Grindstone Creek Watershed

Natural Assets Management Project

Summary of Results and Recommendations

September 2022

Municipal Natural Assets Initiative

MNAI.CA
Making Nature Count

Invest in Nature

The Municipal Natural Assets Initiative (MNAI) is a Canadian not-for-profit that is changing the way municipalities deliver everyday services — increasing the quality and resilience of infrastructure at lower costs and reduced risk. The MNAI team provides scientific, economic and municipal expertise to support and guide local governments and watershed agencies in identifying, valuing and accounting for natural assets in their financial planning and asset management programs, and developing leading-edge, sustainable and climate-resilient infrastructure.

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Project Partners: City of Burlington, the City of Hamilton, Conservation Halton, and Royal Botanical Gardens

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Executive Summary

Canadian local governments and watershed agencies face infrastructure challenges. These are increasing in number, frequency and severity as the climate continues to change. Ontario's current infrastructure is vulnerable to climate change, both in terms of social and economic impacts[1].

Seeking to address flooding risks through the better understanding, management and protection of nature, the City of Burlington, the City of Hamilton, Conservation Halton, and Royal Botanical Gardens (the Project Partners) elected to work with the Municipal Natural Assets Initiative (MNAI), a Canadian non-governmental organization, on the *Grindstone Creek Watershed Natural Assets Management Project*.

The Project focussed on the 91 km² Grindstone Creek Watershed, which is located downstream of predominantly rural areas and the Niagara Escarpment World Biosphere and is associated with risks that will increase in a changing climate. The Project's objectives were to:

1/ Identify, understand, and quantify the current and possible roles of natural assets in the Grindstone Creek watershed as a component of services such as flood mitigation, stormwater management, and water quality control.

2/ Determine associated costs and benefits of providing these services from natural assets in the Grindstone Creek watershed relative to engineered alternatives and/or long-term operations and maintenance for engineered assets (e.g., diversion channels, stormwater management ponds, stormwater management facilities and systems).

From 2019 to 2021, the Project produced data, modeling, and strategies to incorporate natural assets into long-term asset management for all Project Partners. These included:

- Developing an interactive, web-based inventory with information on location, size, and extent of natural assets in the Grindstone Creek watershed, condition of natural assets, and risks to natural assets
- Modelling to assess role of natural assets in flood reduction (peak flow attenuation and infiltration)
- A valuation of how natural assets contribute to stormwater management and co-benefits
- Scenario development to consider future states of the watershed and analyses to inform continual improvement
- Recommended next steps to advance comprehensive natural assets management efforts

1 *NRCAN 2022. Read Ontario's chapter in the Changing Climate Regional Perspectives Report: ftp.maps.canada.ca/pub/nrcan_rncan/publications/STPublications_PublicationsST/330/330561/gid_330561.pdf*

Stormwater management benefits

The estimated value of the natural assets for stormwater management (specifically peak flow reduction and infiltration) is approximately $65/m² for forests; $200/m² for swamps; $203/m² for marshes; and $324/m² for open water. This means that the total value of natural assets for one service — stormwater management — is approximately $2 billion ($2,071,941,487)[2] in terms of capital costs of equivalent engineered infrastructure assets to provide that same service. Operational costs, such as monitoring and maintenance, were not estimated and are an additional cost to be considered. Emerging research is demonstrating that, on average, natural infrastructure is more cost-effective than engineered infrastructure, due to lower capital investment requirements, lower long-term operating and maintenance costs, and lower requirements for labour, chemicals, and other inputs throughout asset life.[2]

In addition to stormwater management, natural assets can provide a wide range of **co-benefits**. The estimated annual service value of natural assets in the Grindstone Creek watershed in terms of recreation, soil retention and erosion control, climate mitigation, habitat and biodiversity, and atmospheric regulation is approximately $34 million. Health benefits and Indigenous values were considered qualitatively.

Risk mitigation

Modelling quantified the functions of natural assets in terms of core local government services, in this case, peak flow attenuation and runoff reduction. The Project modelled six scenarios: three to determine baseline natural asset functions, and three to explore climate change scenarios and the impacts of major improvements in the Grindstone Creek watershed.

The Project identified several risks related to natural assets, particularly in the Lower Grindstone Creek subwatershed. The *overall* average risk to natural assets in this location is very high when the risk and condition are considered together; this means that natural asset management leading to improved condition could have a high beneficial impact.

2 *World Business Council for Sustainable Development, 2017.*

Recommendations

The project team compiled a list of recommendations for the Grindstone Creek watershed Project Partners. Recommendations are structured to support the Partners' joint priorities and within their jurisdictional context. The full list of recommendations is outlined on page 22.

1/ Review policies to protect existing natural assets
2/ Develop a collaborative watershed management strategy and plan for the Grindstone Creek watershed
3/ Develop a terms of reference and collaborative governance approach for developing the plan for the Grindstone Creek watershed
4/ Develop a collaborative monitoring plan
5/ Advance priority restoration projects
6/ Install low impact development projects in priority areas
7/ Strengthen assessment of natural assets in the Grindstone Creek watershed
8/ Develop a communications plan and presentation to build awareness of natural asset management needs in the Grindstone Creek watershed
9/ Better integrate natural asset management into overall asset management practices
10/ Identify additional watersheds within Conservation Halton's jurisdiction for natural asset management

OVERALL, THE PROJECT DEMONSTRATED THAT:

1/ Natural assets in the Grindstone Creek watershed provide immense benefits and service value that have direct implications when it comes to the predicted effects of climate change. Nevertheless, there is no single intervention that will ensure they are understood and protected in the long term; natural asset management is an ongoing, adaptive management cycle.
2/ Conducting watershed assessments to identify and plan for natural assets is dependent on consistent, well-managed data. The Project has some limitations due to lack of available data; this is an ongoing challenge for cross-jurisdiction assessments, but proper reporting governance and shared objectives across entities could greatly strengthen available natural asset data.
3/ Natural assets do not typically align with political boundaries and jurisdictions, and many local governments rely on natural assets that are under the ownership and/or jurisdiction of others. Therefore, collaboration across entities and coordinated action at a watershed scale is vital for effective natural asset management.

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1 Introduction

Natural Assets

What are natural assets?

The term *municipal natural assets* refers to the stock of natural resources or ecosystems that a municipality, regional district or other form of local government could rely on or manage for the sustainable provision of one or more local government services.

Why manage natural assets?

Effective stewardship of municipal natural assets helps local governments to provide more cost-effective and reliable delivery of services, support climate change adaptation and mitigation, and enhance biodiversity. Natural asset management can provide a resilient alternative to trying to "build their way out" of infrastructure challenges. They can also provide both local government services and many co-benefits that add to community quality of life.

Legend for map below

- Conservation Halton
- City of Hamilton
- City of Burlington
- Royal Botanical Gardens

