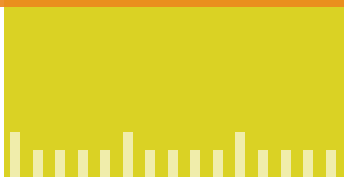


Toward natural asset management in the **City of Vaughan** Ontario



Summary of inventory results and recommendations February 2022

This document features interactive elements! Clicking on a heading or sub-heading in the Table of Contents (ToC) will take you directly to that page. Also, clicking on page numbers in the footer will bring you back to the ToC.



Municipal Natural Assets Initiative





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 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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1 Purpose

This document summarizes the results of a project to develop a natural asset inventory for the City of Vaughan and documents steps the local government can take to proceed to a full natural asset management initiative.

2 Introduction

What are municipal 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 upon or manage for the sustainable provision of one or more local government services¹.

Why manage natural assets

A growing number of local governments recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered assets. Doing so can enable local governments to better provide *core* services such as stormwater management, water filtration, and protection from flooding and erosion, as well as *additional* services such as those related to recreation, health, and culture. Outcomes of what is becoming known as *municipal natural asset management* can include cost-effective and reliable delivery of services, support for climate change adaptation and mitigation, and enhanced biodiversity.

How to manage natural assets

There are numerous ways for local governments to manage natural assets. The Municipal Natural Assets Initiative (MNAI) uses methodologies and tools rooted in standard asset management and provides a range of advisory services to help local governments implement them. MNAI has developed the methods and tools with significant investments, piloting, refinement, peer review, and documentation of lessons in multiple Canadian provinces. MNAI's mission is to make natural asset management a mainstream practice across Canada, and in support of this, for local governments to accept and use the methodologies and tools in standard ways across the country.

¹ mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf

What is a natural asset inventory?

Natural asset inventories provide details on the types of natural assets a local government relies upon², their condition, and the risks they face. As depicted in Figure 1 and explained in detail in the Annex, a natural asset inventory is the first component of the Assessment phase. The Assessment phase, in turn, is the first of three phases of a full natural asset management project. By itself, an inventory will not give a sense of asset value but is an essential first step in the full natural asset management project.

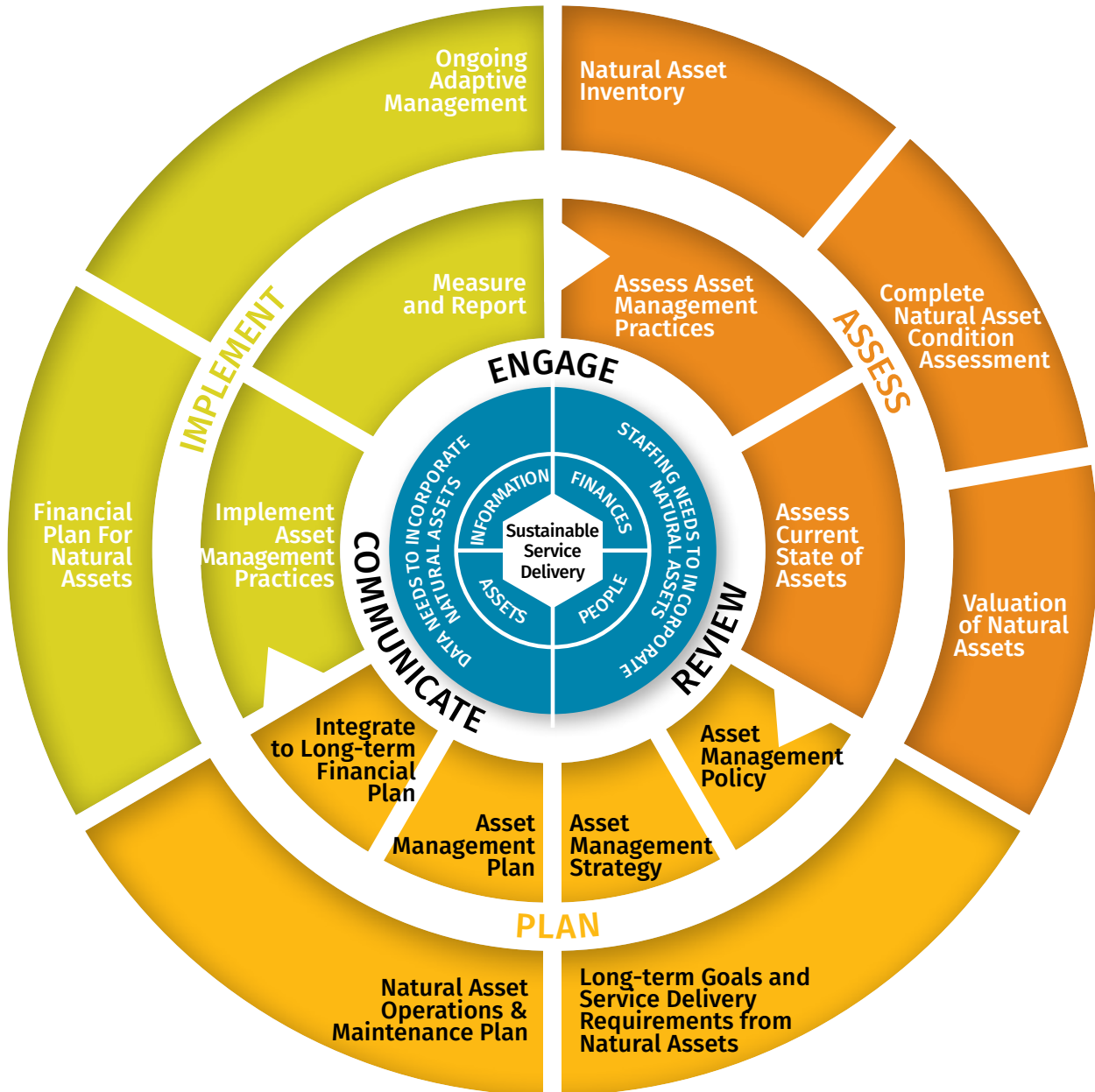


Figure 1: The Asset Management Process. MNAI has adapted this for use with natural assets.

² Note that many local governments rely on services from natural assets they do not own.

3 Local government context

3.1. General

We respectfully acknowledge that the City of Vaughan is situated in the Territory and Treaty 13 lands of the Mississaugas of the Credit First Nation. We also recognize the traditional territory of the Huron-Wendat and the Haudenosaunee. The City of Vaughan is currently home to many First Nations, Métis and Inuit people. As representatives of the people of the City of Vaughan, we are grateful to have the opportunity to work and live in this territory.

