Authority has identified and is already leading other programs and initiatives that will play a role in reducing the amount of phosphorus entering Lake Scugog. The primary source of nutrient loading to the lake is from surrounding land owners. Changing their behaviours to reduce nutrient and phosphorus loading will ultimately be the most effective means of achieving the targeted annual phosphorus loading reduction of 320 kg. Most certainly the phosphorus offset program now operational in the Lake Simcoe watershed using a $35,000 per kilogram for phosphorus offset charge would likely affect landowner and developer behaviours.

11 Email correspondence with Dr. David Schindler, University of Alberta, June 18, 2019.

Photo courtesy of Janani Sivarajah

7

Overall Conclusions

This analysis of three restoration projects in the Greater Golden Horseshoe demonstrates the complexities and value in comparing the cost of restoration projects to the benefit they provide society. While in every case the valuation of the ecosystem services estimated is likely lower than the real value of the projects, there is still strong evidence that each is a necessary investment in natural infrastructure that will provide economic and well-being returns.

While two of the projects, Brock Lands and Saltfleet, are new natural infrastructure projects that will provide significant value associated with their primary services of providing recreational opportunity and flood control respectively, the Lake Scugog Enhancement Project is a demonstration of a rehabilitation investment to maintain current ecological function and associated benefits.

The case studies also highlight the benefit of having local monitoring programs that collect data on both ecological and social conditions and preferences.

It is clear from the case studies that impacts from climate change and population growth can lead to increased natural infrastructure values, making investments in natural infrastructure today a wise investment. Beyond the economic value that nature provides, the important function it plays in human happiness and well-being in addition to supporting local biodiversity should not be understated. Natural infrastructure provides triple bottom line returns in the form of financial, social and ecological benefits.

Photo courtesy of Kawartha Conservation

References

Adamowicz, W., J. Louviere and M. Williams. 1994. *Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities* in Journal of Environmental Economics and Management. Volume 26, Issue 3, May 1994. Pp 271-292.

Alberta Forestry, Lands and Wildlife. 1988. Bow River recreation study: an assessment of recreational use and economic benefits. https://archive.org/details/bowriverrecreati00albe_0

Altus Group. 2017. Canadian Cost Guide 2017. https://www.altusgroup.com/wpcontent/uploads/2017/05/altusgroup_costguide2017_web.pdf

Altus Group. 2014. Canadian Cost Guide 2014. http://online.fliphtml5.com/dysg/sjha/#p=10.

Amec Foster Wheeler. 2011. Stoney and Battlefield Creek Flood & Erosion Control Class EA (2011).

Amec Foster Wheeler. 2018. Flood and Erosion Control Project for Upper Battlefield Creek and Upper Stoney Creek, City of Hamilton. Prepared for the Hamilton Conservation Authority.

Canada Revenue Agency. 2019. Automobile Allowance Rates. https://www.canada.ca/en/revenueagency/services/tax/businesses/topics/payroll/benefits-allowances/automobile/automobile-motorvehicle-allowances/automobile-allowance-rates.html

Carson, Richard T. 2000. *Contingent Valuation: A User's Guide* in Environmental Science and Technology, Volume 24, No. 8, pp 1413-1418. https://econweb.ucsd.edu/~rcarson/papers/CVusersguide.pdf

Christie, M., J. Warren, N. Hanley, K. Murphy, R. Wright, T. Hyde, and N. Lyons. 2004. Developing measures for valuing changes in biodiversity. Report prepared for DEFRA London

De Groot, R.S. 2002. "A typology for the classification, description and valuation ecosystem functions, goods and services." *Ecological Economics*. 41: 393-408

Environment Canada, 1990a. The Importance of Wildlife to Canadians in 1987: Highlights of a National Survey. Federal-Provincial Task Force for the 1987 National Survey on the Importance of Wildlife to Canadians.