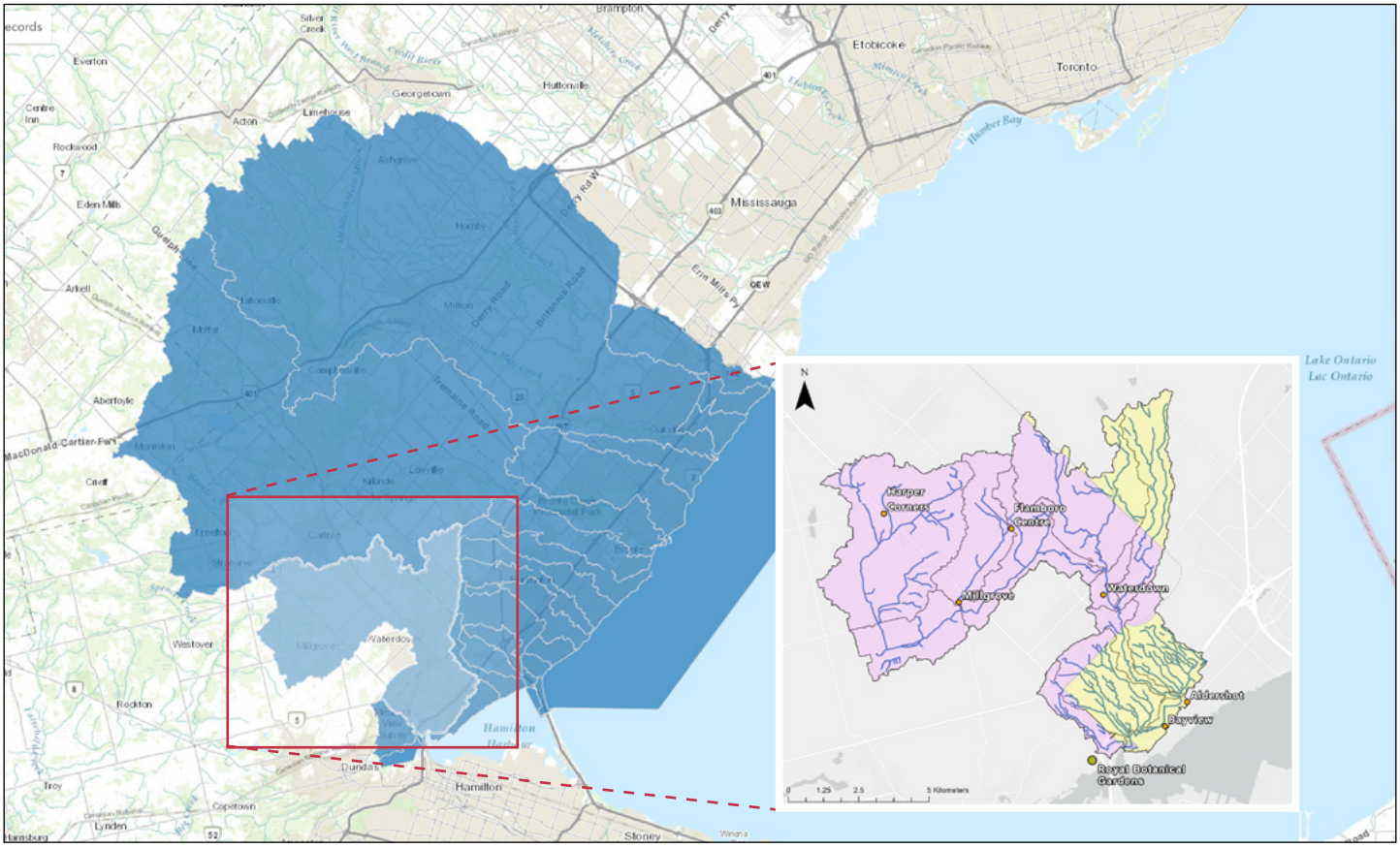


***Figure 1**: Map of Project Partner jurisdictions in the Grindstone Creek Watershed*

Local Context

The Grindstone Creek watershed is located in southwestern Ontario, in the Greater Golden Horseshoe region between Hamilton and Toronto within Ontario's Greenbelt. It is partially within the Cities of Burlington and Hamilton, and the Regional Municipality of Halton.

The *entire* watershed jurisdiction of Conservation Halton covers 1,059 km². The Grindstone Creek watershed itself is just one of three main watersheds, and many other smaller watersheds that drain into Lake Ontario, that Conservation Halton manages and is the focus of this study. Established in 1963 under Ontario's Conservation Authorities Act[3], Conservation Halton plays an important role in natural asset management and is responsible for the delivery of programs and services that further the conservation, restoration, development, and management of natural resources on a watershed basis.

The Grindstone Creek watershed originates in primarily rural wetland areas above the Niagara Escarpment, within the boundaries of the City of Hamilton. It comprises 9,046 ha of land and supplies 14% of natural water into Hamilton Harbour / Burlington Bay at the site of Royal Botanical Gardens. The watershed is the northern limit of the Lake Erie Lowland ecoregion that houses a greater number of flora and fauna species than any other ecoregion in Canada, including species found nowhere else[4].

GOVERNANCE

The Grindstone Creek watershed falls entirely within the geographic jurisdiction of Conservation Halton and comprises a multi-owner, multi-jurisdiction, and multi-use area. Many entities including local governments and Conservation Halton share governance responsibilities as the watershed includes portions of both the City of Hamilton and the City of Burlington.

The City of Burlington (population ~183,000) is within the Regional Municipality of Halton and forms the western end of the Greater Toronto area. **The City of Hamilton** (population ~587,000) is southeast of the City of Burlington and outside the jurisdiction of the Regional Municipality of Halton. Water, in part, flows from the City of Hamilton towards the City of Burlington.

Conservation Halton is responsible for carrying out watershed planning and monitoring, land acquisition and management, operation and maintenance of water control infrastructure, flood forecasting and flood warning, administration of regulations to keep development away from hazard areas, planning advisory services, environmental restoration and stream rehabilitation, provision of outdoor recreation, and conservation education and awareness in its jurisdiction.

3 *www.ontario.ca/laws/statute/90c27*

4 *Carolinian Canada 1994*

Royal Botanical Gardens is Canada's largest botanical garden. It owns approximately 90 hectares of land at the mouth of the Grindstone Creek and approximately 1,100 ha overall. It has a statutory mandate focused on human interaction with the natural world and protection of environmentally significant lands. The organization is an important element of governance in the Grindstone Creek watershed[5].

ECOSYSTEM SERVICES FROM NATURAL ASSETS IN THE GRINDSTONE CREEK WATERSHED

The watershed's natural assets buffer flooding and erosion effects of storms and snowmelt, and moderate summer flows by allowing surface water to infiltrate into groundwater, filter contaminants and sediment, and reduce the rate and total volume of runoff into Grindstone Creek and its tributaries. It also provides recreational opportunities as part of the Cootes to Escarpment EcoPark System, including the City of Burlington-owned Hidden Valley Park, the Conservation Halton-owned Clappison and Waterdown Woods, and various landholdings of Royal Botanical Gardens.

The Project provided an opportunity for Project Partners to take a holistic, evidence-based, watershed-scale approach to maintain and enhance these services, likely at a lower lifecycle cost than engineered assets alone. It also leverages opportunities presented by engaging a Conservation Authority with a mandate and means to undertake programming at a watershed scale.

Project Overview

The project had two primary objectives that support the four project goals:

1/ Support and guide Conservation Halton and the City of Burlington in identifying, valuing and accounting for natural assets in their financial planning and asset management programs and ensure that the City of Hamilton has the required information from the project for the same.

2/ Develop leading-edge, sustainable, cost-effective, and climate-resilient flood management and stormwater management infrastructure on a watershed basis

3/ Reduce risk and potential liability due to flooding, erosion, and sedimentation

4/ Provide sustainable municipal service delivery to communities

CLIMATE CHANGE AND PRIORITY RISKS

In their regional perspectives report, Natural Resources Canada (NRCAN) confirms that Ontario's current infrastructure is vulnerable to climate change[6]. While progress on adaptation efforts remains limited in terms of mainstream

5 *Conservation Halton has undertaken other risk management efforts for flooding and erosion as well, including restoration work and implementing regulations to keep development away from flood hazards*

6 *NRCAN 2022*

application, nature-based solutions can help maintain ecosystem services and reduce risk of impacts to biodiversity in the province.

The Grindstone Creek watershed faces several physical risks that climate change continues to increase. Modelling completed for the Project for the years 2050 to 2100 suggests a ~30% increase in total rainfall for 12-hour, 100-year storm events and that peak flow rate increases, in general, will become larger. Such storms may increase physical and socioeconomic risks, such as health impacts from long-term exposure to elevated levels of air pollution, more extreme weather events (heat waves, droughts, winter storms, tornadoes, and windstorms), and increased pressure on existing infrastructure[7]. Modelling also suggests that natural assets play an important role in preventing peak flow rate increases from climate change[8].