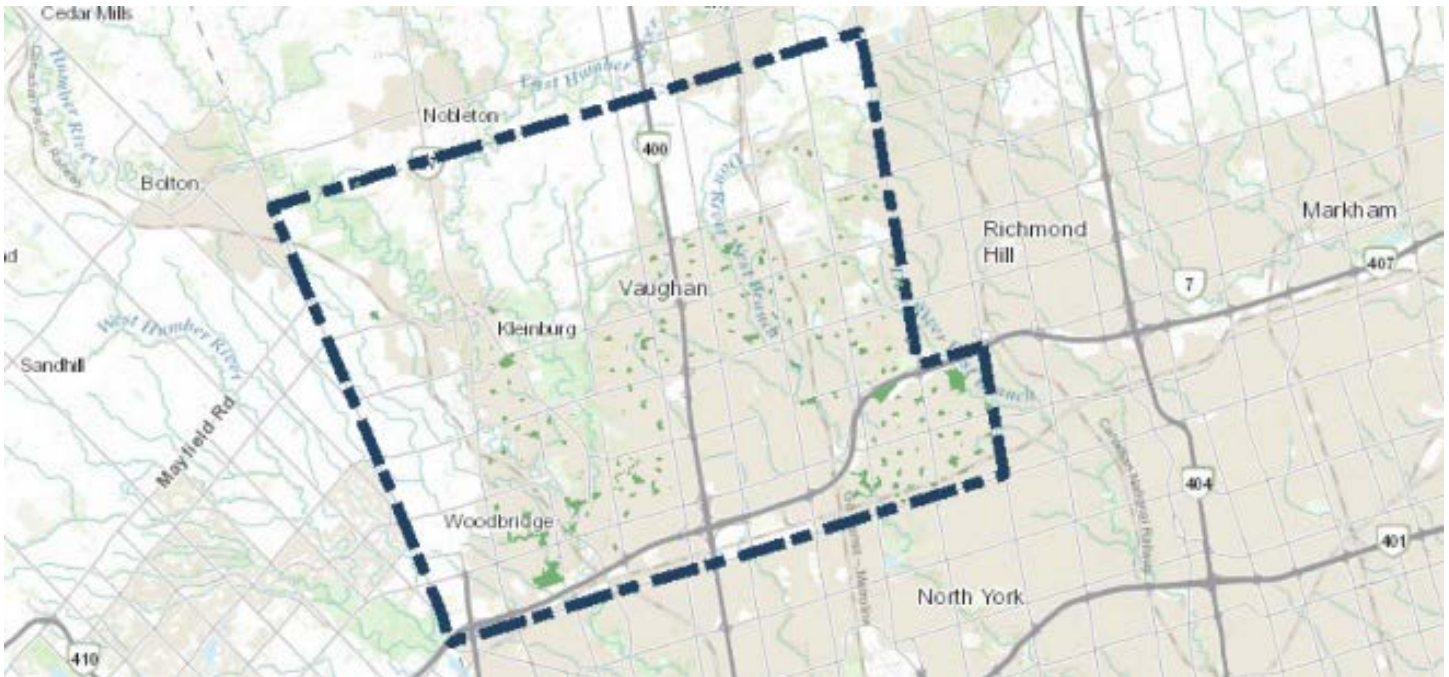


Figure 2: City of Vaughan³

The City of Vaughan (population ~306,200) is in the Regional Municipality of York, north of Toronto, Ontario. It is the fifth-largest city in the Greater Toronto Area, and the 17th largest city in Canada⁴.

The City of Vaughan's interest in natural assets is two-fold. First, it wants to expand and update its earlier work in the natural inventory domain such as the Natural Heritage Network Study (2014-2016), the Forest Inventory Report (2019), and its Stormwater Management Ponds Bathymetric Study (2017-2022) for improved capital planning.

³ Geographic Information System, City of Vaughan. Retrieved August 2021 from www.vaughan.ca/maps/Pages/default.aspx

⁴ Wikipedia. Retrieved August 2021 from en.wikipedia.org/wiki/Vaughan

Second, the City of Vaughan identifies the natural asset inventory as foundational for several objectives in Green Directions Vaughan 2019 and the Service Excellence Strategic Plan. These objectives include improving the annual budgeting process, building the case for appropriate funds for management and enhancement of natural assets, better assessing ecosystem services with particular attention to climate adaptation and resilience, and, better communicating the benefits of existing natural assets and conservation plans^{5,6}.

The City of Vaughan has identified urban forests, rivers, stormwater ponds, woodlands, and trees as priority natural assets. Stormwater management, slope stability, habitat protection, provision of clean water, and amenity space are amongst the high priority services from natural assets.

3.2. Asset management readiness assessment

As part of inventory development, MNAI helps local governments determine their overall state of asset management maturity. To do this, MNAI has adapted the Federation of Canadian Municipalities (FCM)'s asset management readiness assessment tool⁷ to help local governments measure their progress on both asset management and natural asset management in four competency areas, with each area describing outcomes based on five levels of progress or maturity.

The completed readiness assessment helps local governments prioritize actions that increase their effectiveness in managing all assets, including natural ones.

Competency 1: Policy & Governance

The City of Vaughan's council approved the Asset Management Policy on March 19, 2021. The Policy does not distinguish between the engineered and natural assets, so it is assumed to be inclusive of green infrastructure, which includes natural assets⁸. Council also endorsed the Urban Forest Asset Management Plan on Sept. 27, 2021.

The City of Vaughan has a roadmap to guide the detailed actions surrounding its asset management program over the next 3 to 5 years. This includes ecosystem-based management activities such as identifying plans and procedures to assess the health of natural assets. Documents supporting this work include Green Directions Vaughan 2019, the City of Vaughan Official Plan 2010, the Active Transportation Master Plan 2020, and the City-Wide Erosion Control Study 2021.

5 *Green Directions Vaughan – 2019 Community Sustainability Plan. Retrieved August 2021 from www.vaughan.ca/cityhall/environmental_sustainability/General%20Documents/Green%20Directions%20Vaughan%20VPR2%2006-13-19.pdf*

6 *City of Vaughan. 2014-2018 Term of Council Service Excellence Strategic Plan. Retrieved August 2021 from www.vaughan.ca/serviceexcellence/Pages/Reports.aspx*

7 *See fcm.ca/sites/default/files/documents/resources/tool/asset-management-readiness-scale-mamp.pdf for details*

8 *See mnai.ca/media/2019/07/SP_MNAI_Report-1-_June2019-2.pdf for definitions used by MNAI*

Competency 2: People & Leadership

The City of Vaughan is quite advanced in the people and leadership competency area. It has a permanent asset management team tasked with guiding and supporting the asset management function across the organization on an ongoing basis. The Asset Management team has specific asset management responsibilities included in their job descriptions.

A member of the asset management team is responsible for leading, communicating and supporting improvements to natural asset management. However, the job descriptions of staff that manage green infrastructure in Parks, Forestry and Horticulture Operations, Environmental Services (SWM ponds), and Policy Planning (Natural Heritage Network) as part of their regular responsibilities do not yet include specific references to green infrastructure planning with an asset management lens.

Council has demonstrated support for asset management and has approved funding for ongoing asset management planning improvements, including to strengthen natural asset management. In 2014, council approved funding for a Corporate Asset Management department and has been supportive of developing a Forest Asset Management Plan. Council also supported Natural Heritage Network (NHN) policies as part of the City of Vaughan Official Plan in 2010.

Competency 3: Data & Information

The City of Vaughan is at an intermediate stage of asset management related to its asset data and information. It has basic inventory data for all assets, with some service information and standardized condition ratings. It has also defined life-cycle investment requirements for critical assets and has linked asset management and financial information for critical assets. It has some information on asset condition and performance of critical assets from a variety of sources, including for some natural assets. With respect to financial data, the City of Vaughan has captured capital and operating expenditure data for some assets and has developed a strategy to link asset management and financial information.

With respect to natural assets, the City of Vaughan has completed a Street Tree inventory and a Natural Heritage Network inventory that includes woodlands and wetlands. These inventory projects are helping the City of Vaughan address some of the gaps in data and inventory for green infrastructure. For street trees, the City of Vaughan has information on their condition and performance and has defined the desired level of service for them. It has a financial strategy for engineered and green infrastructure and has done an economic valuation of the urban forest (street trees in particular) and reviewed it with council. The City of Vaughan is in the process of developing a Parks Asset Management Plan to be completed in Q1 2022 that will include financial information for engineering (hard) assets.

Competency 4: Planning & Decision-making

The City of Vaughan is in the process of developing a structured asset investment planning approach across service areas that will set priorities using similar criteria based on organizational goals and objectives. This includes approaches for managing both engineered and green infrastructure, although there is still some variation in approaches between how engineered and green infrastructure is managed and between departments. It has begun to incorporate investment plans for natural assets and in particular, the urban forest.

The City of Vaughan has completed Asset Management Plans for its core engineered infrastructure as well as capital renewal planning for those assets. In addition to the core engineered infrastructure work, some natural asset management plans have been developed for stormwater management ponds and street trees. It currently prepares annual capital and operating budgets based on a mix of historical values and new priorities. It is enhancing its financial system (Oracle JD Edwards) to improve the use of Work Orders for Capital and Operating expenditures in more departments. This is expected to improve budgeting and prioritization of work.

4 Natural asset inventory

4.1. Inventory overview

MNAI's natural asset inventories have two main components to express natural asset information: an asset registry (which is a tabular representation of the data) and an online dashboard. MNAI provided the registry to the City of Vaughan in an Excel file and the dashboard as a website address. Information on the condition of the assets is a subset of the inventory and is depicted in both the registry and dashboard.

4.2. Inventory data

To establish the inventory, MNAI obtained data from the City of Vaughan, Toronto and Region Conservation Authority Open Data, and the Government of Ontario. MNAI combined the spatial data layers to establish a comprehensive depiction of natural assets. Table 1 describes the data sources used to develop the inventory and complete the condition assessment.