Environment Canada, 1990b. The Importance of Wildlife to Canadians in 1987: The Economic Significance of wildlife-related Recreational Activities. Federal-Provincial Task Force for the 1987 National Survey on the Importance of Wildlife to Canadians. http://www.env.gov.bc.ca/wld/documents/econ.pdf

Environment Canada, 1994a. The Importance of Wildlife to Canadians: Highlights of the 1991 Survey. Federal-Provincial Task Force for the 1987 National Survey on the Importance of Wildlife to Canadians. https://cfs.nrcan.gc.ca/publications?id=11052

Environment Canada, 1994b. The Importance of Wildlife to Canadians: The Economic Significance of wildlife-related Recreational Activities in 1991. Federal-Provincial Task Force for the 1987 National Survey on the Importance of Wildlife to Canadians. https://cfs.nrcan.gc.ca/publications?id=24342

Environment Canada (Midsummer Analytics). 2015. Algal Blooms: Estimating Costs to the Lake Erie Basin Economy., Great Lakes Issue Management and Reporting Section. March 31, 2015

Federal, Provincial and Territorial Governments of Canada. 2014. 2012 Canadian Nature Survey: Awareness, participation and expenditures in nature-based recreation, conservation and subsistence activities.nature to Canadians in 2012. https://biodivcanada.chm-cbd.net/documents/canadian-nature-survey.

Freeman, Mark C. and Ben Groom.2016. How certain are we about the certainty-equivalent long term social discount rate Journal of Environmental Economics and Management. Volume 79, September 2016, pages 152-168. https://www.sciencedirect.com/science/article/abs/pii/S0095069616300845

Hamilton Conservation Authority. 2010. The Dofasco 2000 Trail. http://conservationhamilton.ca/wpcontent/uploads/sites/5/2016/06/Dofasco-Trail-Brochure.pdf

Hunt, Randall J. 1996. Do Created Wetlands Replace the Wetlands that are Destroyed? U.S. Department of the Interior – U.S. Geological Survey. https://pubs.usgs.gov/fs/1996/0246/report.pdf

IBI Group. 2015. Provincial Flood Damage Assessment Study. Prepared for the Government of Alberta. https://open.alberta.ca/dataset/807b9710-0867-453e-8fa7-50c239bcd7d0/resource/f2d0a88c-b04b-4a39-af76-0aa8cd1e880b/download/pfdas-alberta-main.pdf

Insurance Bureau of Canada. 2018. Combatting Canada's Rising Food Costs: Natural Infrastructure is an underutilized option. September 2018. Co-authored with the University of Waterloo, Intact Centre on Climate Adaptation, and the International Institute for Sustainable Development.

Kawartha Conservation. 2013. *Port Perry Stormwater Management Plan*. Final Report prepared December 10, 2013

Kawartha Conservation. 2010. Lake Scugog Environmental Management Plan. https://www.kawarthaconservation.com/library?view=document&id=9:lake-scugog-environmentalmanagement-plan&catid=58:lake-management-plans.

Moudrak, N.; Hutter, A.M.; Feltmate, B. 2017. When the Big Storms Hit: The Role of Wetlands to Limit Urban and Rural Flood Damage. Prepared for the Ontario Ministry of Natural Resources and Forestry. Intact Centre on Climate Adaptation, University of Waterloo. https://www.intactcentre.ca/wpcontent/uploads/2017/07/When-the-Big-Storms-Hit.pdf

Natural Resources Canada Public Safety Canada Her Majesty the Queen in Right of Canada, As represented by the Minster of Natural Resources Canada, 2016 Canadian Guidelines and Database of Flood Vulnerability Functions March 2017 DRAFT http://hazuscanada.ca/sites/all/files/nrc-canadianguidelines-final_2017-03-30_draft.pdf

Ontario Ministry of Finance. 2018. Ontario Population Projections Update, 2017–2041. https://www.fin.gov.on.ca/en/economy/demographics/projections/table4.html

PricewaterhouseCoopers Canada LLP. 2017. Assessing Green Infrastructure Benefits for Mount Pleasant GO Station Parking Lot Infrastructure Project. Prepared for Metrolinx

Robbins, A. S. T., & Daniels, J. M. 2012. Restoration and Economics: A Union Waiting to Happen? Restoration Ecology. 20(1) 10–17. Accessed at: www.missioncreek.ca/wpcontent/uploads/2014/05/2012-Restoration-and-Economics.pdf

Ross, L.C.M. and D. Martz. 2013. Integrating Natural Wetlands and Improving Design of Naturalized Stormwater Management Facilities in the City of Edmonton, Workshop Guidebook. https://www.edmonton.ca/city_government/documents/PDF/Wetlands_Stormwater_Workshop_Guidebook.pdf

Outi Salminen , Hannele Ahponen, Pasi Valkama, Teuvo Vessman, Kari Rantakokko, Eeva Vaahtera, Andrew Taylor, Harri Vasander, and Eero Nikinmaa. 2012. Benefits of green infrastructure - socio-economic importance of constructed urban wetlands. Published for The Economics of Ecosystems and Biodiversity, Nordic Series.