Through inventory condition and risk assessments, the Project determined that the Grindstone Creek watershed contains 8,769 natural assets covering 7,232 hectares (ha). Of these, almost 70% are rated as being in fair condition, while smaller portions are rated poor (2.45%) and excellent (7.72%) condition.

The goal of this report is to provide other communities with an overview of method examples and outcomes to both guide and inspire their own journey towards a watershed natural asset management plan.

Limitations and Assumptions

MNAI uses an asset management-based methodology to understand the relationship between local governments and nature, for several reasons:

- Asset management is becoming popular among Canadian local governments (and in Ontario, among Conservation Authorities), which offers a platform to make natural asset management a broadly based, scalable and comparable practice.
- Asset management provides a useful and practical approach for conceptualizing nature not simply in narrow aesthetic terms, but as something communities rely on for a number of important services.
- Asset management is proving to be a mechanism that helps integrate nature-related considerations into core local government decision-making, thus broadening its relevance beyond departments that focus on environmental matters.

MNAI recognized that asset management terminology and approaches may not align with First Nations, Inuit and Métis worldviews and perspectives. The Grindstone Creek watershed is situated upon the traditional territories of the Erie, Neutral, Anishinaabeg, Huron-Wendat, Haudenosaunee and the Mississaugas, covered by the Dish With One Spoon Wampum Belt Covenant and the Between the Lakes Purchase – Treaty 3 (1792).

7 *Fact Sheet included in MOU*

8 *IPCC 2022*

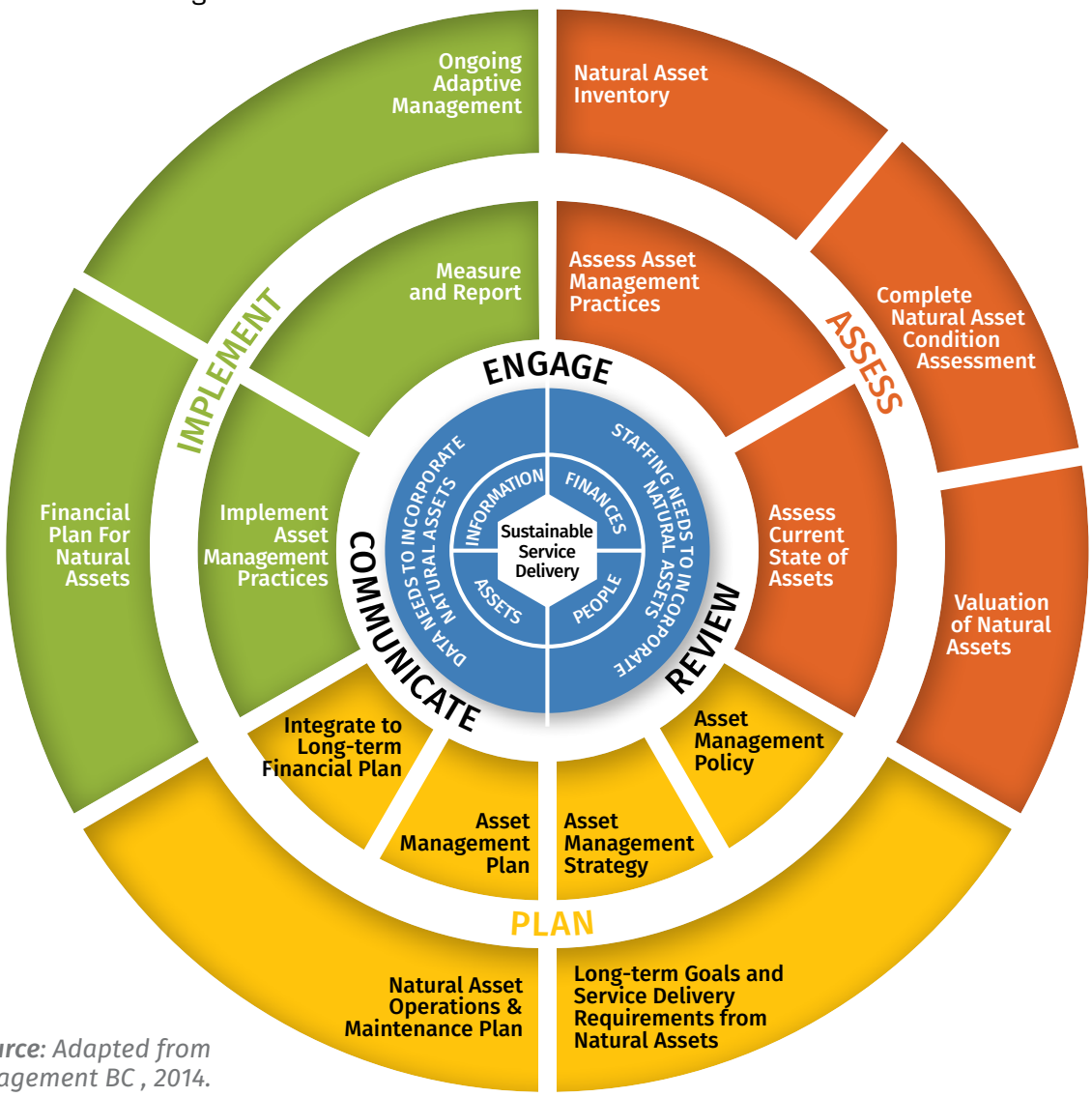
Another Project limitation is that, as illustrated in Figure 1, asset management is an adaptive management cycle, not a finite process. While this report is current at the time written, many elements will evolve in response to data, feedback loops, actions taken by Project Partners, and continuous improvement.

MNAI undertakes detailed hydrologic modelling to assess the levels of services that natural assets provide, and the value of those services, to allow for service-based comparisons with engineered assets. However, *all* modelling uses assumptions, has limitations and is not predictive.

MNAI estimated the value of some of the services from nature relevant to the beneficiaries in this project: local governments, Conservation Halton, and communities more generally. Together, these service values provide a composite figure that can be considered as a *minimum service value*. This figure can support and inform decision-making; however, it is only part of a broader understanding of what is meant by nature's "value". While there are many services provided by the ecosystems of the Grindstone Creek watershed, only a portion of them were quantified in this Project.

2 Approach

The methodology for the project is based on standard asset management practices that local governments are increasingly required to adopt in Canada, and which are articulated by organizations such as Asset Management BC, based on global norms. MNAI has adapted these methodologies to ensure that natural assets, which are complex in their role in service delivery, context-specific, and present novel considerations, can be effectively integrated and considered into asset management.



***Source**: Adapted from Asset Management BC , 2014.*

***Figure 2**: The diagram depicts the natural asset management cycle.*

As depicted in Figure 2, a natural asset inventory is a first component of the natural asset management assessment phase. Natural asset inventories provide details on the types of natural assets a local government relies upon[9], their condition, and the risks they face.

9 Federation of Canadian Municipalities 2018

Developing a Watershed Natural Asset Inventory

To be able to apply MNAI's inventory process in the context of a watershed, an innovative approach using a multi-scale asset inventory structure was developed. The multi-scale inventory provides a better foundation to integrate watershed and subwatershed data to meet the needs of the project partners.

Figure 2 depicts the Natural Asset Inventory structure for Grindstone Creek watershed. In essence, the natural asset inventory is the collection of three connected "sub-inventories," which are organized as groups of watershed elements each with their own structure. There are three sub-inventories:

1/ **Core natural asset inventory:** captures terrestrial natural assets across the Grindstone Creek watershed. This includes the location and extent of forests, swamps, marshes, ponds, successional, and agricultural land covers.

2/ **Watercourse-based inventory:** using the same conceptual approach as the core asset inventory but based on water-related natural assets. This inventory captures the hydrologic network, where stream reaches are defined as unique assets, for the purpose of creating a basis for the overall asset inventory to incorporate the detailed monitoring data collected regularly by Conservation Halton.

