Natural Assets Initiative

MAKING NATURE COUNT

A GUIDEBOOK FOR LOCAL GOVERNMENTS

Nature is Infrastructure: How to Include Natural Assets in Asset Management Plans

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Acknowledgments

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Possibility grows here.

MFOA

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Table of Contents

Purpose

As natural asset management is a relatively new practice, standard terms and approaches for its integration into municipal asset management frameworks (which were originally designed exclusively for built assets) are still evolving. However, there are key terms that have become widely adopted by natural asset practitioners and have been used for this project. **The purpose of this guidance document is to align natural asset management with approaches and practices already in place for built assets while (a) using the most current and widely adopted lexicon for natural assets, and (b) recognizing that natural assets have some unique attributes and functions (e.g., much longer or indefinite lifecycles) that do not always allow them to fit neatly into the same "boxes" as built assets.**

1 Introduction

Local governments across Canada have been using asset management processes to manage their built assets for decades. Recently, the importance of incorporating natural assets (e.g., wetlands, forests, grasslands, meadows, or watercourses) into similar management frameworks has been recognized because, like built assets, natural assets represent a critical part of a community's infrastructure and need to be accounted for and managed proactively.

As articulated by the Canadian Standards Association in *CSA W218:23 Specifications for natural asset inventories*, natural assets "provide or contribute to the delivery of ecosystem services." In many cases, these ecosystem services contribute to the improvement of public services such as through the provision of clean drinking water, improved air quality, and flood control, as well as added benefits such as recreation and greenspace. Recognizing natural assets and the range of services they provide to local governments and their residents is essential to ensure these assets are effectively managed and that the vital services they provide do not deteriorate. As with built assets, having in place a natural asset management plan is essential to ensure a sustainable long-term supply of critical ecosystem services. The Ontario government recognizes that having a general understanding of the services and the benefits provided by natural assets is an important consideration for asset management.[1] Ontario is the only jurisdiction in Canada that officially requires natural assets to be accounted for in asset management plans through its asset management regulation, O. Reg. 588/17 (see *Section 1.2.1*).

This guidance document provides direction and insight for local governments who are seeking to undertake natural asset management. An *asset management plan* is a plan for managing a local government's assets to deliver an agreed standard of service. The purpose of such a plan is to make explicit the costs

1 CSA (2023) provides additional information on the role of ecosystem services and how they can inform natural asset management.

and benefits associated with service delivery and to manage such costs appropriately, while also adequately addressing and handling any associated risks. An asset management plan is distinct from a conservation management plan, which may address some of the same natural areas. *Appendix A* contains a comparison of natural asset management plans and conservation management plans.

Each section of the guidance document outlines a **key component of an asset management plan**, which taken together results in a complete asset management plan for natural assets, as follows:

- **Section 2** provides direction on how to document the state of natural assets by undertaking an asset inventory and condition assessment and establishing replacement costs for natural assets.
- **Section 3** identifies and assesses the range of risks that natural assets are vulnerable to.
- **Section 4** provides guidance on how to establish levels of service for natural assets.
- **Section 5** considers the process for articulating lifecycle management strategies.
- **Section 6** documents financial strategies to support the lifecycle management strategies.
- **Section 7** summarizes common funding sources for natural asset management.

The remainder of this section (**Section 1**) explores the terminology relevant to natural assets, and describes existing regulations and standards. It also identifies the unique attributes of natural assets that are important to consider while developing a holistic asset management plan.

1.1 Key Terms and Definitions

As articulated in CSA (2023), “assets exist on a continuum from engineered to enhanced to natural. Typically, asset managers focus on engineered assets. However, a more comprehensive approach to public sector asset management would expand the [application] to include nature for the valuable services they provide.” *Figure 1* demonstrates the types of assets that may be managed by a local government, including green and grey infrastructure, all of which interact with each other. *Figure 1* also demonstrates relationships between terms commonly used when referring to green infrastructure (GI). The figure distinguishes between three sub-types of GI (natural assets, enhanced assets, and engineered assets) with examples of each. It also shows how these different assets align with other commonly used terms such as low impact development (LID) and nature-based solutions (NbS).

Figure 1: Range of Assets that Local Governments Manage, Adapted from Green Infrastructure Ontario Coalition

Green Infrastructure (GI)

Nature-based (climate) **Solutions** (Nb[c]S)

Natural Infrastructure (NI)

Low Impact Development (LID)

Natural (GI) **Assets**	**Enhanced** (GI) **Assets**	**Engineered** (GI) **Assets**	**Grey Infrastructure**
• Wetlands • Swamps • Forests • Meadows • Watercourses • Lakes and ponds • Soils	• Rain gardens • Green roofs and walls • Bioswales • Street and park trees • Naturalized stormwater ponds • Manicured lawns	• Permeable pavement • Rain barrels • Cisterns • Perforated pipes • Infiltration trenches	• Bridges • Roads • Parking lots • Culverts • Pipes

These terms are defined in more detail below to help distinguish the range of possible infrastructure solutions between completely engineered and completely natural. The cited text is from the Canadian Council of Ministers of the Environment (CCME, 2021, pp. 3-8) unless otherwise noted.

- **Infrastructure** "refers to the managed elements of interrelated systems that provide goods and services essential to enabling, sustaining or enhancing the living conditions of human communities."
- **Grey infrastructure** "refers to engineered assets made exclusively of materials such as concrete and steel [...] including bridges, dams, water treatment plants, culverts, ditches, and storm drains".
  - "Grey infrastructure elements are generally designed for singular purposes, and although considerable expertise has accrued over time on best practices for their design and management, they are not highly adaptable to changing conditions such as extreme precipitation events and have a limited lifespan" (Sutton-Grier et al., 2015, as cited in CCME, 2021).
  - "Further to this, grey infrastructure has a large carbon footprint given the emissions associated with manufacturing concrete and steel structures" (Bataille, 2019, as cited in CCME, 2021).