Sharp, Basil and Geoff Kerr. 2005. Option and existence Values for the Waitaki Catchment. Prepared for the New Zealand Ministry for the Environment. https://www.mfe.govt.nz/sites/default/files/media/Fresh%20water/Option%20and%20existence%20values%20for%20the%20Waitaki%20Catchment.pdf

Robert B. Smith, Brad Bassb, David Sawyer, David Depew, Susan B. Watson. 2019. Estimating the economic costs of algal blooms in the Canadian Lake Erie Basin. Harmful Algae 87 (2019) 101624.

Statistics Canada. 2019. Table 14-10-0307-01 Employee wages by occupation, annual.

Statistics Canada. 2018. Table 11-10-0222-01 Household spending, Canada, regions and provinces. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110022201. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410030701&pickMembers%5B0%5D=1.7&pickMembers%5B1%5D=2.2&pickMembers%5B2%5D=3.1&pickMembers%5B3%5D=5.1&pickMembers%5B4%5D=6.1

Statistics Canada. 2016 Census of Agriculture,. Total farm area and value of land and buildings, Canada, Province,2016

Schreiner, Dean F., Dolores A. Willett, Daniel D. Badger, and L. George Antle. 1985. Recreational Benefits Measured by Travel Cost Method for the McClellan-Kerr Arkansas River Navigation System and Application for Other Selected Corps Lakes. https://www.iwr.usace.army.mil/portals/70/docs/iwrreports/85-c-1.pdf

Toronto and Region Conservation Authority. No date. Brock Lands Restoration Plan. https://trca.ca/conservation/green-infrastructure/brock-lands-restoration-plan/

Toronto and Region Conservation Authority. 2011. Brock Lands Restoration Plan. http://www.trca.on.ca/dotAsset/120175.pdf

Toronto and Region Conservation Authority. 2014. Greenwoods Conservation Lands Master Plan August 2014. https://trca.ca/app/uploads/2016/04/GCL_MP_Final.pdf

Township of Scugog. 2017. Lake Scugog Enhancement Class Environmental Assessment Display Boards, December 5, 2018 Public Open House. https://www.scugog.ca/en/townshipoffice/resources/11115101---Lake-Scugog-Enhancement-POH-Display-Boards---Nov-29-FINAL.pdf68

Treasury Board of Canada Secretariat. 2007. Canadian Cost-Benefit Analysis Guide: Regulatory Proposals. https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

Troy, A. and K. Bagstad. 2009. Estimating Ecosystem Services in Southern Ontario. Prepared for the Ontario Ministry of Natural Resources.

The Trust for Public Lands. 2008. Downtown Parks: Funding Methods, Management Structures, and Costs A Report for the City of Minneapolis April 1, 2008. Report is accessible from http://cloud.tpl.org/pubs/ccpe-DowntownParkFinance-inMN.pdf

US Environmental Protection Agency. 2013. Final Ecosystem Goods and Services Classification System (FEGS-CS). EPA/600/R-13/ORD-004914. August 2013

Victoria Transport Policy Institute. 2018. Transportation Cost and Benefit Analysis - Travel Time Costs. http://www.vtpi.org/tca/tca0502.pdf

Walter, M. 2018. Lake Simcoe Phosphorus Offset Program. Presented at the National Nutrient Recovery and Reuse Forum, Toronto, Ontario, March 8, 2018

Watson, Kelly and Tim Whitley. 2017. Applying Social Return on Investment (SROI) to the built environment. Building Research and Innovation, 45:9, 875-891

Wilson, Sara J. 2008. Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-services. Prepared for the David Suzuki Foundation.

XCG Consultants Ltd. 2010. Review of Phosphorus Removal at Municipal Sewage Treatment Plants Discharging to the Lake Simcoe Watershed. Kingston, Ontario: Water Environment Association of Ontario.

Young, Don A. and John P. Thompson. 1990. Prairie Pothole Wetlands: Function and Evaluation. Prepared for State of the Environment Reporting, Canadian Wildlife Services, and Wildlife Habitat Canada.