TABLE 1: SUMMARY OF DATA SOURCES

DATASET NAME	SOURCE	PURPOSE
ELC_TRCA	Toronto and Region Conservation Authority Open Data	Used as the main source for delineating natural assets. The ELC was given precedence over the landuse dataset below. The detailed species information was maintained in the inventory dataset.
TRCA_Landuse_NaturalCover_2017	Toronto and Region Conservation Authority Open Data	Used as one of the main sources for delineating natural and enhanced assets where the ELC was not present.
TRCA_Subwatersheds	Toronto and Region Conservation Authority Open Data	The TRCA subwatersheds were used to fill in any missing subwatersheds not present in the Humber or Don subwatershed datasets. Subwatershed data was merged into one single dataset and used to split assets among the subwatershed boundaries. Natural assets are summarized by subwatershed in the dashboard.
TRCA_Trails	Toronto and Region Conservation Authority Open Data	Used to summarize length of trails running through assets.
NRN_ON_RDSEG	Government of Canada	Used to determine density of roads within a 100m buffer, and to perform the road density condition assessment.
Vaughan_Boundary	City of Vaughan	Used as the study area boundary.
LandUse_Parks	City of Vaughan	This dataset was used to capture pervious surfaces not present within the main landcover datasets.
Don_Subwatersheds	Toronto and Region Conservation Authority	Subwatershed data was merged into one single dataset and used to split assets among the subwatershed boundaries. Natural assets are summarized by subwatershed in the dashboard.
Humber_Subwatersheds	Toronto and Region Conservation Authority	Subwatershed data was merged into one single dataset and used to split assets among the subwatershed boundaries. Natural assets are summarized by subwatershed in the dashboard.
ParcelOwnership_PublicPrivate	Municipal Property Assessment Corporation	Used to indicate which assets fall within public ownership and summarize total asset area which is under public ownership versus private ownership.
Vaughan_Zoning	City of Vaughan	Zoning designation assigned to each asset based on greatest area of overlap between the asset and the zoning parcel.
ANSI	Government of Ontario	Used to summarize area of assets classified as ANSI and to assign the name of overlapping ANSI polygons to assets.

TABLE 1: SUMMARY OF DATA SOURCES

DATASET NAME	SOURCE	PURPOSE
Birds_Area_Sensitive_OpenCountry	City of Vaughan	Used to summarize area of assets which overlap with a bird area and the type of bird area was assigned to the asset.
Birds_Area_Sensitive_Woodland	City of Vaughan	Used to summarize area of assets which overlap with a bird area and the type of bird area was assigned to the asset.
Birds_Shrub_Early_Successional	City of Vaughan	Used to summarize area of assets which overlap with a bird area and the type of bird area was assigned to the asset.
Birds_SpecialConcern_OpenCountry	City of Vaughan	Used to summarize area of assets which overlap with a bird area and the type of bird area was assigned to the asset.
Birds_Threatened_Grasslands	City of Vaughan	Used to summarize area of assets which overlap with a bird area and the type of bird area was assigned to the asset.
BirdsSpecies_ConservConcern_Woodland	City of Vaughan	Used to summarize area of assets which overlap with a bird area and the type of bird area was assigned to the asset.
ESA	Government of Ontario	Used to summarize area of assets which overlap with ESA's and to assign ESA names to relevant assets via a spatial join.
Floodlines_TRCA	Toronto and Region Conservation Authority	Used to indicate which assets fall within the floodline boundary.
FP_Don_5yr	Toronto and Region Conservation Authority	The Don and Humber 5-year floodplain polygons were merged and used to determine area of assets within the 5-year floodplain.
FP_Hum_5yr	Toronto and Region Conservation Authority	The Don and Humber 5-year floodplain polygons were merged and used to determine area of assets within the 5-year floodplain.
FP_Hum_100yr	Toronto and Region Conservation Authority	The Don and Humber 100-year floodplain polygons were merged and used to determine area of assets within the 100-year floodplain.
FP_Don_100yr	Toronto and Region Conservation Authority	The Don and Humber 100-year floodplain polygons were merged and used to determine area of assets within the 100-year floodplain.
Greenbelt ORM_Plans	Government of Ontario	Used to determine assets within the Greenbelt ORM and assign the greenbelt ORM landuse to relevant assets based on the greatest area of overlap method.

TABLE 1: SUMMARY OF DATA SOURCES

DATASET NAME	SOURCE	PURPOSE
HighlyVulnerableAquifer_TRCA	Government of Ontario	Used to indicate which assets lie within the vulnerable area as well as asset area within the vulnerable aquifer.
Provincial_PrimeAgLands	Government of Ontario	Used to summarize area of assets falling within prime ag land and to assign the agricultural land indicator to assets based on greatest area of overlap method.
SigGroundWater RechargeArea	Toronto and Region Conservation Authority	Used to summarize area of assets falling within significant groundwater recharge areas.
SignificantForest	City of Vaughan	Used to summarize area of assets falling within the significant forest polygons.
Waterbodies_TRCA	Toronto and Region Conservation Authority	Used to assign the waterbody name and type (artificial, pond, etc.) to water assets.
WellheadProtectionArea	Toronto and Region Conservation Authority	Used to summarize area of assets falling within the wellhead protection area.

The inventory project defined a total of 7,155 individual assets, covering 14,562 hectares (ha), as noted in Table 2. An asset is defined as a continuous area of the same land cover type. For example, an intact forested area would be defined as one asset, but a forested area that is bisected by a road would constitute two assets. The majority of the asset area in the City of Vaughan was agriculture, followed by meadow/successional forest.

TABLE 2: SUMMARY OF NATURAL ASSETS BY TYPE

NATURAL ASSET TYPE	NUMBER OF ASSETS	TOTAL AREA (HA)
Agriculture	432	5,459
Aquatic	152	93
Built-up Pervious*	1,009	1,914
Forest	2,039	3,244
Hedgerow	65	18
Meadow/Successional	1,940	3,250
Riparian	18	3
Wetland	1,500	581
Total	7,155	14,562

** Built-up pervious includes manicured lawns and greenspaces (e.g., sports fields)*

Figure 3 shows the spatial distribution of the natural assets.