- **Green infrastructure** “refers to the natural vegetative systems, engineered and built features, and green technologies that collectively provide society with a multitude of economic, environmental, and social outcomes… At present, green infrastructure is still strongly associated with the planning philosophy of LID and technologies that support the ecological and hydrological processes needed to manage rain- and stormwater in towns and cities.” Green infrastructure has three sub-types of assets; from “most” to “least” engineered these are:
  - **Engineered (green) assets** are built or manufactured structures intended to mimic natural functions, particularly hydrologic functions, at the site-specific scale. They generally do not have a “green”/vegetated component. Examples include rain barrels, permeable pavement, and infiltration trenches.
  - **Enhanced (green) assets** incorporate “land, water and vegetation features alongside human-made elements to sustain ecosystem functions and services… the enhancement of conventional grey infrastructure (e.g., piped, ditch and culvert, dam and reservoir systems) with nature-based elements, [often] in order to achieve the active and everyday management of the full rainfall-runoff spectrum”. Examples include bioswales, green roofs, trees in built-up areas with engineered rooting environments, and native topsoil added to developed areas (with grass and/or other groundcovers) for its water infiltration and retention capacity.
  - **Natural assets/natural infrastructure** “refers to the use of preserved, restored, or enhanced elements or combinations of vegetation and associated biology, land, water, and naturally occurring ecological processes to meet targeted infrastructure outcomes”.
- **Nature-based solutions or nature-based climate solutions** “are measures that protect, restore and sustainably manage natural or modified ecosystems, with the aim of maintaining or enhancing the services provided to human communities and benefits to biodiversity.”
  - “[C]an be used in place of or in tandem with grey infrastructure to create a hybrid approach, to enhance resilience of the infrastructure asset, and provide many other co-benefits”.
  - As illustrated in *Figure 1*, these include natural assets and enhanced assets, but exclude engineered assets that mimic natural functions but use grey infrastructure to do so.

1.2 Existing Regulations and Standards

This subsection summarizes some of the existing regulations and standards that maybe helpful for local governments undertaking natural asset management. The focus is specifically on Canadian-based standards, with the intention being to build on the progressive work that has already been accomplished in Canada.

1.2.1 Ontario Regulation 588/17

In Ontario, Ontario Regulation 588/17 (Asset Management Planning for Municipal Infrastructure) under the *Infrastructure for Jobs and Prosperity Act (2015)*, came into effect January 1, 2018. O. Reg. 588/17 made Ontario the first and currently only province in Canada to regulate asset management planning at the municipal level and to require consideration of both human-made and natural assets as part of this process.

O. Reg. 588/17 requires all municipalities in Ontario to have a comprehensive asset management plan in place for all municipal infrastructure assets by July 1st of 2024 for current levels of service, and July 1st of 2025 for proposed levels of service.

The definition of what constitutes a municipal infrastructure asset for the purpose of O. Reg 588/17 includes green infrastructure, which comprises natural assets as well as other green infrastructure assets as per the following definition:

> Infrastructure asset consisting of natural or human-made elements that provide ecological and hydrological functions and processes and includes natural heritage features and systems, parklands, stormwater management systems, street trees, urban forests, natural channels, permeable surfaces, and green roofs. (O. Reg 588/17, 2021).

The following are the expectations of The Ontario Ministry of Infrastructure regarding compliance with O. Reg 588/17 with respect to natural assets:

- The goal of the Asset Management Planning for Municipal Infrastructure Regulation (O. Reg. 588/17) is to promote a greater degree of standardization and consistency, while providing flexibility for municipalities to create plans unique to their circumstances.
- Municipalities are to use recognized and generally accepted good engineering practices where appropriate and other industry best practices where applicable.

This intent of this guidance document is to demonstrate existing good industry practices that can be followed by local governments to meet the O. Reg. 588/17 requirements.

1.2.2 Standards

In 2023, the Canadian Standards Association (CSA) released a voluntary standard for the specifications of natural asset inventories (CSA, 2023). This standard focuses on the creation of a natural asset inventory and provides high-level guidance on completing a condition assessment. It provides little guidance on risk identification or levels of service (both of which are components of an asset management plan and hence addressed in this Guidebook). Where appropriate, this Guidebook refers the reader to CSA (2023) for more details.

Local governments undertaking natural asset management can draw from a range of existing documents such as climate change plans, risk assessments, and conservation plans to inform their natural asset management plans. Some specific standards that may be helpful include:

- Canadian Council of Ministers of the Environment:
    - Best Practices and Resources on Climate Resilient Natural Infrastructure (2018)
    - Natural Infrastructure Framework (2021)
- International Organization for Standardization (ISO):
    - 55000:2014 Asset Management – Overview, Principles and Terminology

Appendix B provides a list of resources that can support the incorporation of natural assets into asset management plans.

1.3 Uniqueness of Natural Assets

Natural assets have several unique features that make them an essential and important part of a local government's asset management strategy. Some of these features also pose challenges when attempting to integrate natural assets into a traditional asset management plan. Below are key characteristics of natural assets, and the advantages and challenges they present. The following sections address how to deal with these differences when undertaking asset management for natural assets.

Irreplaceable: Unlike many built assets, natural assets can be irreplaceable and/or take decades, if not centuries, to regenerate once depleted. Some features, like ancient forests or unique geological formations, are irreplaceable once lost, making their long-term preservation critical.

Complex Interactions: Natural assets are embedded within complex ecological systems with intricate interdependencies. Altering or mismanaging one component can have cascading effects on the entire ecosystem, which can disrupt not only the environment but also impact built infrastructure and human well-being. These complexities necessitate a holistic approach to natural asset management. They also speak to the challenge of defining the boundaries of natural assets (i.e., where one asset 'ends' and another starts).

Climate Resilience: Many natural features can withstand a certain amount of stress and in many cases can "self-repair" when damaged, if the damage sustained is not too severe, and if the asset is not subject to a succession of stressors or already in poor condition. This is an advantage over built assets, which require regular maintenance and eventual replacement. However, cumulative effects and/or exposure to multiple stressors can cause even the most resilient natural assets to reach tipping points that can cause cascading or widespread failure of the asset's function.