Appendix A: Detailed Valuation Methodologies

Flood Control (Disturbance Prevention)

Determining potential benefits that natural assets (e.g. wetlands) have in terms of flood control involves estimating damages associated with floods of different sizes (frequencies) within and without the natural asset, with the difference representing the benefits of the natural asset. Flooding can cause a variety of different types of damages. Figure A1shows a categorization of both direct and indirect tangible costs as well as potential intangible (social) costs associated with floods. While most flood damage assessments estimate the tangible (financial) costs associated with attenuation of flooding by constructing wetlands, there have been few assessments of the intangible costs.

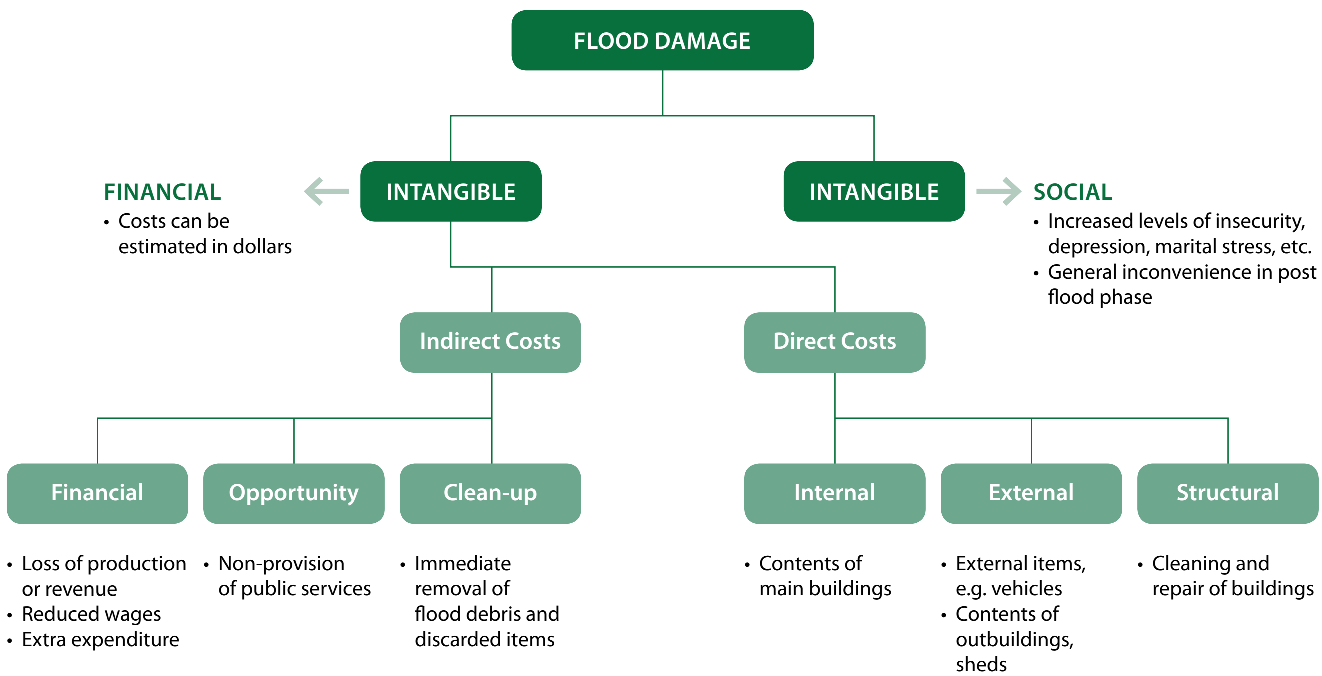


Figure A1 *Types of Flood Damages*

Direct damages are those that occur immediately and can be directly attributed to the flood inundation. They include damage to both public infrastructure and private property. Indirect damages also occur as a result of direct flood impacts, but they are also more difficult to quantify. They include reduced economic activity and individual financial hardship, as well as adverse impacts on the social well-being of a community, and encompass disruptive impacts, including lost trading time and loss of market demand for products. Consequently, indirect damages are often estimated as a percentage of direct damage.

This study follows the a four-step process developed in a paper prepared for the Ontario Ministry of Natural Resources, by Moudrak et al. (2017), as shown in Figure A2.