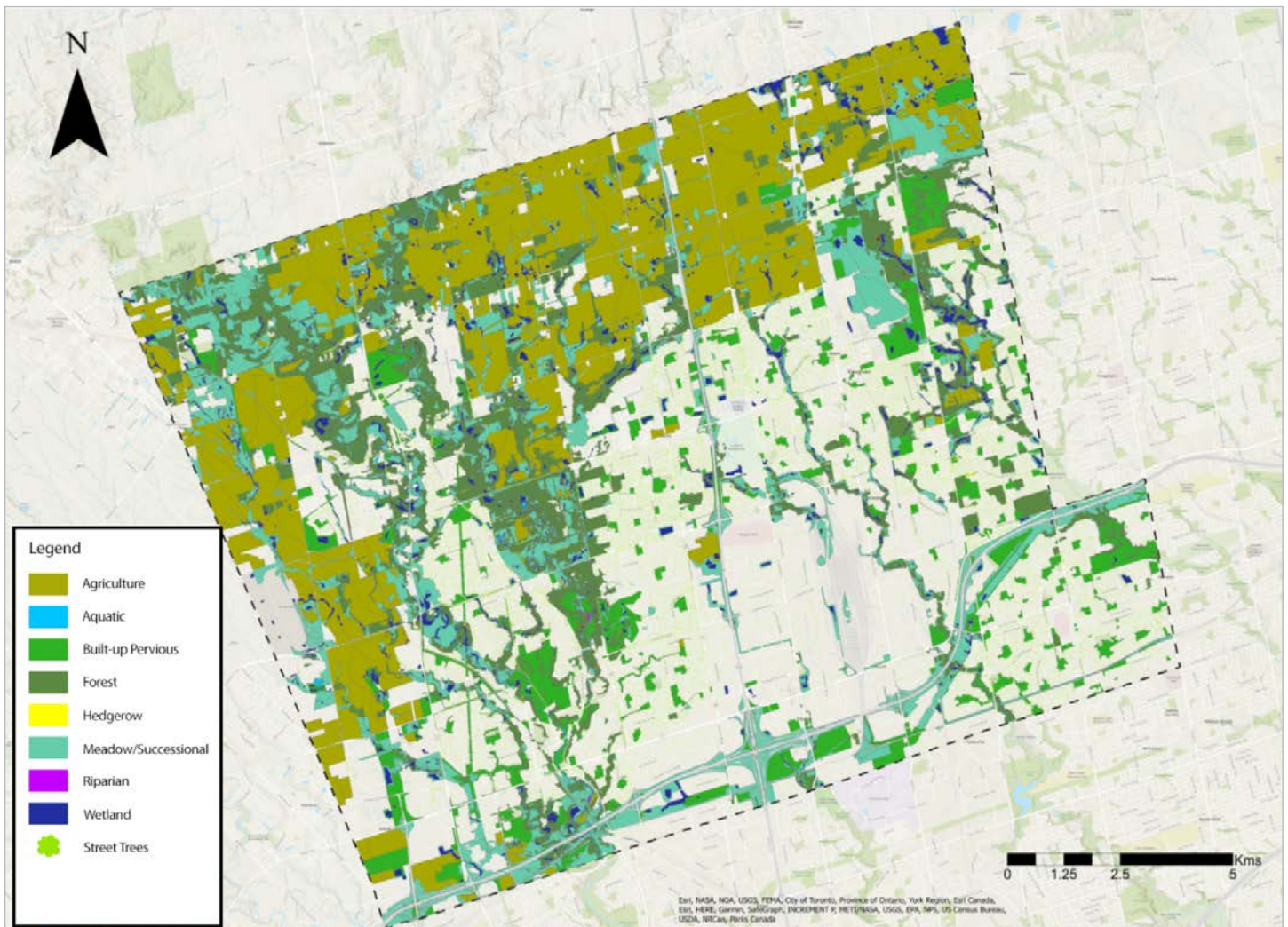


Figure 3: Spatial distribution of natural assets.

4.3. Asset registry

Each asset within the inventory has a unique identification number that allows users to select and analyze individual assets and manipulate the corresponding data as required. For example, changes in condition can be noted for individual assets. Information on each asset is housed in an asset registry. Table 3 is an excerpt from the City of Vaughan's online registry showing natural asset characteristics and details. Additional detail is provided in the online dashboard.

TABLE 3: EXCERPT FROM THE REGISTRY

Asset ID	Asset Type	Asset Area (ha)	Sub-Asset ID	Asset Area (ha) in Subwatershed	Subwatershed Identifier	In 5 Year Floodplain?	5 Year Floodplain (ha)	In 100 Year Floodplain?	100 Year Floodplain (ha)	Greenbelt ORM Area (ha)	Greenbelt ORM Land Use(s)	Vaughan Trails (km)	TRCA Trail Length (km)	Erosion Study Points	Majority Bank Erosion	Max Erosion Score	Adjacent Land Use Score	Permeability Score	Relative Size Score	Road Density Score	To
FOR1201	Forest	11.11	FOR1201-1	3.48	Catch22.13	Yes	1.47	Yes	2.02			0.00	0.00	0		0	8	10	5	1	
FOR1201	Forest	11.11	FOR1201-2	0.08	Catch22.13	No		No				0.00	0.00	0			8	10	5	1	
FOR1201	Forest	11.11	FOR1201-3	7.54	Catch22.06	Yes	1.02	Yes	3.46			0.00	0.00	0		0	8	10	5	1	
FOR1203	Forest	0.96	FOR1203-1	0.96	Catch13.1	No		Yes	0.01			0.00	0.00	0			9	10	1	1	
FOR1204	Forest	1.30	FOR1204-1	1.30	Catch22.14	Yes	0.33	Yes	0.35			0.00	0.00	0		0	8	10	1	10	
FOR1205	Forest	0.73	FOR1205-1	0.73	Catch13.1	No		No				0.00	0.00	0			8	10	1	1	
FOR1207	Forest	0.36	FOR1207-1	0.36	Catch13.3	No		No				0.00	0.00	0			8	10	1	1	
FOR1212	Forest	14.16	FOR1212-1	14.16	Catch18.1	No		No				1.63	2.18	0			9	10	5	1	
FOR122	Forest	0.07	FOR122-1	0.07	Catch26.04	Yes	0.07	Yes	0.07			0.00	0.00	0			10	10	1	10	
FOR1224	Forest	1.16	FOR1224-1	1.16	Catch309	Yes	0.17	Yes	0.23			0.26	0.00	1	Less than 5%	1	7	10	1	1	
FOR123	Forest	0.23	FOR123-1	0.23	Catch26.04	Yes	0.09	Yes	0.18			0.00	0.00	0			10	10	1	10	
FOR1232	Forest	2.11	FOR1232-1	2.11	Catch309	Yes	0.45	Yes	1.26			0.14	0.00	2	Less than 5%	1	8	10	1	1	
FOR124	Forest	0.31	FOR124-1	0.31	Catch26.04	Yes	0.05	Yes	0.12			0.00	0.00	0			10	10	1	10	
FOR1245	Forest	0.30	FOR1245-1	0.30	Catch26.04	Yes	0.00	Yes	0.00			0.00	0.00	0			9	10	1	5	
FOR125	Forest	0.12	FOR125-1	0.12	Catch26.04	Yes	0.10	Yes	0.12			0.00	0.00	0			10	10	1	10	
FOR126	Forest	0.16	FOR126-1	0.16	Catch26.04	Yes	0.07	Yes	0.11			0.00	0.00	1			10	10	1	10	
FOR1265	Forest	0.31	FOR1265-1	0.31	Catch310	No		No				0.00	0.00	0			3	10	1	1	
Total				14,569.36			498.16		969.26	6,543.27		87.09	75.11	3713							

4.4. Online dashboard

Inventories may provide more insights when characterized visually in a dashboard, which enables users to explore different aspects of the data. For instance, natural asset information can be quickly summarized by watershed area, or, if users want to dive into the specifics of forest assets, they can quickly filter the data to focus on that particular asset. Figure 4 is a screenshot from the dashboard that MNAI provided to the City of Vaughan. The full version can be accessed at go.greenanalytics.ca/Vaughan.