No End of Useful Life: Most natural assets do not depreciate overtime or have an end of useful life. If left alone, undisturbed by human impacts, natural assets can exist indefinitely. However, in most contexts, natural assets experience some form of human impact. Natural assets in heavily populated regions are likely to experience various degrees of degradation. In such situations, their ability to provide services can be depreciated. This reinforces the need for natural assets to be considered a key part of a community's asset management plan.

Provision of Multiple Service Benefits: Natural assets provide a wide array of ecosystem services, including carbon sequestration, recreation, and flood control. Furthermore, individual natural assets are capable of providing this array of benefits simultaneously. This is sometimes referred to as co-benefits or benefits stacking. The value proposition of leveraging natural assets to provide community services at lower costs than built assets is in part driven by their ability to simultaneously provide a range of services. While benefits stacking makes natural assets a compelling solution for community service delivery, it adds to the complexity of incorporating natural assets into an asset management plan in a consistent and useful way.

Long-term Benefits and Costs: Managing natural assets requires a long-term perspective due to their regenerative nature. While investments may not yield immediate returns, the benefits can be substantial in the form of ecosystem services, resilience against natural disasters, and enhanced quality of life. In fact, the value of some natural assets has been shown to appreciate in the face of climate change (MNAI, 2018). For example, wetlands may be able to handle extreme rainfall events thereby maintaining water quality and managing flood waters, making the assets more valuable in terms of their contribution to water management and disaster mitigation services.

Data Discrepancies: Unlike conventional assets, natural assets are often not well-documented or easily quantified. Collecting and maintaining accurate data on these assets can be challenging, requiring specialized knowledge and methods.

Jurisdictional Boundaries: Natural assets often do not align with political boundaries, and the services provided are often provided by natural assets outside municipal or governance boundaries (e.g., drinking water provided by headwaters located well outside a municipal boundary as is the case with Calgary). This can be a challenge for asset management, but also an opportunity for collaboration.

Multiple Landowners: Many of the natural assets that provide ecosystem services to a community are, at least in part, located on privately-owned land and not under a local government's direct control. Local governments must consider non-infrastructure solutions, such as policies, partnerships, stewardship programs, conservation easements or joint-management arrangements to achieve their desired levels of service for privately owned natural assets.

The Complexity of Natural Asset Management

The service delivery context for natural asset management will be different for each local government. It is important for local governments to build an understanding of their own service delivery context when starting natural asset management. This will support them in identifying the key services they deliver that rely on natural assets, and the priority risks to those services. For example, the Comox Valley Regional District (CVRD) in British Columbia is responsible for delivering water services to the Town of Comox, the City of Courtenay, and K'Omoks First Nation. The majority of the drinking water comes from Lake Comox and maintaining the health of the watershed is critical to protect water quality and manage treatment costs. The Village of Cumberland is a neighbouring local government in the same watershed, and the creek system that runs through and around Cumberland directly impacts health of the watershed; however, the Village has opted to manage its own drinking water services and mostly relies on groundwater as opposed to drawing from Lake Comox.

A big challenge for CVRD in providing water services is that it owns virtually none of the land in the watershed. A large majority of the land is owned by private forest companies; some is also owned by BC Parks. CVRD therefore needs to collaborate with all parties to manage water services effectively and sustainably. CVRD may need to tap into a whole suite of natural asset management activities to manage the costs and risks of water service delivery, including: working with all parties to collect and share data related to the ecological health of the watershed and ensure risks are managed; collaborating with neighbouring jurisdictions; supporting land stewardship programs or land securement (acquisition); and developing policies, covenants, or conservation easements to protect critical assets. To this end, CVRD chairs a watershed advisory group comprised of all relevant parties to sustain the health of the watershed.[2]

2 See *Comox Lake Watershed Protection Plan (updated 2022)*, Comox Valley Regional District.

Intrinsic Value: Natural assets possess an intrinsic value that goes beyond what can be captured economically. This concept recognizes that nature has a right to exist and flourish, underscoring a moral and ethical responsibility to protect and preserve natural resources for the sake of the environment and all living creatures, regardless of their tangible benefits to humanity.

Indigenous Perspectives: Indigenous Peoples have been living in close relationship with the natural world for thousands of years. Their knowledge, skills, and values about the environment are crucial for effective natural asset management. Incorporating natural assets into municipal asset planning can be a catalyst for reconciliation if it results in working toward shared stewardship and ensuring that the cultural significance of natural assets is recognized, respected, and preserved. Not only is this desirable, but also necessary in our evolving legal context. Local governments will have to address the reality that Indigenous peoples' inherent right of self-government and right to self-determination will affect the management of some land and natural assets currently under local government jurisdiction. For example, land may fall outside of local government control or under shared decision-making arrangements.

2 Establish the State of Natural Assets

This section summarizes the content that should be included in a **state of natural assets report**. The process can be described in five key steps:

1/ Define the scope
2/ Inventory natural assets
3/ Conduct and incorporate a condition assessment
4/ Establish replacement costs for natural assets
5/ Summarize the results in a state of natural assets report

Each step is explored in more detail below.

2.1 Define the Scope

The first step in documenting the state of natural assets is to **clearly define the scope of the inventory** by specifying:

1/ The assets to be included in the inventory
2/ The geographic boundary of the inventory

2.1.1 Scope the Assets

As articulated in *Section 1.1*, there is a spectrum of green infrastructure assets that may be included in an asset management plan. One of the first considerations is to **decide what asset types will be included in the management plan**.

This Guidebook focuses specifically on natural assets; however, it can be advantageous to consider if, how, and when to address other types of green infrastructure. Possible components to include in a green infrastructure asset management plan include the range of asset classes described in Table 1.