3/ **Subwatershed inventory:** high-level inventory where each subwatershed within the Grindstone Creek watershed is defined as an asset. The catchment area is characterized by pre-existing Watershed Report Card data from Conservation Halton[10] and key variables from the core inventory formatted for the subwatershed.

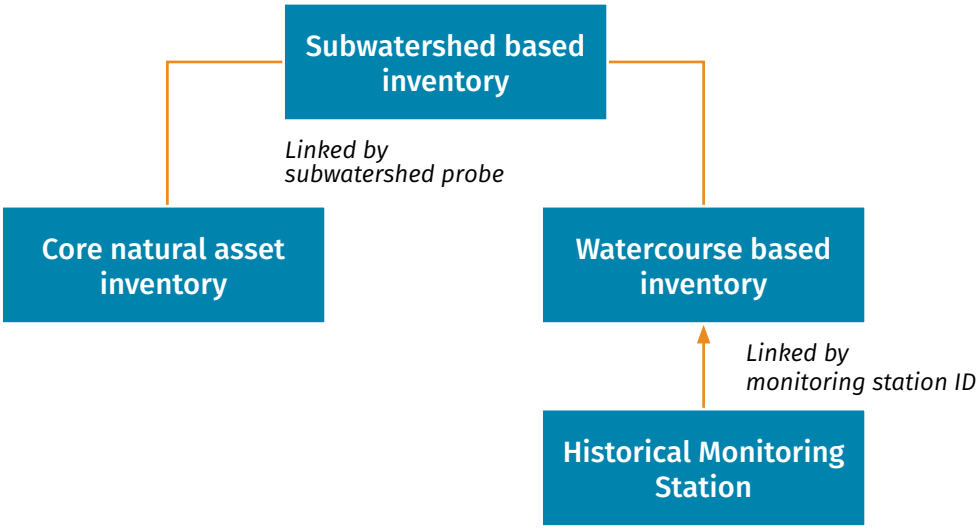


Figure 3: Structure of the Grindstone Creek Watershed Natural Asset Inventory

10 *RBG did not complete a readiness assessment, but noted that it has data on the natural assets at the mouth of the creek including wetland habitat, water quality, and health of the forests and surrounding terrestrial habitat*

Core Natural Asset Inventory

Developing a natural asset inventory starts with robust mapping of the natural features within a study area. MNAI acquired data layers from the project partners, which were then reviewed and filtered based on the MNAI research team's expertise with developing natural asset inventories and the expertise of the project partners. The following is an overview of the steps taken to develop the detailed base land cover dataset, from which this inventory was developed.

Step 1: Define Natural Assets

Developing a complete picture of the natural features within the Grindstone Creek watershed required combining information from several available data sets and organizing them based on a hierarchy that prioritized the most definitive data sets.

Top priority layer	**Wetlands (swamps and marshes)**. Evaluated wetland scores (Biological, Hydrologic, Social, Special Feature, and Overall Wetland scores) from the Ontario Wetlands Evaluation System (OWES) were merged into Conservation Halton's wetland mapping layer using the ArcGIS identity tool. This effectively imported condition ratings for any wetlands in the Grindstone Creek watershed that have already been assessed through OWES.
Second priority layer	**Ponds and Waterbodies.** Data was provided by Conservation Halton. This layer was used to define the location of ponds and other waterbodies, that did not overlap with the above wetlands. The only attribute retained form the source file was pond type.
Third Priority Layer	**Ecological Land Classification (ELC).** Conservation Halton's ELC data was used to define the spatial boundaries for natural and semi-natural areas other than wetlands, ponds, or waterbodies.
Final Priority Layer	**Southern Ontario Land Resource Information System (SOLRIS).** Data from the Government of Ontario was used to fill in remaining land cover areas for agriculture-related cover types

Once the base natural inventory was completed, a riparian zone was developed from watercourse data. This zone was defined as a 30m buffer from watercourse line features.

Step 2: Define Boundaries of Individual Natural Assets

Some natural asset areas cross subwatershed boundaries within the Grindstone Creek watershed. To link the assets to their respective subwatersheds, individual assets were split according to these boundaries. This was completed by clipping natural assets by subwatershed boundaries and importing the subwatershed name into the core asset inventory. Therefore, an asset can be defined as:

Any continuous natural or semi-natural area as defined by ELC or SOLRIS cover types that are contained within the same subwatershed.

Defining assets in this way allows the core inventory to be linked to a higher order asset inventory based on subwatershed boundaries.

Step 3: Add Attributes to Further Describe the Natural Assets

Once the base asset inventory was established, additional attributes beyond boundaries were added to define whether the assets are associated with:

- City and regional parks
- Street trees
- Development permit applications
- Tile drainage areas

Watercourse Inventory

Watercourse network data provided by Conservation Halton formed the foundation of the watercourse inventory. Building on this spatial data set, a few additional attributes were added to round out the inventory. Each stream reach was given a unique asset ID and was characterized by the following attributes:

- Stream type
- Stream order
- Length of reach
- The relevant subwatershed (stream reach was overlaid with subwatershed data provided by Conservation Halton, then allocated to specific areas)
- Monitoring station ID (if present)
- Hazard flood plain (if relevant, received separately from Conservation Halton)

Subwatershed Inventory

Building on the spatial data set provided by Conservation Halton, a few additional attributes were added to round out the inventory. First, each subwatershed is treated as an asset that is defined by the collection of assets from the core and watercourse inventories. Existing subwatershed numbers are used as the unique asset ID. The subwatershed assets are then characterized by the following attributes:

- Subwatershed name
- Subwatershed area
- Percent natural assets
- Percent forest assets

- Percent wetland (swamp and marsh) assets
- Percent agriculture

Overall Inventory Results

Table 1 summarizes the overall natural asset inventory (e.g., core + watercourse + subwatershed) in the Grindstone Creek watershed.

TABLE 1: SUMMARY OF NATURAL ASSET INVENTORY FOR GRINDSTONE CREEK

ASSET TYPE	NUMBER OF ASSETS	AREA OF ASSETS (HA)
Agriculture	2,728	3,892
Forest	977	1,017
Marsh	2,110	475
Meadow Successional	400	374
Swamp	2,554	1,474
Total	**8,769**	**7,231**

Table 1: Summary of natural asset inventory for Grindstone Creek

The Grindstone Creek inventory is available for viewing in a web-based dashboard at *go.greenanalytics.ca/grindstonecreek*

3 Conditions Assessment

A condition assessment provides valuable information on how well natural assets function relative to their ability to provide specific services. Baseline condition assessment data, expressed in an inventory, is a starting point and can also be used to assess changes in the level of service provision that result from impacts that either improve or degrade asset conditions.

In the case of the Project, the condition assessment is based on a GIS desktop assessment and incorporates existing condition metrics for the natural features within the watershed. This approach was taken to ensure that existing data was leveraged and expanded upon by incorporating additional condition metrics of interest to Project Partners.

The over-arching framework proposed by MNAI was developed by NatureServe[11,12]

11 *NatureServe: www.natureserve.org*

12 *US Forest Service (2002) recognizes tree height as a core indicator of forest health.*

Condition of Core Natural Asset Inventory

Nine condition metrics were incorporated into the Grindstone Creek watershed project condition assessment. Each are described in the table below; detailed assessment processes are provided in the Grindstone Creek Watershed Inventory Technical Report.