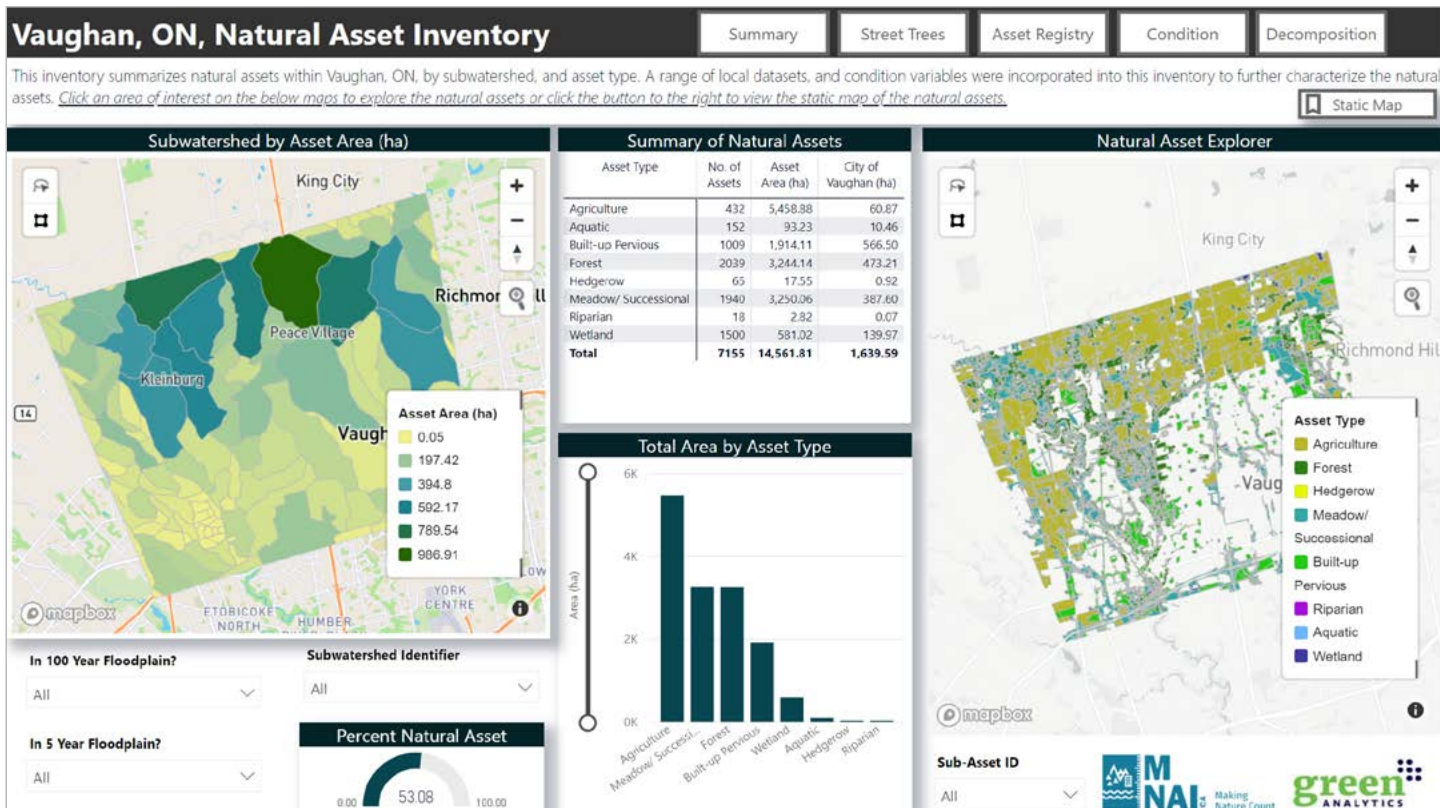


Figure 4: Screenshot of main inventory summary.

4.5. Condition of natural assets

Documenting the condition of natural assets is a key aspect of natural asset inventories. A natural asset condition assessment provides an understanding of both the ecological health of natural assets, and the ability of natural assets to provide services. This information, in turn, can support the effective management of natural assets, be reflected in the registry and the dashboard, and updated over time.

MNAI completed a desktop-based condition assessment and built it into the inventory to provide an initial understanding of the status of the natural assets for the City of Vaughan. As part of a full natural asset management project, MNAI would expand this assessment to include metrics related to condition (e.g., relative biodiversity, riparian and wetland health, soil condition, connectivity, and others and possibly employ site visits to confirm and verify the condition ratings. The desktop exercise completed as part of this inventory is a reasonable first step in assessing condition and can be used as a foundation for future work in this area.

Table 4 summarizes the condition assessment steps and indicators. MNAI chose these indicators for their relative ease of measurement (given time and budget constraints) and for their relevance to measuring the ecological health and service delivery capabilities of natural assets. They are proxy metrics for these broader condition considerations. For example, larger asset size implies more connectivity of natural areas, higher road density implies more fragmentation

and higher hydrologic impairment of water flows, and more permeability implies greater ability to store water which means more effective stormwater management. The adjacent land use metric measures and distinguishes natural assets that are next to other natural assets from natural assets that are next to built infrastructure. How and the extent to which a given natural asset is influenced by the drainage in the adjacent landscape varies depending on factors such as the local topography and soils, orientation (e.g., upland versus lowland, position in the watershed) and the size and nature of the feature itself. However, it is well-established that the condition of a natural asset in an urban context tends to be negatively impacted when more of the surrounding land uses are impervious (i.e., paved, concrete or buildings) because this tends to alter pre-existing drainage and infiltration pathways, which can cause a natural area to receive much more or much less drainage than prior to being in an urban context. Urban runoff also typically carries a host of sediments and contaminants, and when such runoff is directed to natural areas and not properly treated, it can negatively impact the feature and its functions for plants and wildlife.

TABLE 4: CONDITION ASSESSMENT APPROACH AND INDICATORS

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator*
Relative asset size	For each natural and semi-natural asset type, total area is calculated, and a rank is assigned to the assets within each class based on its percentile score. Natural assets within the top third of the ranking (e.g., the largest assets within a class) received a 3, those within the middle third of the ranking received a 2, and those within the bottom third of the ranking received a 1.	Natural asset inventory
Road density	Measures the density of the roads in and around the assets according to high density (assets with more than 2km of roads per km squared), medium density (assets with between 1km and 2km of roads per km squared) and low density (assets with less than 1km of road per km squared).	Natural asset inventory plus spatial representations of roads
Surface permeability	The permeability of surfaces is ranked on a scale of nil to high depending on the type of landcover present. Urban areas, roads and industrial areas are ranked as nil. Assets within impervious surfaces are assigned as low permeability. Agriculture and shrublands are ranked as medium. Wetlands, waterbodies and forests are ranked as high.	Natural asset inventory, spatial representations of land uses and roads, as well as the Global Man-made Impervious Surfaces Dataset from NASA data.nasa.gov/dataset/Global-Man-made-Impervious-Surface-GMIS-Dataset-Fr/dkf4-4bi3

TABLE 4: CONDITION ASSESSMENT APPROACH AND INDICATORS

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator*
Adjacent land use	Considers the distance to, and the nature of, the area surrounding natural assets. Intense land uses (e.g., airports) in close proximity to natural assets result in a poor rating, while distant land uses that are less intense (e.g., agriculture) result in a good rating. If there are no human land uses within 100 m of the assets, the assets are scored 10. If there are intensive land uses within 100 m of the assets, the score is 0.	Natural asset inventory plus spatial representation of land use as well as intensity rankings of land uses

* Data sources provided in Table 1 unless noted here.

Once conditions were allocated to each asset, an overall score was derived for the project area. The maximum possible score for an asset was 40, based on a possible 10 points for each of 4 categories:

- Road density as low (10), medium (5) or high (1).
- Surface permeability rated as high (10), medium (5), low (1), or nil (0).
- Adjacent intensive land use (0 for intense land uses, otherwise 10).
- Relative asset size where the largest 3rd areas receive 10, 5 for middle 3rd, and 1 point for the lowest 3rd.

The total condition score was then converted into a rating scale:

- **Good** - assets with a score of 30 or higher
- **Fair** - assets with a score between 20 to 29
- **Poor** - assets with a score between 10 to 19
- **Very Poor** - assets with a score lower than 10

Figure 5 summarizes the natural asset condition assessment results as per the online dashboard.