***Table 1:** Potential Asset Classes for Green Infrastructure Asset Management Planning*

ASSET CLASS	DESCRIPTION
Terrestrial Natural Assets	This asset class captures the natural feature-based areas (e.g., woodlands, grasslands, wetlands, meadows, etc.). Assets can be subdivided into more detailed classes that might further support the management of the asset or components of the asset (e.g., deciduous forest stand, mixed forest stand, coniferous forest stands).
Watercourse Natural Assets	This asset class captures linear natural aquatic features (e.g., rivers and streams).
Waterbody Natural Assets	This asset class captures non-linear aquatic features including lakes and ponds.
Groundwater or Aquifer Natural Assets	This asset class applies to municipalities that rely on groundwater as their source of drinking water supply.
Street and Park Tree Assets (Enhanced Green Infrastructure)	This asset class captures the individual street trees that are owned and managed by a local government. They are considered enhanced assets.
Manicured Open Space Assets (Enhanced Green Infrastructure)	This asset class captures pervious surfaces owned and managed by a local government that typically require a higher degree of management and maintenance (e.g., mown turf or other landscape features). They are considered enhanced assets and include, for instance: • Active use and sports field open space • Passive use open space • Other mown turf • Artificial beaches • City owned golf courses • Gardens
Low-impact Development (LID) Assets (Engineered or Enhanced Green Infrastructure)	This asset class captures engineered and enhanced assets related to LID such as: rain gardens, bioswales, permeable pavement, infiltration trenches, etc.

For the purpose of creating an asset management plan, grouping assets into the classes identified above can be useful for two reasons:

1/ The spatial data in a GIS (geographic information system) database varies by class. For instance, street and park trees are commonly represented as point features, watercourses are typically represented as linear features, and natural areas are typically represented as polygons.

2/ Each grouping has unique ways of dealing with the various aspects of asset management (e.g., replacement cost, useful life, operations, and maintenance planning, etc.).

Practitioners should also consider if natural assets or green infrastructure assets are already included in a local government's asset management plans. For example:

- Naturalized stormwater management ponds may already be captured in a stormwater asset management plan; or
- Manicured lawns, sports fields, and other turf features may already be captured in a parks and recreation asset management plan.

The class distinctions in Table 1 provide a relatively easy way to group most assets that might be considered natural or part of a community's overall green infrastructure. However, some natural assets might not clearly fit into these classes. For instance, natural stormwater ponds or constructed wetlands could fit the natural asset, waterbody asset, or LID asset classes. They may also fit more directly into a local government's stormwater asset management plan, in which case they can be left out of the natural asset management plan. Each local government will need to decide what the best structure is for their individual context. In general, asset management plans should be completed for groups of asset classes with the acknowledgment that some classes may be addressed in separate asset management plans. The ultimate objective is to ensure that all natural assets are captured in one or more relevant asset management plans and that no duplication of efforts exist (the same asset should not be captured in more than one plan). For instance, stormwater management ponds may be included in a stormwater asset management plan, and the naturalized area around the pond captured in the natural assets management plan. These assets deliver different services (stormwater management versus habitat, recreation, and urban cooling) and should thus be managed differently and according to the services they provide. For example, in the City of Saskatoon, the parks department is responsible for managing the area around naturalized stormwater ponds while Saskatoon Water monitors the stormwater services provided by the pond itself (e.g., storage capacity). Coordination between managing bodies will be required to ensure the full suite of assets are captured across the management plan(s).

2.1.2 Scope the Geographic Boundary

It is necessary to define the geographic boundary within which the natural assets are inventoried. This may be the jurisdictional boundary of the local government or some other geographic boundary. There are three main options for defining the geographic boundary for an asset management plan[3], namely:

1/ Focus on municipally owned natural assets;
2/ Include all natural assets within the municipal boundary (regardless of ownership); or
3/ Include the natural assets that provide a service to the community (e.g., the watershed boundary that provides drinking water services).

For Ontario municipalities to meet O. Reg 588/17, **the geographic scope needs to cover all municipally owned natural assets**. This represents a good baseline target scope for all local governments across Canada. However, there are several reasons to consider broadening the scope of the inventory to all natural assets within a municipal jurisdiction, including:

- Many services provided by natural assets result from a broader system of interconnected natural features within a jurisdiction.
- Some condition assessment metrics require information about lands that surround municipally owned natural assets (see *Section 2.3*).
- In many cases, the additional effort required to organize the information for all natural assets is minimal. It often requires the same GIS processing steps to include all natural assets within a municipal boundary as it does to restrict it to only municipally owned assets.
- Ownership of the assets can be an attribute built into the inventory to allow asset managers to focus in on the natural assets they have the most control over. In addition, when data is organized in this manner, a local government's stewardship and outreach activities can be strategically tied to asset management objectives.

For these reasons, a local government may wish to **inventory all the natural assets within their municipal boundary** regardless of ownership. Subsequent steps (i.e., establishing replacement costs, conducting the condition and risk assessments, and defining life cycle management strategies) can be focused on the municipally owned assets.

An alternative approach to scoping natural assets is to **define the boundary around the natural assets that deliver priority services, especially if those assets are high risk**. This could mean including natural assets that contribute to delivering stormwater management or drinking water provision, for example. These services are generally provided by the assets within a watershed or subwatershed that may exist well outside a municipality's jurisdiction.

3 See *Appendix A* for details on asset management in Ontario and the role of Conservation Authorities.

Taking this approach formally recognizes a community's dependence on other jurisdictions or landowners for sustained service flows over time, which can help establish cooperation and bilateral asset management agreements.

When capacity and resources are limited, it is recommended that local governments prioritize the assets they own and actively manage along with those that provide key services particularly when those assets are at risk of deterioration. **The scope of the asset management plan can be expanded over time to include assets not owned or directly managed by the local government.** For example, the condition of natural assets that are upstream of the local government and under the jurisdiction of another entity may have a profound effect on service delivery.