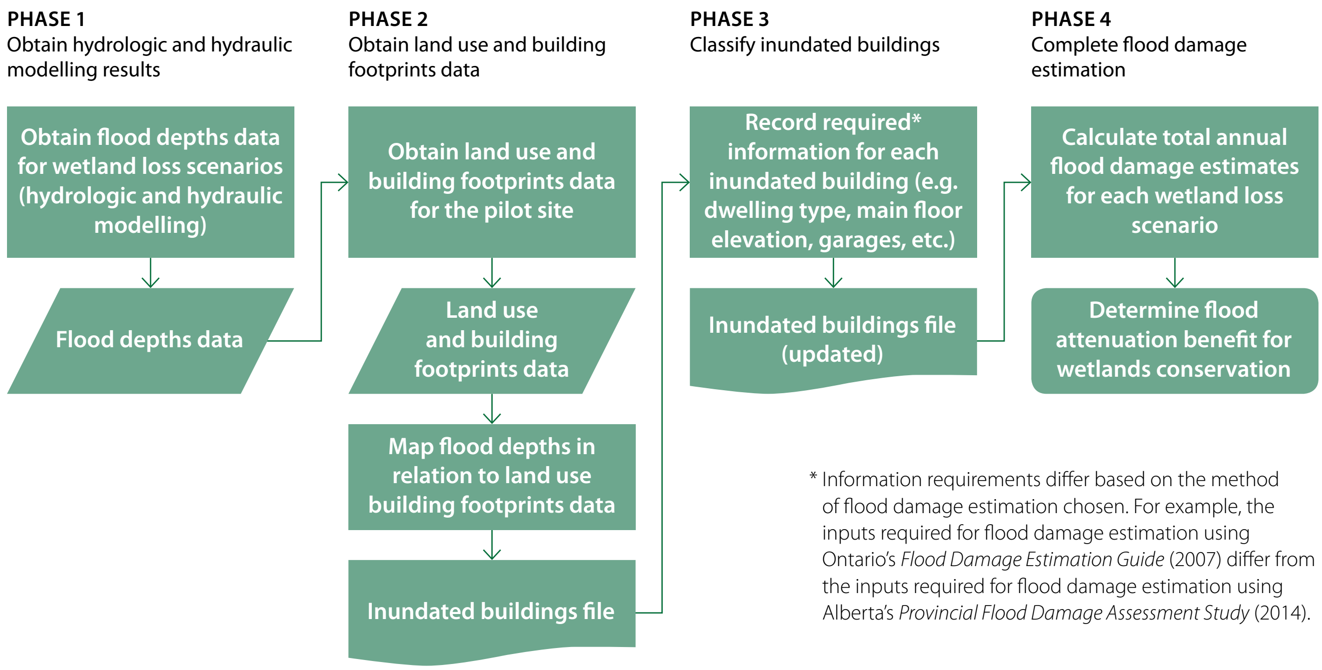


Figure A2 *Four Step Method for Assessing the Financial Value of Wetlands for Flood Damage Reduction*

Source: Moudrak, N.; Hutter, A.M.; Feltmate, B. 2017. When the Big Storms Hit: The Role of Wetlands to Limit Urban and Rural Flood Damage. Prepared for the Ontario Ministry of Natural Resources and Forestry. Intact Centre on Climate Adaptation, University of Waterloo.

The first step involves estimation of possible flood depths under various flood conditions with and without the effects of the proposed wetlands. This requires some understanding of flood hydrology. Moudrak et al. (2017) note that floodplain modelling carried out by Ontario conservation authorities can be used to estimate flood depths and that this typically involves the use of various hydrologic models, including the HEC-RAS 2D model. This information is used in subsequent steps to predict flood depth relative to the heights and location of properties above normal base year flows, to estimate potential property damages.

The second step in the assessment process involves obtaining data on land use and the footprints of buildings in the areas that would potentially be affected by flooding. This information, when combined with the flood depth data from step one, can then be used to predict the depths of flooding for buildings in affected areas with and without wetlands.

The third step involves obtaining detailed information about the types of buildings that would be affected by flooding. Individual buildings need to be classified according to type of use (e.g., residential, office, institutional, industrial, retail), type of structure (e.g., single-family home, apartment building, etc.), the elevation of the main floor relative to grade, and whether the structures have underground parking or basements.

The fourth and final step involves completing the flood damage assessment by calculating the tangible financial costs of potential flooding by estimating damage costs based on the depth of flooding and the types of buildings. Unless actual cost data are available based on previous flooding in the affected areas, Moudrak et al. (2017) recommend estimating damages using flood-depth-damage functions taken from a Government of Alberta study (IBI Group 2015).