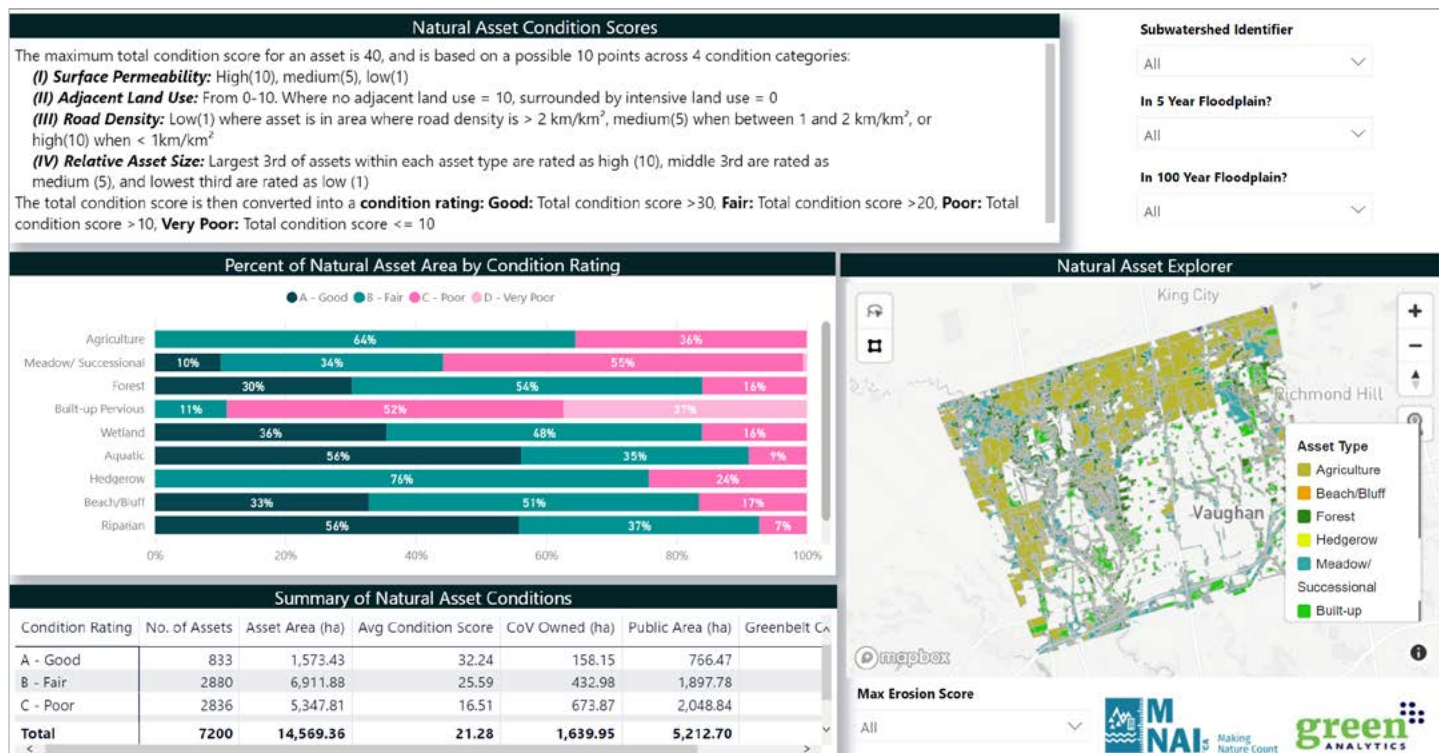


Figure 5: Screenshot of condition assessment details.

Overall, about 1,573 ha (or 11 per cent) of natural assets were assessed in good condition and 6,912 ha (or 47 per cent) were assessed in fair condition. Riparian, aquatic and hedgerow largely ranked good and fair, while built-up pervious largely ranked poor and very poor.

Table 5 summarizes condition ratings and Figure 6 summarizes condition by natural asset type. Additional insights on the condition results can be obtained through the “Decomposition” tab of the online dashboard.

TABLE 5: SUMMARY OF NATURAL ASSET CONDITION RATINGS

Condition Rating	Number of Assets	Total Area (ha)	Average Condition Score
Good	833	1,573	32
Fair	2,880	6,912	26
Poor	2,836	5,348	17
Very Poor	651	736	9
Total	7,200	14,569	21

Percent of Natural Asset Area by Condition Rating

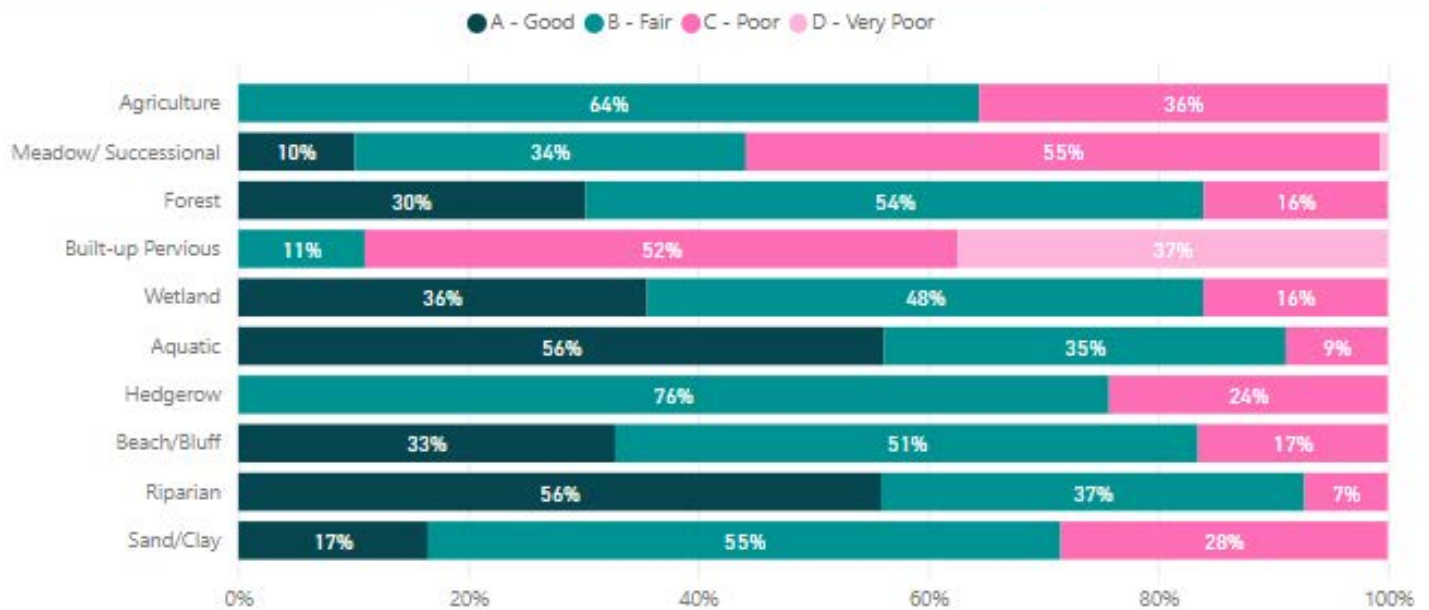


Figure 6: Summary of condition rating by natural asset type.

4.6. Maintaining the inventory

Inventories are not static. Both the registry and the dashboard can be expanded as new information becomes available. For example, asset condition might improve as a result of restoration efforts, or new studies may add insights on the condition of the assets. New data can be reflected in the asset registry and subsequently in the online dashboard as it becomes available. Furthermore, the level of desired detail may evolve as asset management readiness increases or as areas of natural asset management focus emerge. That said, inventories should grow in detail and sophistication only insofar as they remain aligned with the capacity of the communities to maintain them and the uses to which they will be put. Their evolution and development should be a function of the monitoring, reporting and lessons of the asset management cycle and be driven by the imperative of ensuring sustainable, cost-effective delivery of services to the community, which is the core of asset management.

5 Risk identification

5.1. Risk identification tool overview

Identifying risks facing natural assets can help local governments prioritize their management of natural assets. To this end, MNAI provides local governments with a tool entitled Risk Identification Process in the Development of Natural Asset Inventories and guidance in self-administering it.

Risk management is a four-stage process that includes risk identification, analysis of probability and consequence, development of risk mitigation strategies, and control and documentation. The use of the risk identification tool informs the first and second stages of risk management by identifying the top risks to natural assets and their associated services, plus a high-level analysis of impacts and consequences.

Risk types relevant to natural asset management typically include:

- **Service risk:** the risk of an asset failure that directly affects service delivery.
- **Strategic risk:** the risk of an event occurring that impacts the ability to achieve organizational goals.
- **Operations and maintenance risk:** risks related to poor asset controls and oversight, which can lead to poor record-keeping and poor monitoring of asset.
- **Financial risk:** risks related to the financial capacity of the City of Vaughan to maintain municipal services.
- **Political risk:** risks related to the nature of municipal politics.

5.2. Using the risk identification tool

Using the risk tool, the City of Vaughan considered possible risks that the loss of natural asset functions could pose to built infrastructure, personal health and safety, and private property, including:

- Flooding
- Extreme weather events
- Erosion
- Invasive species
- Development pressure
- Environmental contamination
- Construction activity
- Dry season
- Wildland fires

Each risk was then ranked low, medium or high according to the probability of an impact occurring, and the relative magnitude of its negative consequences. To assess impact and consequence, the City of Vaughan considered four questions:

- i/ what impact is likely to happen?
- ii/ what is the consequence of that impact happening?
- iii/ what can be done to mitigate the probability of impact and/or consequence?
- iv/ what cues will signal the need for mitigation?