TABLE 2: DESCRIPTION OF CORE INVENTORY CONDITION VARIABLES

CONDITION VARIABLE	DESCRIPTION
Hydrologic Score	Obtained from the Ontario Wetlands Evaluation System (OWES), which provides a score based on flood attenuation, water quality improvement, carbon sink, shoreline erosion control and groundwater recharge.
Linear Road Density	Higher road density implies more fragmentation and higher hydrologic impairment of water flows. Road density is measured as km of road per km2 of area.
Adjacent land use	Measures how isolated an asset is, and distinguishes assets from those next to other natural assets vs. those next to built infrastructure
Development Area Assets	Areas where development applications exist are rated as a development. Other assets are rated as intact.
Percentage Interior Natural Area	Degree to which individual natural assets are contributing to a greater network of continuous natural area.
Percentage Interior Forest Area	Degree to which individual forest assets contribute to a greater network of continuous forest area.
Canopy Cover Rating	Forest area health based on the assumption that larger forest assets with larger canopy cover mean better forest condition.
Drainage Density	Drainage density (km/km²) was determined for each subwatershed using the locally relevant data on the stream network to determine total stream length (km). This was then divided by total area of the subwatershed (km²).
Tile Drainage	Agricultural areas that are tile drained were considered to have a low (L) condition for stormwater management services; areas with no tile drainage were considered to have a high (H) rating.

Table 2: Description of Core Inventory Condition Variables

WATERCOURSE INVENTORY CONDITION

For the watercourse inventory, a similar approach to assessing the condition was applied. Three condition variables were added:

Road Crossings. The number of road crossings for each stream reach asset was calculated and converted to a ratio of road crossings / km of stream. Road networks interact with stream networks and have the potential to affect biological and ecological processes in stream and riparian systems.

Association with Hazard Flood Plain. Any stream asset within the hazard flood plain was rated as (Y), otherwise it was registered as not within the hazard flood plain (N). Although flooding is a natural process, floods can be destructive to humans and the natural environment.

Surface Water Quality (SWQ) Grade. The surface water quality grade from Conservation Halton's Watershed Report Card was applied to each relevant stream asset and subwatershed. Grade ratings are: A=Excellent, B=Good, C=Fair, D=Poor, F=Very Poor, and "Insufficient Data". The grade is based on an aggregated assessment of chemical analysis of water quality and indicators of benthic communities in the stream carried out by Conservation Halton, using their stream water quality monitoring data.

SUBWATERSHED INVENTORY CONDITION

The subwatershed inventory links natural assets to their hydrologic areas and incorporates data from Conservation Halton's Watershed Report Card. Eight condition variables were added to the inventory, described in Table 3.

TABLE 3: SUBWATERSHED BASED CONDITION VARIABLES

CONDITION VARIABLE	DESCRIPTION
Surface Water Quality (SWQ) Grade	The surface water quality grade from Conservation Halton's Watershed Report Card was used and is based on an assessment of chemical analysis of water quality and indicators of benthic communities in the stream.
Forest Grade	The forest grade from Conservation Halton's Watershed Report Card was used for each subwatershed. It is based on the percentage of forest cover, forest interior (100m from the forest edge) and streamside vegetation that is forested.
Impervious Grade	The surface water quality grade from Conservation Halton's Watershed Report Card was applied to each relevant stream asset and subwatershed. The impervious grade is based on the area of impervious surfaces within each subwatershed.
Percent wetland cover	Percent wetland is the percentage of the subwatershed with wetland cover. Wetlands include swamps (treed and thicket), bogs, fens and marshes, but only swamps and marshes are present in the Grindstone Creek watershed.
Percent Forest	Percent forest is the percentage of the subwatershed with forest cover.
Percent Natural	Percent natural is the percentage of the subwatershed with natural cover. Natural areas are defined as forest, wetland, grassland, shrubland, cliff and talus, and cultural.
Percent Agriculture	Percent agricultural is the percentage of the subwatershed with agricultural cover.

Drainage Density	Drainage density (km/km²) was determined for each subwatershed using the locally relevant data on the stream network to determine total stream length (km). This was then divided by total area of the subwatershed (km²).

Table 3: Subwatershed Based Condition Variables

Condition Results

The majority (almost 70%) of natural assets in the Grindstone Creek Watershed are rated fair. A small portion are rated either poor (2.45%) or excellent (7.72%).

The assessment revealed that:

- Forest assets hold the highest area of assets in poor condition.
- Forest assets located close to Highway 403 and the southern portion of Highway 6, where the majority of the poor rated forest assets are located, would be more impacted by road density and adjacent land use condition metrics.

4 Valuing Natural Assets

Natural asset management is about far more than assigning a financial value to their services. Nevertheless, valuations can be helpful tools to build awareness and inform decision-making when they are situated within a broader understanding of the importance of nature.

The primary objective of the economic evaluation in MNAI's process is to measure how natural assets contribute to the core services that a local government and other agencies provide. These are 'operational' figures that directly support asset management decision-making.

The secondary objective of the economic evaluation is to measure additional service values, or *co-benefits*, from the same natural assets to users other than the local government — for example, recreational land users who may receive quantifiable health benefits.

Together, these two evaluations provide a *composite valuation* which, while far from exhaustive, provides a basis for asset management, community awareness and other processes.

Modelling and Valuation Exercise

To understand the benefits that natural assets provide related to stormwater management (SWM), a modelling and valuation exercise was completed. Three primary scenarios were modelled:

1/ baseline conditions
2/ "bare-earth" where natural assets had been removed, and;
3/ conditions with the use of low-impact development measures.

Detailed descriptions of scenarios and valuation methods are provided in the Technical Report.

To value the role of natural assets in SWM, the team analyzed the capital replacement cost of natural assets with built stormwater infrastructure (i.e., stormwater ponds and low-impact development [LID]). Results of the average per unit cost based on recent tenders by Project Partners were used to estimate construction costs.

To underscore, the figures do not include operating, maintenance and renewal costs; good asset management planning requires an understanding of infrastructure lifecycle costs, and these could be added in the future.

The total value of natural assets for stormwater services alone is estimated at more than $2 billion ($2,071,941,487).

TABLE 4: VALUE OF NATURAL ASSETS BY ASSET CLASS

NATURAL ASSET TYPE	AREA (HA)	POND COST	LID COST	TOTAL SWM COST
Forest	452.39	$ 129,260,470	$ 49,480,361	$ 178,740,831
Marsh	53.65	$ 155,204,143	$ 961,390	$ 156,165,533
Swamp	789.15	$ 1,607,866,305	$ 10,616,012	$ 1,618,482,317
Open water	36.06	$ 117,768,428	$ 784,378	$ 118,552,806
Total	**1331.25**	**$ 2,010,099,346**	**$ 61,842,141**	**$ 2,071,941,487**

Table 4: Value of Natural Assets by Asset Class

Total cost of the stormwater infrastructure was divided by the natural asset catchment area to obtain cost/m². The cost/m² was averaged between natural assets with the same land-use type. Based on this approach, the cost of replicating natural assets' hydrologic functions using conventional SWM and LIDs was estimated at a rate of $65.11/m² for forest, $200.02/m² for swamp, $203.17/m² for marsh, and $324.38/m² for bodies of water.

Value of Other Services (Co-benefits)

This project also considered the following co-benefit services related to healthy watersheds:

- Recreation and tourism
- Soil retention and erosion control
- Climate mitigation
- Habitat and biodiversity preservation
- Atmospheric regulation
- Health
- Indigenous values

A detailed overview on the valuation process and outcomes measured is included in the Technical Report. Table 5 provides an overview of the estimated values of quantifiable services. Note that Health and Indigenous values were not assigned a definitive dollar amount and instead examined qualitatively.

TABLE 5: SUMMARY: PARTIAL LIST OF CO-BENEFIT SERVICE VALUES FROM GRINDSTONE CREEK NATURAL ASSETS ($/year – indicative estimates)

SERVICE	AGRICULTURE	FOREST	MEADOW SUCCESSIONAL	SWAMP	MARSH	Asset Area (ha)
Recreation and tourism	$ 899,000	$ 21,986,000	$ 33,000	$ 6,945,000	$ 2,210,000	**$ 32,073,000**
Erosion control	Not assessed	$ 1,300,000	$ 3,000	$ 1,900,000	N/A	**$ 3,203,000**
Carbon sequestration	$ 397,000	$ 254,000	$ 53,000	$ 623,000	$ 198,000	**$ 1,525,000**
Habitat Preservation values	Not assessed	$ 220,000	$ 55,000	$ 321,000	$ 48,000	**$ 644,000**
Atmospheric regulation	Not assessed	$ 218,000	$ 10,000	$ 318,000	$ 10,000	**$ 556,000**
Asset Area (ha)	**$ 1,296,000**	**$ 23,978,000**	**$ 154,000**	**$ 10,107,000**	**$ 2,466,000**	**$ 38,001,000**

***Table 5**: Summary: Partial List of Co-benefit Service Values from Grindstone Creek Natural Assets*

When combined with information on asset condition, resource managers can examine assets of interest, and assess the likelihood or significance of each of the key "additional" services likely to be provided by the asset of interest.