2.2 Inventory the Natural Assets

Establishing an inventory of natural assets is the second step of an asset management plan. The 2023 CSA standard provides excellent guidance on how to inventory natural assets. The creation of an inventory is a systematic and data-driven process, which is summarized here. There are five key steps to establishing an inventory of natural assets:[4]

1/ Obtain and review data
2/ Categorize assets and establish an asset hierarchy
3/ Construct a natural asset registry
4/ Identify other key attributes to incorporate into the inventory
5/ Develop inventory metadata

2.2.1 Obtain and Review Data

The first step, based on CSA (2023) is to determine the **best available source of land use and land cover data** from which to build the base natural asset inventory.[5] Available data should be identified and assessed to select that which will be most useful. Consider consulting with experts in ecology, environmental science, and local rightsholders to ensure the most appropriate data is identified and selected.

When choosing the best available data, keep in mind that GIS is necessary to delineate the natural assets. While an asset inventory can be completed in table (or spreadsheet) form, establishing a spatially based database in GIS enables the visualization of assets' spatial distribution and can be essential when exploring relationships with other infrastructure, conditions, and risks. Integrating the natural asset inventory into a GIS system can also streamline ongoing monitoring, analysis, and inventory revisions. Also consider that the

4 These steps provide additional information, guidance, and generally expand on sections *5.3 (data gathering)* and *5.4 (delineating natural assets)* of the CSA standard (CSA 2023).

5 If data is not available, a local government may choose to collect the data needed to inform the asset inventory.

spatial data should be relatively easy to update as the natural assets change over time.

The best available data can vary significantly from community to community. Table 2 provides a general checklist of the types of data that might be useful when establishing a natural asset inventory. Note that most of the data listed in Table 2 is considered optional. These data types are ones that have been found to be useful under different circumstances. Furthermore, Table 2 should not be considered a definitive list. Local governments might have access to other data not listed here that may also be beneficial. The overall goal is to centrally organize the relevant information to help improve the management of the natural assets.

Table 2: *Potentially Relevant Types of Data to Support a Natural Asset Inventory and Condition Assessment*

DATA TYPES	IMPORTANCE	DESCRIPTION AND POTENTIAL USE
Land Cover Classification	Essential	Land cover data is a pre-requisite for establishing a natural asset inventory. Spatial boundaries of the natural land covers will form the boundaries of natural assets.
Orthophotography	Optional	While not critical, this information can be a very helpful reference for a wide range of tasks associated with creating an inventory and condition assessment. It can support general refinements to land cover data or verify information such as extent of asset boundaries or natural asset types. In the absence of a pre-existing land cover data set, one could be established through interpretation of orthophotography.
Land ownership	Essential / Optional	Geographic boundaries of publicly owned and managed lands will be essential for scoping natural assets to only those owned or managed by the local government. Other ownership data is optional but is a very helpful attribute to include if the inventory intends to include all relevant natural assets.
Sub/Watershed boundaries	Optional	Can be a useful attribute to assign to individual assets.
Forest canopy	Optional	Canopy cover can be a useful inventory attribute to assign to individual assets (e.g., percent of canopy cover within each asset). This information might support condition metrics.
Designated land use planning areas	Optional	Can be a useful inventory attribute to assign to individual assets. For instance, some local governments have certain natural areas with special designations that limit or restrict development (e.g., natural heritage systems, greenway, greenbelts, environmental reserve, etc.).

DATA TYPES	IMPORTANCE	DESCRIPTION AND POTENTIAL USE
Park-level plans, data, and studies	Optional, Resources for reference	If a local community has completed any detailed park or natural area plans or completed other research/studies, such information can be used as reference or source material. This could be particularly useful for developing condition metrics.
Road network	Optional	Can be useful supporting information to help refining land cover data. For instance, if road networks have not been incorporated in the land cover data it might be advantageous to split any natural assets that are separated by the road network, as road proximity has direct impacts on a natural asset's condition and performance. Alternatively, it could help support a desktop-based condition assessment (if one is being completed).
Trails, recreation sites and other built assets that intersect with natural assets	Optional	Can be a useful attribute to assign to individual assets. In some cases, a local government may wish to clip out the footprint of any built assets located within a defined natural asset boundary to have a more accurate area calculation. It could also support a desktop-based condition assessment (if one is being completed).
Elevation	Optional	Can be a useful attribute to assign to individual assets, or to have as a separate data layer. This information can also help define and classify the specific conditions of each asset.
Soil type / erosion sites	Optional	Can be a useful attribute to assign individual assets, or to have as separate data layer. This information can also help define and classify the specific conditions of each asset.
Any existing monitoring data	Optional	For example, any monitoring data related to invasive species, species at risk, or other general condition information. This can be helpful in establishing condition metrics for natural assets. To the extent relevant, linking any monitoring data to the natural asset inventory can help build a more robust asset management data infrastructure.

Depending on the scope of the natural asset inventory (see *Section 2.1*), different data may be available for different components of the inventory. For example, if the inventory includes privately owned assets, there may be less data readily available to depict such assets and their associated attributes. In cases where privately owned assets are included in the inventory, data limitations may mean that these assets are excluded from condition, risk, and levels of service assessments.

The minimum data required to establish a natural asset inventory is a sufficiently current land use and land cover (LULC) dataset that covers the municipally owned properties. What qualifies as "sufficiently current" will depend on the pace of development within a municipality. Ideally, LULC data is less than five years old. In communities with a lower rate of land use change, older LULC data may suitable.

Some communities may not have any LULC data available. In this situation, communities can look to national or remote sensing-based data. Examples of data sources are noted in Table 3. Practitioners should refer to federal and provincial open data portals for additional datasets. In the absence of current detailed LULC data a decision may be required to either:

- Use lower resolution data;
- Use older data; or
- Invest in specialized LULC mapping.