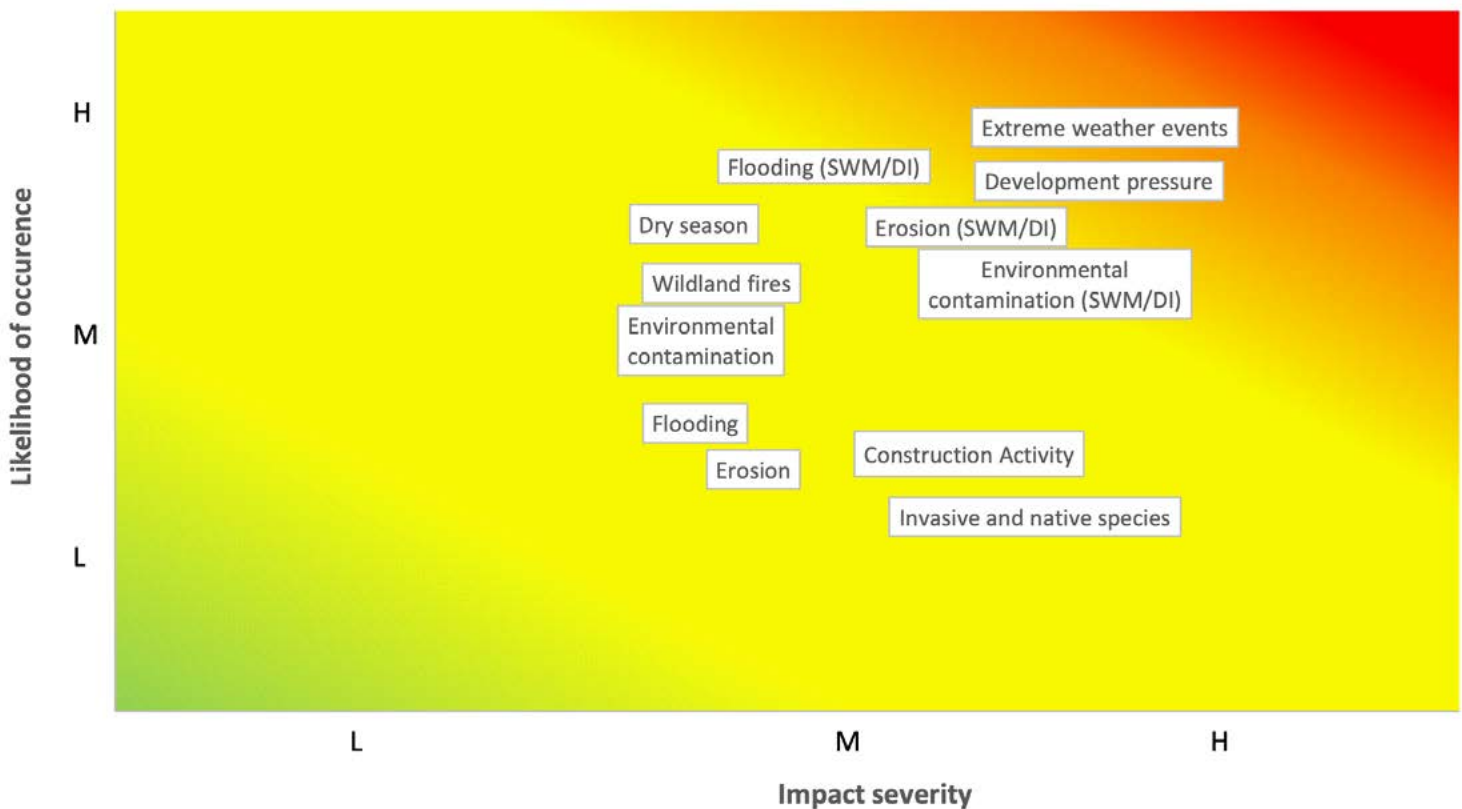
5.3. Results of the risk identification process

The risk identification process revealed:

- 2 high-level risks (development pressure and extreme weather events)
- 3 moderate-high level risks (flooding, erosion, and environmental contamination)
- 4 moderate-level risks (construction activity, dry season, invasive and native species, and wildland fires)

In terms of scope, the identified risks affect natural assets across the City of Vaughan with numerous risks potentially affecting stormwater management ponds and the drainage system. The identified risks also have the potential to negatively impact engineered assets (both city-owned and non-city-owned), property, personal health and safety, and reputation.

Risk Matrix



LEGEND Minor Moderate Major Severe

Figure 7: Results of risk identification process.

5.4. Potential priorities for the local government

The outcomes of the risk identification process highlight potential priorities on which the City of Vaughan could focus their natural asset management efforts. Where possible, these are also informed by the condition assessment. These are:

- Development pressure:** Development pressure was identified as a high-level risk to all natural assets (with the exception of Parks, which was ranked at a moderate level of risk from development). Impacts are felt across the City of Vaughan, particularly in greenfields and intensification areas such as the Vaughan Metropolitan Centre. As a high-growth municipality, development pressure is a top consideration. The City of Vaughan should review increasing requests to develop in the floodplain against the potential consequences of multiple interacting threats such as flooding causing impacts to property, community safety, critical infrastructure, and reputation.

- **Extreme weather events:** Extreme weather events involving snow, rain, high winds, ice storms, tornados, lightening, and excessive rain was identified as a high-level risk to trees, parks, stormwater management ponds, and drainage infrastructure across the City of Vaughan. These risks are anticipated to increase in frequency, intensity, and duration with climate change.
- **Flooding:** Flooding was identified as a moderate- to high-level risk to natural assets in flood prone areas and Special Policy Areas, including Woodbridge, Thornhill, and Vaughan Metropolitan Centre. Heightened risks to stormwater management ponds and drainage infrastructure were noted.
- **Erosion:** Erosion was identified as a moderate- to high-level risk to natural assets, particularly stormwater management ponds and drainage systems. This risk is most acute in the lands along the Humber River (e.g., Woodbridge works yard, Rainbow Creek) and in Western Vaughan (e.g., Marita Payne Park). Current impacts include the erosion of higher banks along the Humber River, sinkholes, and an increase in traffic issues.
- **Environmental contamination:** Environmental contamination caused by industrial pollutants, dumping, and human activity was identified as a moderate- to high-level risk to natural assets, particularly stormwater management ponds and drainage systems. Natural assets and parks adjacent to industrial and transportation routes, the railyard (e.g., eco parks, Langstaff), and close to chemical sites are at greatest risk of contamination. In response, the City of Vaughan follows hazardous materials protocols; a quick clean-up response is essential to avoid contaminants from entering waterways and damaging natural assets.

Table 6 lists and provides brief descriptions of risk mitigation strategies. Future stages of the MNAI process can address these.

TABLE 6: RISK MITIGATION STRATEGIES	
Accept	Risk may be acceptable if probability and consequences are small
Minimize	Risk under local government's control that warrants exposure reduction
Share	Partners in a project permit the sharing of larger risks to reduce it for each
Transfer	Insurance, fixed price contracts, and other risk transfer tools

6 Recommendations

This section provides insights that can be gained from considering both the inventory - including the condition and risk assessments - and the asset management readiness assessment. It is divided into (6.1) opportunities to strengthen natural asset management at an organization-wide level (6.2) possible actions for the further development of the inventory, and (6.3) steps the City of Vaughan can consider to advance to a full natural asset management initiative.

6.1. Opportunities to strengthen natural asset management at an organization-wide level

The City of Vaughan will be able to apply its Asset Management Policy as it begins to implement its newly developed Asset Management Plans. The Asset Management Policy does not exclude natural assets and, therefore, any plans developed for natural asset management will be aligned with the Policy.

This inventory project is the first step in formally incorporating green infrastructure, including natural assets, into the City of Vaughan's asset management planning. This project has allowed senior staff to identify green infrastructure as a missing gap in their current work. A next step will be to identify additional asset inventory data gaps and develop processes to close those gaps.

New Asset Management Plans will include information about levels of service and incorporate risk-based management strategies and prioritization for critical assets. They will also evaluate the lifecycle investments associated with critical assets and inform the frequency of asset data updates. This will support the City of Vaughan in establishing regular measuring and monitoring, including for natural assets.

The new Asset Management Plans will include level of service measurements for critical service areas and the results of monitoring will be communicated to senior staff and Council. This will inform updates to the Strategy roadmap as needs evolve and support continued progress on asset management. O. Reg. 588/17 requires Asset Management Plans to be updated on a regular basis.

The City of Vaughan is aspiring to develop a detailed investment plan based on its newly developed asset management plans. The first iteration of Asset Management Plans was developed to meet O. Reg 588/17, so investment planning needs to be more structured and formalized.