5 Risk Assessment

Local governments and watershed agencies can determine how to prioritize efforts by identifying risks facing natural assets. The risk assessment was only completed on the Core Natural Asset Inventory.

Risk Identification Workshop

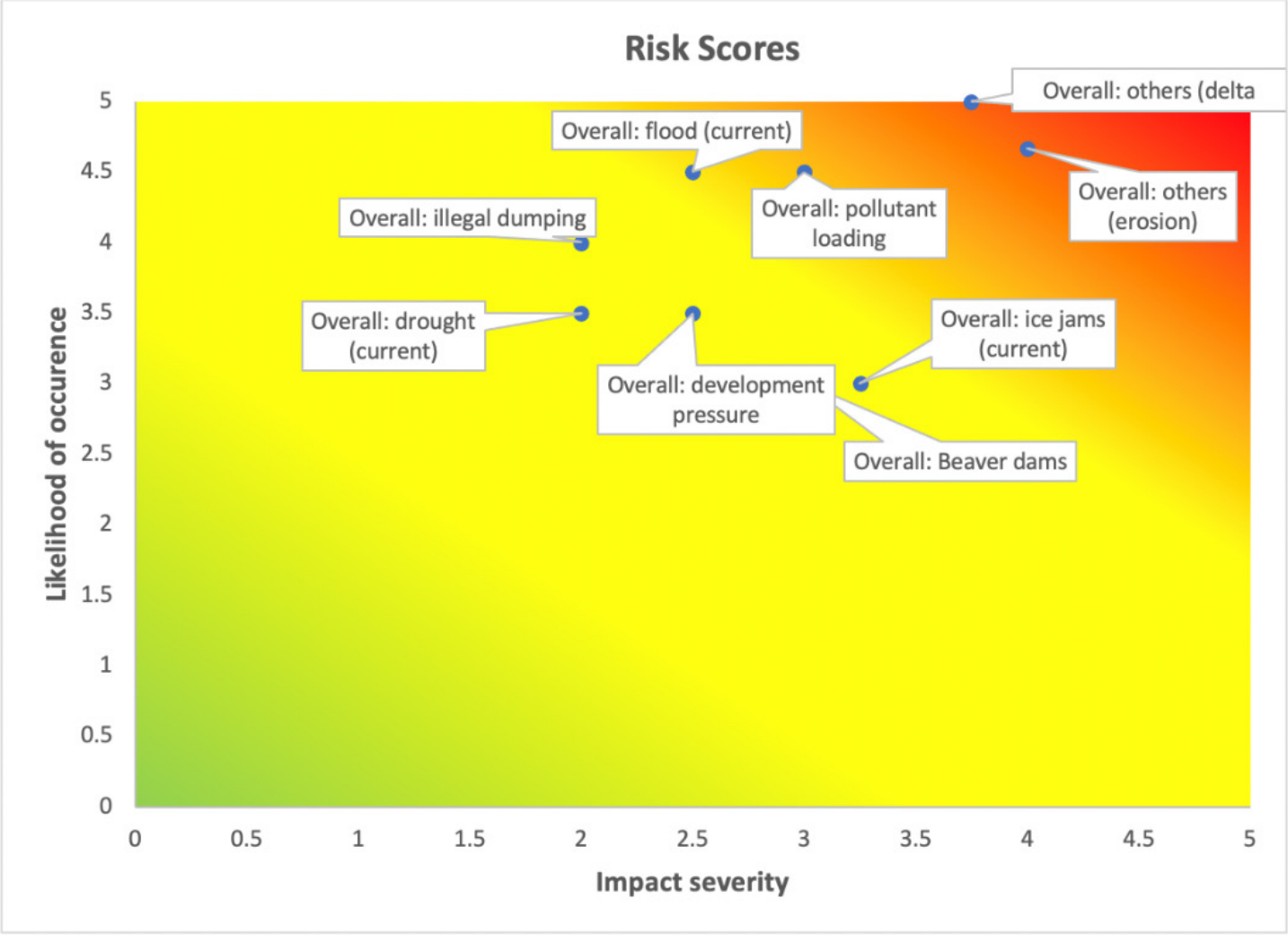
To establish the priority risks, a workshop was held in November, 2020 with the Grindstone Creek project partners and two additional workshops were led by Conservation Halton in December, 2020. The objective was to identify and rank top risks to natural assets and associated stormwater services, based on the likelihood of risk occurring and the severity of impact.

Nine priority risks for Grindstone Creek watershed were identified and ranked:

1/ Flood
2/ Drought
3/ Illegal dumping
4/ Development pressure
5/ Beaver dams
6/ Ice jams
7/ Pollutant loading
8/ Erosion
9/ Changes to sediment deposition

(A detailed overview of the workshop and risk ranking process is available in the Grindstone Creek Watershed Inventory Technical Report).

As shown in Figure 3, the risk ranking is the result of multiplying the likelihood of occurrence (a rating scale from 0 to 5, where 0 is no likelihood and 5 is extremely likely) and the impact severity (a rating scale from 0 to 5, where 0 is no impact severity and 5 is extreme impact severity). The resulting risk ranking is a scale from 0 to 25. The rank is then converted to an overall rating such as minor, moderate, major, or severe.



LEGEND Minor Moderate Major Severe

~0

~ Overall: Beaver dams
~ Overall: development pressure
~ Overall: drought (current)
~ Overall: ice jams (current)
~ Overall: illegal dumping

~ Overall: flood (current)
~ Overall: Others (erosion)
~ Overall: pollutant loading
~ Overall: others (delta deposition)

~

Figure 4: Summary of Risk Rankings for the Grindstone Creek

Ranking Assets with Risk Exposure

Following the workshops, MNAI worked with Project Partners to refine how to incorporate these risks into the inventory. Through collaboration, the spatial extent of each risk was defined; the extent is outlined in Section 3.3 of the Grindstone Creek Watershed Inventory Technical Report.

Once the potential extent of the priority risks was defined, each asset's exposure to those risks was assessed based on the percent of the asset area that overlaps with the risk extent boundary. In other words, an asset's risk exposure is defined as *the percent of the asset area exposed to each risk*.

For example: if an asset has 10% of its area exposed to flood risk, 30% of its area exposed to erosion risk, and 100% of its area exposed to drought risk, then it would have an overall risk raking of 11.25 * 0.1 + 18.75 * 0.3 + 7 * 1 = 13.75. Because risk areas are not mutually exclusive (i.e. it is possible to have 100% exposure to all risks), the theoretical maximum risk ranking is 400 (likelihood of impact of 5 * impact severity of 5 = 25 * 8 possible risks = 400). The following score categories were used:

- Any risk < 32 is minor
- Any risk >= 32 (2*2*8) is moderate
- Any risk >= 98 (3.5*3.5*8) is major
- Any risk >= 162 (4.5*4.5*8) is severe

TABLE 6: SUMMARY OF RISK RANKINGS BY RISK TYPE

RISK	OVERALL RANK
Flood	11.25
Development	8.75
Erosion	18.75
Ice Jams	9.75
Road salt	13.5
Beaver Dams	9
Illegal dumping	8
Drought	7

***Table 6**: Summary of Risk Rankings by Risk Type*

Note: The only risk that was not incorporated in some way was changes to sediment deposition in the Grindstone Creek delta due to lack of data. This risk may be more relevant to the watercourse inventory.