Table 3: LULC Datasets That Could be Useful for Communities with Limited Access to Detailed Current Data

DATASET	DESCRIPTION	SPATIAL COVERAGE
Land Cover Classification	A remote sense LULC data set produced annually by Agricultural and Agri-food Canada (AAFC). Its primary purpose is to provide a national agricultural crop inventory. However, it does include other land cover features that could help establish a basic natural asset inventory.[6]	Covers most of southern Canada.
Orthophotography	High-resolution, open, and comparable land use data provided by ESRI.[7]	Complete coverage across Canada.
Land ownership	Most provinces and territories maintain some form of LULC data. Examples include: • ABMI Wall-to-Wall Land Cover Inventory of Alberta • Saskatchewan Prairie Landscape Inventory (PLI) • British Columbia Vegetation Resource Inventory (VRI) • Southern Ontario Land Resource Information System (SOLRIS) • Manitoba Land Use and Development Web Application • Southern Quebec Land Accounts and Interactive map, 2023 Edition • Nova Scotia Topographic Database (NSTDB) • Newfoundland and Labrador Land Use Atlas (LUA) • New Brunswick GeoNB Map Viewer • Prince Edward Island Maps, Aerial Photography and Land Use Information	Typically covers provincial or territorial boundaries, or strategic portions of the jurisdictional boundary.

6 See *open.canada.ca/en/apps/aafc-crop-inventory*
7 See *livingatlas.arcgis.com/landcover/*

In some cases, it may be necessary to use more than one LULC dataset to capture all natural assets. In such cases a data hierarchy should be established where the best available data takes priority in the creation of the inventory and any data gaps are fill by the second and third priority datasets as needed.

2.2.2 Categorize Natural Assets and Establish an Asset Hierarchy

As noted at the outset of this section, the natural asset inventory should seek to align with the CSA standard for natural asset inventories.

Natural assets should be categorized based on their type and function. Consider using a standardized classification system most relevant to the local government. For instance:

- In southern Ontario the *Ecological Land Classification System for Southern Ontario* (Lee et al., 1998) is commonly used. Outside of southern Ontario, the broader Provincial Ontario *Ecological Land Classification System*[8] may be suitable.
- In British Columbia, the *Terrestrial Ecosystem Mapping*[9] is commonly used.
- In New Brunswick, the *Ecological Land Classification*[10] contains ecosites and ecoelements that capture and detail individual landforms.

The asset hierarchy defines the relationship between asset classes, asset types, and asset components. The hierarchy should align with the asset classification system. Focusing on natural assets, Table 4 provides a sample hierarchy. At the top of the hierarchy the asset class is natural assets. The asset class is subdivided in different **asset types** that distinguish unique natural features (e.g., forest, wetlands, or grasslands). Asset types can be further differentiated by **asset components** to the degree that existing data and management needs require this level of detail. For most asset management applications, the natural asset type is likely to be sufficient to support the asset management planning process. However, to the extent that more component level details exist, they can be useful attributes to build into the data structure of an inventory.

8 *www.ontario.ca/page/ecological-land-classification*

9 *www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/ecosystems/tei-standards*

10 *www.snb.ca/geonb1/e/DC/Ecosite.asp*

Table 4: Sample Asset Hierarchy

ASSET CLASS	ASSET TYPE	COMPONENTS
Natural Assets	Forest	Coniferous Forest
		Deciduous Forest
		Mixed Forest
	Wetland	Swamp
		Marsh
		Bog
		Peatland
		Fen
	Grassland	Tallgrass Prairie
		Savanah
		Fescue Grasslands

EXAMPLES OF USE OF ASSET COMPONENTS IN A NATURAL ASSET INVENTORY

In some cases, including asset components in a natural asset inventory may help to track levels of service and inform investment decisions when the desired services depend on a specific asset component. For example, peatlands (as a component of wetlands) store a significant amount of carbon and a local government may wish to prioritize protection of peatlands to help meet climate change goals. For forests, some examples are the Coastal Douglas-fir or Garry Oak ecosystems on Vancouver Island, which may require special protections and management.

Note that the sample in Table 4 is provided for general reference, not as a prescriptive guide. For instance, some local governments might prefer to have swamps classified as forest, or perhaps as their own lowland forest asset type. Local governments should consider their unique circumstances, available data, and overall asset management objectives to determine a classification hierarchy that best suits their needs. Finally, the hierarchy structure can be adjusted overtime as needs, objectives, and data availability evolve.

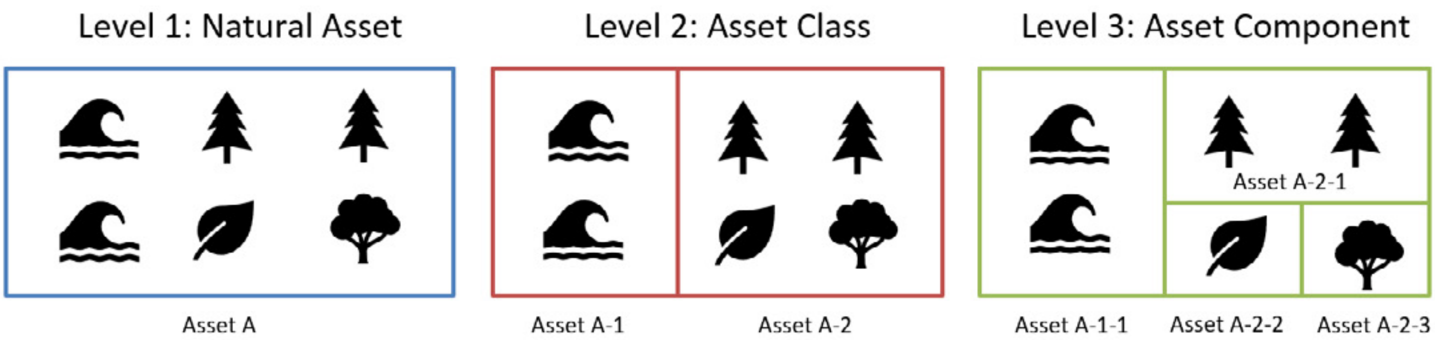
Ultimately, the asset categorization and hierarchy should be based on the best available land cover data. Establish the hierarchy by considering the range of asset types and components needed to support asset management decisions and the degree to which those components can be captured with the spatial data available. Note that it is not necessary to have three or more levels to the asset hierarchy. Each local government should assess and identify the best available (i.e., most current and accurate) LULC data and should not be deterred by data limitations. **There are options to use data from provincial or federal**

sources and to combine data from numerous sources to get the best possible depiction of natural assets where local data is limited. The objective is to get a complete picture of the location and extent of natural assets present within the geographic boundary under consideration. For example, at a minimum the inventory needs to define the location and extent of each natural asset type; lack of information on the component (e.g., type of wetland or tree species in the forest) does not negate the value of the inventory.