Staff noted that more education is needed for both internal and external stakeholders about how to embed natural asset management into overall asset management planning. The City of Vaughan expects this can be done through other planned work such as the Official Plan Review and Greenspace Strategic Plan. The City of Vaughan also hopes to conduct studies of the value

of ecological services to natural heritage assets following the completion of this project.

It is recommended that the City of Vaughan recognizes green infrastructure planning in performance reviews and work objectives, including in senior environmental planner positions.

6.2. Possible actions for the further development of the inventory

Based on the inventory, the City of Vaughan could consider the following, regardless of whether or not it pursues a full natural asset management process. These are mostly incremental measures.

- Expand the risk identification process to include field verification of results.
- Determine acceptable levels of risk to the City of Vaughan's risk mitigation strategies (see Table 6).
- Further develop the condition assessment and risk assessment for rivers, wetlands, and woodland using local climate projections, land use modelling, and other data already at their disposal.
- Identify linkages between services and assets and assess the condition of, and risks to, the assets from the perspective of their ability to deliver services. From a water supply and stormwater management perspective, watercourses, wetlands and woodland areas in the watersheds will be key.
- Share the inventory with adjacent local governments to stimulate collaboration within the watershed.
- Initiate or enhance monitoring - for example, using gauges, water level sensors, and loggers to improve understanding of trends, feed into condition ratings of assets, and gather information for modelling.
- Schedule regular updates (e.g., every 3-5 years) of the inventory, condition assessment and risk identification to understand trends.
- Maintain interest and momentum in natural asset management to move towards a full natural asset management project.

6.3. Steps to a full natural asset management project

If the City of Vaughan wishes to proceed with a full natural asset management project, including implementation, it will need to consider the following steps.

- 1/ Confirm scope, roles and responsibilities.** Undertake a meeting or workshop to confirm (a) assumptions [for example, that water management and development pressure are the primary services of concern] (b) roles, responsibilities, and capacities (c) community capacity to undertake a larger project.

- 2/ Fill essential knowledge gaps.** If discussions on scope and certainty and related data needs for modelling indicate the need for additional data, these could be filled.
- 3/ Modelling.** Modelling the levels of service that natural assets currently provide and the levels of service under different potential management, local climate change projections, and rehabilitation or restoration scenarios, is central to natural asset management as it gives communities the ability to explore how different actions will affect the health and corresponding performance of natural assets.
- 4/ Economic assessment.** The economic assessment component provides a market-based indication of (a) the current value of the services from natural assets if they had to be provided by an engineered means, and (b) the costs and values of different interventions in terms of service delivery.
- 5/ Planning.** This step allows local governments to explore different scenarios such as “what happens to the services provided by the wetland if there is significant building upstream?” or “what happens to the services if the forest is restored?” Using modelling, changes in service levels can be understood and quantified. Corresponding values can also be determined through continued economic assessment. Based on the foregoing, local governments can begin to consider and prioritize actions ranging from status quo to planning, regulatory, financial operations, maintenance, acquisition, and monitoring interventions.
- 6/ Implementation.** MNAI can provide ongoing advice / guidance on policy pieces and integration of the above information for 12-18 months. After that, the local government, together with local partners and service providers, would ideally have the capacity to continue efforts on their own.
- 7/ Ongoing monitoring.** It is essential to continue monitoring the project to learn whether interventions are working and to share lessons and learnings from other communities undertaking natural asset management. MNAI would typically stay involved with the community for three years through a monitoring arrangement to be established with the communities.

Sources

City of Vaughan. 2014-2018 Term of Council Service Excellence Strategic Plan. Retrieved August 2021 from

www.vaughan.ca/serviceexcellence/Pages/Reports.aspx

Federation of Canadian Municipalities. October 2018. Asset Management Readiness Scale: Municipal Asset Management Program.

fcm.ca/sites/default/files/documents/resources/tool/asset-management-readiness-scale-mamp.pdf

Green Directions Vaughan – 2019 Community Sustainability Plan. Retrieved August 2021 from

www.vaughan.ca/cityhall/environmental_sustainability/General%20Documents/Green%20Directions%20Vaughan%20VPR2%2006-13-19.pdf

MNAI. Defining and Scoping Municipal Natural Assets. June 2017.

mnai.ca/media/2019/07/SP_MNAI_Report-1-_June2019-2.pdf

MNAI. Results from the First National Cohort. Decision-maker summary. 2018.

mnai.ca/media/2019/08/spmnaijuly31-summaryweb.pdf

MNAI. Cohort 2 National Project Overview. February 2020.

mnai.ca/media/2020/02/MNAI-CohortSummary.pdf

Annex: Results of the City of Vaughan's risk identification process

This Annex contains the results of the City of Vaughan's use of MNAI's risk identification tool, which they self-administered with guidance from MNAI. Table 1 was the main product that personnel developed from the exercise.

Step 1: Identification of risks

Common Risks to Natural Assets:

- Overuse of trails/dumping
- Flooding (current and future)
- Forest fire
- Invasive species
- Development pressure
- Pollutant loading from urban, agricultural, or industrial sources (e.g., overuse of salt on roads)
- Drought (current and future)
- Erosion
- Ice jams
- Storm surge
- Lack of flood hazard mapping
- Lack of land management plans
- Lack of monitoring reports
- Construction activity
- Political policy change

Step 2: Complete survey

Rating scale ■ Low (0-19) ■ Moderate (20-39) ■ High (40-59) ■ Extreme (60-80)

TABLE 7: SIMPLIFIED RISK IDENTIFICATION SURVEY

	Hazards	Ranking	Average Score	Affected Assets	Location	Notes
1	Development Pressures	High	40/52*	The risk are all high except 1 moderate Parks	City-wide, primarily in greenfields and intensification areas such as Vaughan Metropolitan Centre	High growth municipality, request to develop in floodplain is increasing
2	Extreme Weather Events	High	36/60*	Trees, Parks SWM and DI	City-wide	Snow, rain, high winds, ice storm, tornado, lightening, excessive rain
3	Flooding	Moderate to High	26/52*	The risk to SWM/DI is slightly higher than other assets	Floodprone areas such as Woodbridge, Thornhill and Vaughan Metropolitan Centre	Floodprone areas, Special Policy Area, have higher risks
4	Erosion	Moderate to High	26/44*	The risk to SWM/Drainage System is slightly higher than other assets	Valleylands along the Humber River (Woodbridge works yard, Rainbow Creek). Also, Western Vaughan e.g. Marita Payne Park	Higher banks along Humber rivers are eroding. Subsidence (sinkholes) created by erosion and water, Increase traffic issues
5	Environmental Contamination	Moderate to High	25/40*	The risk to SWM/Drainage System is slightly higher than other assets	Industrial and all transportation routes, railyard adjacent to parks (eco parks, Langstaff etc.) - near chemical sites	HAZMAT, industrial pollutants, dumping, human caused activity

TABLE 7: SIMPLIFIED RISK IDENTIFICATION SURVEY

	Hazards	Ranking	Average Score	Affected Assets	Location	Notes
6	Construction Activity	Moderate	20/44*	Moderate except with SWM as high	City-wide, primarily in greenfields and intensification areas such as Vaughan Metropolitan Centre	Site alteration - grading, new sewer, dewatering, grading within vegetation protection zones (buffers) of the features is commonly proposed
7	Dry Season	Moderate	28	Moderate for wetlands, woodlands, trees and parks	City-wide	Forestry defines dry season to equate to 4 weeks or no rain
8	Invasive And Native Species	Moderate	27	Moderate for wetlands, woodlands and trees	City-wide, woodlands, individual trees	Ash Borer, Gypsy Moth, Dog Strangling Vine, Buckthorn
9	Wildland Fires	Moderate	24	Moderate for all with highest score for woodlands	Western Vaughan (Woodbridge/407), along rail line systems	Human caused activity

Note 1: *indication of average and highest scoring hazard

Note 2: Consequences applied: Property Damage, Environmental Impacts, Community Safety, Critical Infrastructure, Reputation

Note 3: Natural (Green) Assets Include wetlands, valleylands, woodlands, trees, parks, stormwater management ponds (SWM) and drainage Infrastructure

Municipal Natural Assets Initiative