Results of Risk and Conditions Combined

The Lower Grindstone subwatershed has a small area of assets in poor condition with a moderate risk rating (i.e., < 1%) but the overall average risk to natural assets within this subwatershed is very high. This indicates that natural asset management within the Lower Grindstone subwatershed may have a high impact.

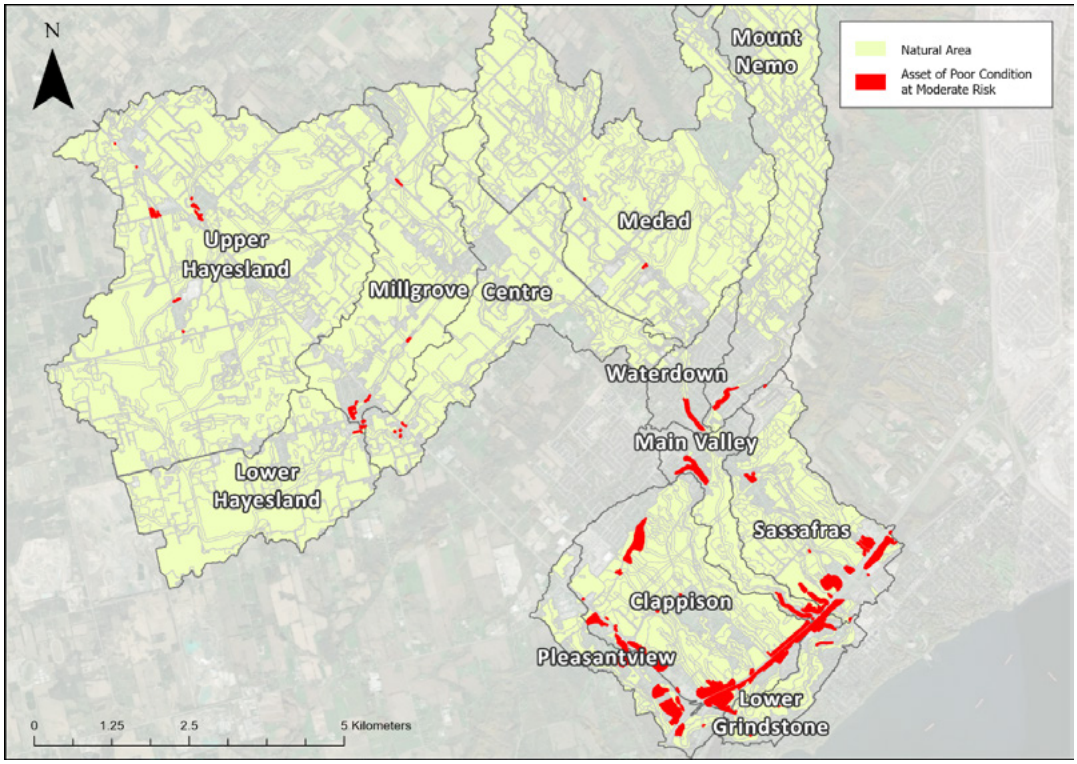


Figure 5: Map depicting natural assets in poor condition with a moderate risk rating

Table 7: Area (ha) of natural assets in poor condition with a moderate risk rating by subwatershed

TABLE 7: AREA (HA) OF NATURAL ASSETS IN POOR CONDITION WITH A MODERATE RISK RATING BY SUBWATERSHED

SUBWATERSHED	ASSET CLASS						
	Agriculture	Forest	Meadow Successional	Swamp	Marsh	Asset Area (ha)	% of subwatershed at high risk
Centre				0.03	0.03	**0.06**	**0.06**
Clappison	0.06	11.51	19.67		0.50	**31.75**	**31.75**
Lower Grindstone		0.10	0.81			**0.92**	**0.92**
Lower Hayesland				0.02	0.01	**0.03**	**0.03**
Main Valley		9.16	2.65			**11.80**	**11.80**
Medad						**0**	**0**
Millgrove				0.05	0.77	**0.82**	**0.82**
Mount Nemo				0.18		**0.18**	**0.18**

TABLE 7: AREA (HA) OF NATURAL ASSETS IN POOR CONDITION WITH A MODERATE RISK RATING BY SUBWATERSHED

SUBWATERSHED	ASSET CLASS						
	Agriculture	Forest	Meadow Successional	Swamp	Marsh	Asset Area (ha)	% of subwatershed at high risk
Pleasantview		0.82	11.38	0.08	0.29	**12.56**	**12.56**
Sassafras	0.09	6.28	6.93	1.80	2.01	**17.11**	**17.11**
Upper Hayesland			0.60	0.24	0.34	**1.17**	**1.17**
Waterdown		1.71				**1.71**	**1.71**
Total	**0.15**	**29.58**	**42.04**	**2.40**	**3.94**		

6 Recommendations

The following recommendations (Table 9) place the project results within the regulatory, jurisdictional and policy contexts, and are based on natural asset management priorities that Project Partners identified: improving watershed governance and strategy (Yellow); restoring natural assets in high-risk areas (Green); and specific asset management-based activities (Blue). Recommendations are structured according to whether they could be undertaken over the short-term (1-2 years), the medium-term (3-5 years), or as part of continuous improvement efforts.

Recommendations to Advance Natural Asset Management in the Grindstone Creek Watershed

improving watershed governance and strategy

RECOMMENDATION

Review policies to protect existing natural assets
Short-term

OBJECTIVE

Ensure that future land use change considers the value of existing natural assets and their role in service delivery.

RATIONALE

This Project demonstrates that natural assets in the Grindstone Creek watershed provide both operational services (such as stormwater management) to local governments and Conservation Halton, and many co-benefits to the local population.

As a rule of thumb, it is more cost-effective to protect what already exists, than to attempt rehabilitation efforts later (Moudrak et al. 2018). Recommendations are to review municipal land use policies and by-laws as well as Conservation Halton's regulatory policies and programs and services in light of this report; assess the effectiveness of environmental restoration projects; and, track the use of natural assets to support their protection and enhancement in the Grindstone Creek watershed, particularly where they provide significant stormwater benefits.

STAKEHOLDERS

Conservation Halton, Halton Region, and the Cities of Burlington and Hamilton

RECOMMENDATION

Better integrate natural asset management into overall asset management practices

OBJECTIVE

Opportunities in information sharing, planning, and awareness building to progress all Project Partners further in their natural asset management journey.

RATIONALE

The Provincial Policy Statement 2020 and the *Conservation Authorities Act* provide the rationale for the development of a collaborative watershed management strategy or plan for the Grindstone Creek watershed, which provides multiple services to multiple jurisdictions. Natural asset management is an important part of cost-effective service delivery over the long-term and of mitigating flood and erosion risks, particularly in the City of Burlington. Changes to the *Conservation Authorities Act* also require Conservation Authorities to undertake watershed-based resource management strategies as a mandatory program.

Collaboration is required to strengthen natural asset data and update it to inform asset management plans. In some cases, actions will need to be included in asset management plans of the Cities of Hamilton and Burlington and in Conservation Halton's own plans. In other cases, Conservation Halton may be the appropriate organization to lead activities and will require funding to undertake them. Lifecycle management plans are needed for creeks in upstream areas and natural assets in the Lower Grindstone subwatershed.

Project Partners noted a window for collaboration as local governments need to have asset management plans that include green infrastructure by 2024. Collaboration on a watershed management plan could ensure a consistent approach across the watershed and ensure that investments are prioritized based on shared objectives.

STAKEHOLDERS

All Project Partners

RECOMMENDATION

Strengthen assessment of natural assets in the Grindstone Creek watershed
Continuous improvement

OBJECTIVE

Enhance the understanding of the condition of natural assets in Grindstone Creek, the risks to them, and the services they provide.