One of the key challenges when building a natural asset inventory is deciding what the boundaries of each individual asset should be. There is no one correct way to proceed on this. To some degree it will depend on the structure of available land cover data. For instance, if using remote sensing data such as the *Annual Crop Inventory or the Sentinel-2 10-Meter Land Use/Land Cover*, the options will be more limited. These tend to be raster datasets that do not lend themselves well to defining assets at a detailed level. On the other hand, if vector-based data like the *Ecological Land Classification System for Southern Ontario, or British Columbia's Terrestrial Ecosystem Mapping* is available, each individual asset can be defined as the continuous area of the same land cover type. For instance, using the Table 4 example, adjacent areas of coniferous, deciduous, and mix forests can be combined into a single 'forest' asset. A similar approach can be applied to wetlands and grasslands. This is typically a good level of detail to support asset management planning. In some cases, it may also be worth considering a higher order aggregation that combines all adjacent areas of forest, wetlands, and grasslands into a single 'natural' asset boundary. Whether assets are defined at the "asset type" level, the "asset class" level, or both depends on what data is available and how the data will be used.

Regardless of the level of detail at which a natural asset is defined (i.e., natural area, forest area, area of specific tree species), a well-defined, unique identification (ID) for each asset should be used to organize the levels of aggregation within a single dataset. *Figure 2* provides a possible approach for aggregating the spatial data and assigning unique IDs. In the figure the boxes represent areas of land. At Level 1, the asset is defined as a continuous area of natural land cover (regardless of the landcover type) in this case comprised of a combination of water and forest assets. The unique asset ID is Asset A. At Level 2, the asset is defined as a continuous area of the same landcover type. Here a distinction is made between the area that is comprised of water assets (Asset A-1) and the area that is comprised for forest assets (Asset A-2). The forest assets in Level 2 are further divided in Level 3 where they are defined as continuous areas of the same tree species with each area of the same species receiving a unique ID (Asset A-2-1, Asset A-2 and Asset A-2-3).

Figure 2: Sample Approach for Aggregating Spatial Data and Assigning Unique IDs



2.2.3 Construct a Natural Asset Registry

A natural asset registry is simply the IT infrastructure that houses the natural asset inventory. Given the nature of natural assets, a GIS environment or a geospatial database is typically the most effective way to organize and house the inventory. Natural asset registries are generally structured such that each individual asset has a unique (ID) and is represented as a row in the registry database. A series of columns in the registry house attributes assigned to the various assets.

2.2.4 Identify Key Attributes to Incorporate into the Inventory

The columns in the asset inventory can contain a wide array of attributes which categorize and describe the assets. These attributes typically capture important components of land use, ownership, or other environmental features that can be useful when managing natural assets. **At a minimum, the inventory should include attributes for the following:**

- Type (e.g., forest, wetland, grassland)
- Quantity (area or length)
- Location

Other high priority attributes include condition, risk, and ownership. Ownership is particularly important if natural assets have been scoped to include all natural assets within a municipal jurisdiction rather than just those owned/managed by the local government. In such cases it is essential to indicate which assets are under municipal control or ownership. Watershed or subwatershed boundaries may also be relevant. These boundaries can be used to identify which watershed, subwatershed, or stormwater catchment each natural asset is located in. If spatial geometries do not align with the boundaries of natural assets, consider using summaries or defining assets by the catchment they are located it.

More advanced attributes can also be incorporated into the natural asset inventory. This might include planning designations, park management zones, areas for restoration, or locations of archeological sites. Each local government can incorporate a range of attributes deemed useful for understanding and managing the associated natural assets.

When incorporating attribute information into a natural asset inventory there are a couple ways to proceed. The GIS dataset files may contain a range of information of varying degrees of relevance for the natural asset inventory. Using the merge function (in GIS) to incorporate this information into a single natural asset inventory can result in natural assets being divided (or split) into numerous small components. It is best to avoid splitting assets in this manner. However, there are cases where doing so can be appropriate. For instance, in cases like watershed boundaries where splitting a single forest asset by the watershed boundary might be useful from a hydrological function perspective. Instead of merging information, using the summarize function (in GIS) can be an effective way to pull important information into the inventory.

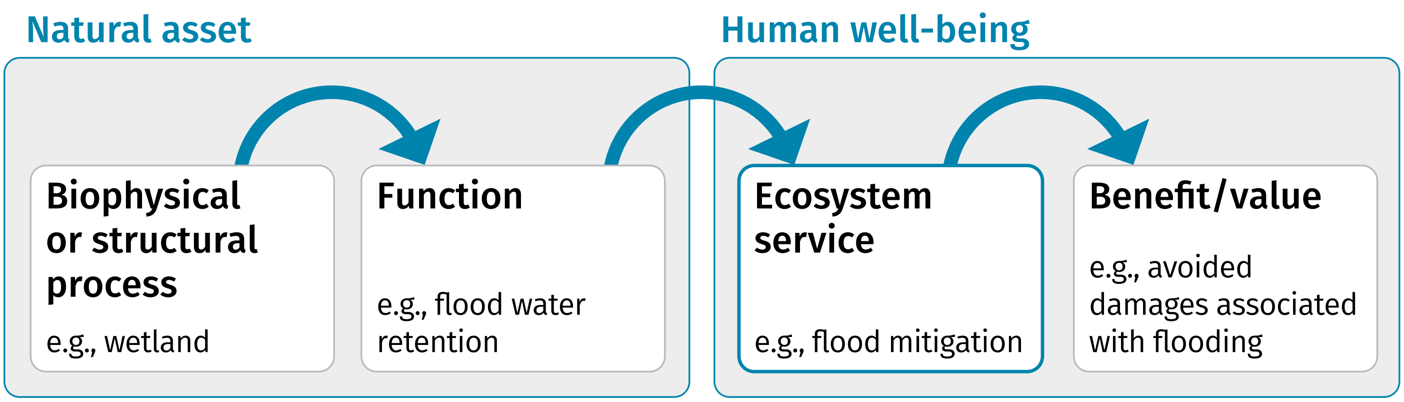
2.2.5 Develop Inventory Metadata

The last step of establishing an inventory is to document key information, assumptions, data processing steps, and data definitions related to each natural asset and the various attributes captured in the inventory. The goal of this documentation should be to ensure that the inventory can be replicated, if necessary, and easily updated and refined over time. Documentation can be in the form of spreadsheets, GIS databases, or other report based metadata.