Recreation Valuation

There are two ways to measure the economic value of recreation. One is to measure the amount of money that people actually pay to participate in recreational activities (market values, e.g. entry fees). The other relates to non-market values, which represent the value that people ascribe to the experience over and above what they actually paid to use recreational resources (non-market values). The methods used to quantify the market and non-market-based values associated with recreation are very data intensive. Even the simplest method requires having site attendance data that is linked to the home location of the visitor. These types of data collection efforts are well beyond the scope of this current study. These data are, however, useful to collect for a variety of management decisions and developing a business case for future recreational amenity is just one reason this information could be collected by land managers, government or tourism organizations.

Many recent studies of recreation values undertaken in the context of ESV studies have used a benefits transfer approach. While this may be appropriate for measuring the total value of all recreation resources in a large landscape, such as was done for 2008 and 2016 Greenbelt studies, the average values reported are not appropriate for measuring the incremental changes in values that would result from adding new recreation sites or changing the attributes of existing sites. The appropriate value measures would need to reflect the supply of recreational opportunities and the demands of the local population. Thus, the challenge in undertaking an accurate analysis of the recreation values associated with the three proposed environmental improvement projects is finding locally and regionally relevant information about recreational demand, supply and values. Finally, it should be noted that even the monetary valuations described are limited and do not include human health and wellbeing benefits of access to greenspace (e.g. restoration and recreation impact on mental health).

Environment Canada has looked at the importance of wildlife to Canadians in studies (1990a; 1990b; 1994a; 1994b). These studies involved surveys with a random sample of residents in each province to determine their participation and levels of activity in wildlife-related activities (e.g. hunting and non-consumptive activities) as well WTP for wildlife recreation. The results of the two studies are compared in Table A1. The study estimated the non-market-based component of recreation value per day (consumers' surplus) ranged between $8.20 and $5.20 per day and represented between 23% and 27% of average daily expenditures to participate in recreation.

Table A1 *Summary of Studies to Determine the Economic Value of Non-Consumptive Use of Wildlife in Ontario*

Participation in Primary Non-Consumptive Wildlife Trips	1987	1991
Percent of Ontario Residents	21.1%	18.5%
Number of Ontario Residents (millions)	1.56	1.44
Average Days per Year	16.2	20.7
Total Days per Year (millions)	25.2	29.7
Average Spending per Day	$30.00	$23.00
Total Annual Expenditures (millions)	$755.9	$699.9
Average Willingness to Pay per Day	$8.20	$5.20
Total Annual Willingness to Pay (millions)	$206.6	$149.8

A similar study of the *Importance of Nature to Canadians* in 2012 (Federal, Provincial and Territorial Governments of Canada, 2014) measured many of the same parameters, including recreational use participation rates, however, did not provide estimates of non-market benefits. In this study, the potential benefits related to projected changes in recreational activity and values that may occur as a result of changes in ecosystem quantity or quality. The overall approach involves estimating the current pattern of recreational activity in a selected area and then predicting how changes in recreation features and/or quality of experience would change as a result of proposed projects. By comparing with and without project cases, it is possible to identify the net shift in recreational activities that might result from project development, allowing estimation of the associated net incremental economic benefits.

The following steps were taken in analyzing the recreational user benefits:

- Geospatial mapping of population (and demographic characteristics (households, age) within 5, 10 and 20 km of the project site.
- Population of people ages 18 years and older living within 20 km of the project area used to estimate the recreation value.
- Percentage participated in hiking, climbing or horse riding
- Estimated participants, based on estimated households and persons per household
- Estimated days per year of participation in nature-based recreation within 20 km of home
- Redistributed trips as a result of new and improved sites
- Average cost per km of driving (based on $0.52/km CRA mileage rates for 2018)
- Estimated total travel cost savings
- Average value of time per trip
- Total time of travel saving
- Total travel cost savings as a proxy for incremental recreation value of the project

In the absence of site-specific recreational user statistics, historical Ontario recreational use participation rates from the 2012 Canadian Nature Survey[12] (used in the 2016 Greenbelt study) were used for both the Hamilton and Brock Lands projects, as a baseline for recreational user statistics and travel cost estimates. Estimates of the percent redistribution of recreational user activity expected from the new recreational site option assumed a 4% redistribution of recreational use. The estimated travel cost savings for the projected number of recreation users was used to estimate the expected recreational benefits for the Hamilton and Brock Lands projects.