RATIONALE

Condition assessment methods carried out by Conservation Halton (e.g., analysis that support the Watershed Report Cards) as well as provincial methods (e.g., OWES) were used in the Project. The following data gaps and limitations can be addressed and should be built into future asset management plans or strategies:

- Inventory and monitoring data
- Condition assessment
- Fully integrate system with real-time monitoring data
- Incorporate Traditional Ecological Knowledge
- Expand modelling to include specific water quality and stormwater scenarios
- Expand risk assessment to include mitigation responses

STAKEHOLDERS

All Project Partners share responsibility for management of natural assets in the Grindstone Creek watershed. Conservation Halton, as the owner of the natural asset inventory, is in a good position to coordinate inventory updates

RECOMMENDATION

Develop a collaborative monitoring plan

Short-term

OBJECTIVE

Project Partners expressed interest in a collaborative monitoring plan; Conservation Halton can build on its existing approach to convene Project Partners in a watershed-based approach, which is an efficient means of undertaking natural asset monitoring and management.

RATIONALE

Conservation Halton expanded water quality sampling in the Grindstone Creek watershed in 2021, to complement the water quality station sampled annually and funded through the Ministry of Environment, Conservation and Parks. As well, since 2015 Conservation Halton has expanded a data collection network for stream flows, rainfall and other information supporting its flood forecasting and operations program.

The plan should include additional ecological monitoring, and monitoring and enforcement of illegal dumping, particularly in the northwest section of the watershed where illegal dumping was identified as a risk. Conservation Halton has authority to address illegal dumping within regulated areas, whereas municipalities have authority to address under a site-alteration by-law.

STAKEHOLDERS

Flow of information currently led by Conservation Halton; Cities of Burlington and Hamilton would coordinate alongside to ensure plan compatibility.

restoring natural assets in high-risk areas

RECOMMENDATION

Advance priority restoration projects
Short-term

OBJECTIVE

Seek funding to undertake restoration projects in areas identified as high priority. Project Partners identified restoration as a priority in Clappison, Pleasantview, Dundas and Dunsworth to address erosion concerns.

RATIONALE

Modelling demonstrated the effectiveness of natural assets to manage peak flows and infiltration. Natural assets are also more flexible and adaptable to change than grey infrastructure assets. Conservation Halton has a robust ecological restoration program to improve the condition of natural assets and reduce risk. Existing tools include a restoration opportunities database for which they recently developed a mobile app for staff to use in the field. Conservation Halton is currently compiling information about existing data (ecology, land cover, water quality) and identifying external data sets of interest.

STAKEHOLDERS

Conservation Halton (external funding needed)

restoring natural assets in high-risk areas

RECOMMENDATION

Install low impact development (LID) projects in priority areas
Continuous Improvement

OBJECTIVE

Seek funding to undertake restoration projects in areas identified as high Seek opportunities to install LID projects in priority areas and to build them into asset management plans.

RATIONALE

Modelling shows that in the future climate scenario, natural assets in the Grindstone Creek watershed combined with the installation of LID in Waterdown would provide additional stormwater management benefits that could mitigate downstream flooding and reduce the stormwater infrastructure needed in the City of Burlington. LID would also reduce the need for stormwater management ponds, which can cause thermal pollution in receiving waters and poor habitat quality for wildlife and fish.

STAKEHOLDERS

City of Hamilton, City of Burlington and Conservation Halton

specific asset management-based activities

RECOMMENDATION

Develop a collaborative governance *approach* for the Grindstone Creek watershed

Short-term (immediate)

OBJECTIVE

Determine roles of - of Project Partners with accountability for making progress on natural asset management, providing input and development of a renewed collaborative watershed management approach for the Grindstone Creek watershed.

RATIONALE

To collaborate effectively, Project Partners will need support from their respective governance bodies. A collaborative governance approach could be established to support effective watershed-scale management of natural assets through the renewal of the Grindstone Creek Watershed Study (1998).

STAKEHOLDERS

Conservation Halton to lead with representation from all Project Partners.

specific asset management-based activities

RECOMMENDATION

Develop a communications *plan and presentation* to build awareness of natural asset management needs in the Grindstone Creek watershed

Short-term

OBJECTIVE

Communicate the value of services provided by the Grindstone Creek watershed among decision-makers and the broader community.

RATIONALE

To progress on natural asset management, additional resources and commitment are required. A first step is to build awareness of Project results and their implications among local elected officials, decision-makers and the broader community. Another target group for communications are the planning staff at the City of Burlington given that part of the Grindstone Creek watershed in North Aldershot (shown below, Schedule D of the City's Official Plan) has a special planning designation due to planned development. Planning staff should be aware of Project implications in that area, including for stormwater management.

STAKEHOLDERS

Conservation Halton is well-positioned to communicate Project results through programs such as its Healthy Neighbourhoods workshop series.59 Project Partners may wish to develop a presentation for the Cities of Hamilton and Burlington Councils, and the governing boards of CH and Royal Botanical Gardens

specific asset management-based activities

RECOMMENDATION

Develop a collaborative watershed management *strategy and plan* for Grindstone Creek watershed

Short- to medium-term

OBJECTIVE

Strategy would describe practices, processes, tools and a decision-making framework that partner organizations can use to prioritize actions and guide management of natural assets in the Grindstone Creek watershed.

RATIONALE

Project Partners noted a window for collaboration as local governments need to have asset management plans that include green infrastructure by 2024. Collaboration on a watershed management plan could ensure a consistent approach across the watershed and ensure that investments are prioritized based on shared objectives. This would be consistent with policy directives in the Provincial Policy Statement 2020. Note that natural asset management strategies or plans developed for the Grindstone Creek watershed must also be consistent with the requirements of the NEC for natural assets in the Niagara Escarpment Plan area and must not contravene the Conservation Authorities Act for natural assets located within regulated areas.

STAKEHOLDERS

Conservation Halton, the City of Burlington, the City of Hamilton, Royal Botanical Gardens, Halton Region, in consultation with Indigenous communities, other stakeholders and landowners.

specific asset management-based activities

RECOMMENDATION

Identify additional watersheds within Conservation Halton's jurisdiction for natural asset management

Continuous improvement

OBJECTIVE

Advance natural asset management in other watersheds.

RATIONALE

The Project approach could be suitable for replication in other watersheds in Conservation Halton's jurisdiction as part of continuous improvement of natural asset management. Conservation Halton may wish to prioritize watersheds where there are risks to be addressed in the short to medium-term.

STAKEHOLDERS

Conservation Halton

7 Conclusion: Natural Asset Management in Canada's Watersheds

The Project provides a basis for progressive, cross-jurisdictional natural asset management not only for the Grindstone Creek watershed, but other stewards seeking to improve service delivery, biodiversity, and climate resiliency in their region.

Project documents establish a replicable methodology and process for local governments to initially understand, measure, and value natural assets at a watershed scale, which can then be used to support in-depth analyses and interventions. Communities who have already advanced in their natural asset journeys can benefit from addressing their data management and collaborative strategies against the lessons learned from Grindstone Creek.

Barriers and limitations identified by the Project should be taken into consideration by local governments ahead of beginning a natural asset inventory to identify possible solutions (whether it's lack of data, governing structure, or other limits) in tandem with an assessment. A benefit of furthering this and future watershed projects is the standardization of data collection methods for the purposes of managing natural assets.

The inventory and assessments clarify quantifiable and qualitative benefits of natural assets within the Grindstone Creek. This information alone is valuable to the Project Partners as they pursue the enhancement and protection of these assets, especially within the context of Ontario's infrastructure challenges against impacts from climate change.

Most importantly, the Project revealed how imperative collaboration across a range of organizations is to be able to pursue the management of natural assets at a watershed scale. At the end of the day, proper natural asset management cannot be achieved if it is confined within one's political boundary — the ability to effectively support nature's services relies on a combined, strategic effort from neighbouring stewards.

8 References

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Municipal Natural Assets Initiative

Making Nature Count