Nutrient Cycling/Waste Treatment – Phosphorus Loading Reduction

In the case of the Lake Scugog project which entails investments in a wetland complex and the installation of oil and grit separators that will remove and reduce phosphorus loading to Lake Scugog from various sources. The opportunity cost method was used to estimate the value of this 'green infrastructure.' That is, the estimated cost of built infrastructure for waste treatment and phosphorus removal was used to estimate the value of the proposed green infrastructure investment.

12 2012 Canadian Nature Survey available from http://publications.gc.ca/site/eng/9.698872/publication.html

The estimated opportunity cost of removing phosphorus (P) in the lake sediment can be evaluated based on the capital cost of tertiary P removal technologies now in use in Canada which can have unit costs above $1,000 per kilogram/yr.[13] In evaluating the benefits of the Lake Scugog wetland (1.49 hectares in size) and Casimir and Baagwating outlets, the $1,000/kg/yr opportunity cost savings would translate into an annual value of P removal of $5,668/ha/yr. This is higher than the 2008 estimate of $3,410/ha/yr,)in 2018 dollars) by David Suzuki Foundation (2008) for waste treatment (phosphorus and nitrogen removal) services by wetlands for the Greenbelt.

Other Non-market ESVs Using Benefit Transfer Protocols

There are several other EGS non-market benefits which we were unable to derive a primary would likely result in future from the conservation project investments that were identified by the respective Conservation Authorities. However, in the absence of baseline ecological data to estimate before and after-project incremental impacts of the projects, the future projected ESVs can only be estimated using what is called a value transfer or 'benefit transfer' protocol —the transfer of the estimated monetary value of ecological functions from one study (often from the academic literature) and one location to another. This meant relying on previous ESV estimates from the 2008 Greenbelt study and ESV meta-analysis by Troy and Bagstad (2009) for Ontario inland lakes. Average values per hectare for wetlands, forests, and inland lakes (Table A2) for the relevant ecological functions for the Greenbelt region were used to estimate the potential future ESVs for the three conservation projects using a benefit transfer protocol. All values are expressed in 2018 dollars. The table shows that are large number of EGS functions have no economic non-market value estimates (i.e. 'n.a.'), either because they do not exist from the literature or have not yet been estimated in primary valuation research.

Table A2 *Ecological Goods and Services Value Estimates from Previous Studies*

Ecological Goods and Services **Greenbelt Annual Value per ha per yr. (2018$)**	**Wetlands** (1)	**Forests** (1)	**Inland Lakes** (2)
Gas regulation	n.a.	$426	n.a.
Climate regulation (carbon sequestration and storage)	$801	$1,083	n.a.
Disturbance (flood) prevention	$4,564	n.a.	n.a.
Water regulation	$93	$1,721	$692
Soil formation	n.a.	$19	n.a.
Nutrient cycling/waste treatment	$3,410	$66	n.a.
Pollination	n.a.	$1,375	n.a.
Biological control	n.a.	$29	n.a.
Biodiversity, habitat, and seed dispersal by birds	$6,590	$697	n.a.
Recreation, aesthetics, and culture	$135	$378	$5,016
Total	**$15,593**	**$6,119**	**$5,708**

Sources: Original 2008 value estimates by David Suzuki Foundation for the Greenbelt were inflated to 2018 dollars using the GDP Implicit Price Index deflator for Canada. Original 2008 ESV estimates (inflated to 2018 dollars) for Ontario inland lakes by Troy, A. and K. Bagstad. 2009. Estimating Ecosystem Services in Southern Ontario. Prepared for the Ontario Ministry of Natural Resources

13 XCG Consultants Ltd. 2010. Review of Phosphorus Removal at Municipal Sewage Treatment Plants Discharging to the Lake Simcoe Watershed. Kingston, Ontario: Water Environment Association of Ontario

In order to accurately estimated the incremental ESVs of conservation projects requires baseline data and primary research related the site-specific ecological and socio- economic conditions, estimating impacts on a before- and after-project basis. However, in the absence of this kind of baseline data, the only reasonable option is to estimate future potential ESVs using previous ESV estimates for the Greenbelt region and drawing from academic research studies. This was the approach taken for this study using the 2008 Greenbelt ESV estimates (e.g. biodiversity/habitat, climate regulation, water regulation) in the 2008 Greenbelt study for wetland, forests, meadows, and lakes and inflated to 2018 dollar values using a GDP implicit price index as the value inflator.

The result is preliminary estimates of future expected ecological service values that could be expected for each of the three conservation projects given the current estimated value of existing ecological landscapes in the Greenbelt. We assumed that the ecological functions for wetlands, forests and other conservation lands would be restored to 100% of their potential ecological health or functionality. Future ESVs of these functions is estimated based on an incremental progression of ecological functionality beginning with 2% functionality in the year following ecological restoration to 100% ecological functionality or maturity 50 years in the future. This incremental ecological function progression is used to estimate the future monetary value of these ESVs using the 0.5% to 2.0% discount rates to estimate the NPV of these future ESVs. This incremental value protocol was applied to forest land, wetlands, meadows and lake ecosystems.

The exception was for Lake Scugog where the projects are intended to maintain or protect current levels of ESVs of the lake's watershed from potential degradation or losses due to lake eutrophication and risks of algal blooms. In the case of Lake Scugog, recent tourism and recreation visitor and expenditure data is used as a proxy for recreational ESV of Lake Scugog. In the absence of primary recreational value analysis similar the incremental recreation benefit estimates for the Hamilton and Brock Lands project, the most recent tourism value of Lake Scugog is used as a second-best proxy for recreational values. The ESV for water regulation services by Lake Scugog used the mean meta-analysis values for inner lakes for Ontario derived by Troy and Bagstad (2009). In future, primary value analysis should be conducted to verify these ESVs for Lake Scugog ecological restoration initiatives. Notwithstanding these limitations, these rough ESV estimates should help decision makers understand the economic values at risk due to human pressures on the lake's ecosystem and then best determine what additional strategies and actions may be taken to manage these risks and protect future ESVs.

Biodiversity Valuation

One of the most challenging ESVs to value is biodiversity. There are currently no official estimates of the value of biodiversity for Ontario other than the 2008 Greenbelt study estimates for habitat/refugae, which could serve as a proxy for biodiversity value. A review of existing valuation studies identified that although a significant amount of work has been undertaken to investigate the value of biological resources, namely the value of individual species and habitats, few studies have attempted to value biological diversity per se. Furthermore, very little research has attempted to disentangle the value of the components of biodiversity.

Biodiversity is defined as the number of species present in an ecosystem or per unit area. Biodiversity may also be measured in terms of habitat diversity and ecosystem diversity. However, there are issues regarding definitions of species and identification of a suitable area in which to measure biodiversity. Ecologists recognise that some species are likely to be more important than other species with respect to enhancing and conserving biodiversity, e.g. keystone species and umbrella species. Humans may have anthropocentric preferences for certain species, even though these species may not necessarily be important in ecological / biodiversity terms (Christie et.al. 2004).

The total economic value of biodiversity comprises direct values (use, passive-use and options values) and indirect values. There are a range of methodologies available to value biodiversity change including revealed preference, stated preference, and cost-based approaches. However, no one method is considered to be capable of valuing all aspects of the total economic value associated with biodiversity change (Christie et. al. 2004). This reflects the complexity in trying to value a complex good like biodiversity.

Different valuation methods including contingent valuation or WTP (willingness to pay), choice experiments, household valuation workshop, and cost-based methods can be useful for revealing the estimated value to human populations of conservation of lands for the purposes of protecting or sustaining plant and wildlife species and ecological health (Chistie et. al. 2004). The WTP approach entails soliciting the willingness to pay by households for habitat re-creation and protection against biodiversity loss. This would require household surveys and thus original primary valuation research. The second approach is to use choice experiments entail soliciting input from the public about a variety of species protection, species recovery or habitat restoration and their relative costs. Valuation workshops is a process that engages households in a discussion about various biodiversity concepts, options and costs. Another approach is the use of a cost-based approaches (e.g. replacement costs, restoration costs, preventative expenditures) that infer a value for natural resources (including ecosystem functions and services) by how much it costs to replace or restore a resource after it has been damaged. This method does not however measure the utility or economic value accrued to individuals from improvements in biodiversity.

While anyone of these methods would generate a good proxy for the value of biodiversity, they can be expensive and time consuming to conduct.

For the evaluation of biodiversity value for the Hamilton and Brock Lands projects we adopted a benefits transfer value approach drawing from the meta-analysis estimates in the 2008 Greenbelt study. Again, in the absence of primary valuation research, the benefits transfer approach will have to suffice as preliminary estimates. Most importantly, the individual species of plants and wildlife (including keystone species) that are expected to be conserved or protected by these projects should ultimately be identified and verified over the 50-year analysis period of the project by ecologists and other experts.