2.3 Assess the Condition of the Natural Assets

The objective of the condition assessment is to conduct a high-level evaluation of each natural asset's ability to provide services. This approach draws on the cascade model summarized in CSA (2023) that demonstrates the linkage between biophysical structure, process, and function and human well-being (see *Figure 3*). Condition metrics that capture ecological condition can be assumed to translate into ecosystem services and values to the community. The underlying assumption is that a natural asset that is assessed as being in "good" condition from an ecological perspective has a greater likelihood of providing a "good" level of ecological services, which are further assumed to be of value to the community.

Figure 3: Illustration of the Linkage Between a Natural Asset, the Ecosystem Services Provided, and the Benefits and Values that Flow to End Users (Source: CSA, 2023)



> Natural assets should be assessed for condition based on in situ inspection, which in the case of natural features requires field assessments of ecosystem components and their functions (e.g., vegetation type and cover, species composition and structure, wildlife use).

The implication for natural asset management is that a condition assessment can focus on the ecological condition of the natural area under consideration. Ultimately, the goal of the condition assessment is to generate information that natural asset managers can use (along with risk information) to inform and prioritize management and restoration actions. There are a number of different ways to approach this, and to date there is no standard approach to doing so. How each local government proceeds will largely depend on available data and capacity.

Ideally, natural assets should be assessed for condition based on in situ inspection, which in the case of natural features requires field assessments of ecosystem components and their functions. While this approach can be detailed and resource intensive, it does not have to be. Condition can be assessed using field-based inspections that require few field staff. Furthermore, asset management plans are typically only updated once every five years, so there is no need to assess each natural asset every year. A five-year rotation cycle can be established where only a portion of the local government's assets are assessed each year. Summer students with a basic understanding of ecology and some on-the-job training can be utilized to collect the necessary information. The key to this approach is establishing a suitable assessment protocol. For example, Credit Valley Conservation Authority in Ontario has been working on developing a Rapid Inventory and Condition Assessment Method (RICAM) that can support this type of approach.[11] Once a local government has established a suitable protocol that has been vetted through local ecological experts, operationalizing

11 Koveshnikova, T. Personal communication, November 7, 2023.

a regular assessment pattern can be feasible, though conducting regular condition assessments of assets that have not have been monitored before will have some budget implications.

It should also be noted that this type of condition assessment would primarily apply to publicly owned and managed properties. If the natural asset inventory includes a broader range of assets, it is completely acceptable to focus condition assessments on those assets owned or managed by the local government.

It may take some time for a local government to determine a useful protocol, which can also be further limited by the capacity available to some communities. A temporary alternative to field-based condition assessments is to establish a series of high-level condition metrics based on landscape ecology principles and science; a synthesis of available desktop data; and, an understanding of the community's biophysical context. Such assessments serve as a starting point that is consistent with an asset management framework. This approach can also be used to fill gaps in the condition data for local governments working on tracking all public and privately owned natural assets.

If using a desktop-based approach, local governments should consider using a minimum of three to five condition indicators grounded in established landscape ecology. Condition indicators that consider key landscape ecology principles can provide an indication on the function and health of natural assets. For example, condition indicators can be framed around measures such as:

- Species richness and diversity
- Patch size and shape
- Interior habitat
- Edge-to-area ratio
- Connectivity of assets across the landscape
- Presence of riparian areas
- Stream/river shading

Annex B in the 2023 CSA standard provides some general guidance and examples of condition criteria, indicators, metrics, and measures (see *Table 5*).

***Table 5:** Examples of Criteria, Indicators, Measures, and Metrics for Forest Condition*[12]

NATURAL ASSET	CRITERIA	INDICATOR	MEASURE	METRIC
Forest (contiguous area, patch, or stand)	Landscape context	Relative asset size	Size of natural asset relative to other natural assets within the inventory	Percentile rank of natural asset area
		Landscape connectivity	Linear road density within a buffer around the natural asset	Kilometre of road per square kilometre of area
	Physical context	Patch size	Percent interior forest area	Interior area divided by total area of asset
		Fragmentation	Density of linear features within the natural asset, including roads and trails	Kilometre per square kilometre of linear features
	Ecological context	Structural diversity	Tree species diversity	Total number of overstory tree species in a given stand
		Species diversity	Invasive species	Percentage of invasive species
			Native species	Percentage of native species

Finally, for some local governments it may not be possible to implement either approach. In such situations, the condition of the assets can be addressed qualitatively within the natural asset management plan. Relying on local expert knowledge, the plan can note specific areas known to have poorer conditions or be in need of specific management actions. This can be as simple as noting or flagging known problem areas, or it can be more involved where specific assets are rated on a simple scale such as:

- **Good –** no immediate management actions needed
- **Fair –** should be considered for management actions
- **Poor –** known area that needs management attention

12 Source: *CSA W218:23 Specifications for Natural Asset Inventories, Annex B.*

Having objective measures of ecological condition is preferred. However, it is recognized that not all local governments have the financial resources or staff capacity to do this level of assessment. In such situations, a more qualitative approach to condition maybe an acceptable short-term action while local governments build their asset management capacity. Table 6 summarizes the three general approaches to establishing a condition assessment.

Table 6: Comparison of Condition Assessments Approaches

FIELD-BASED ASSESSMENT	DESKTOP ASSESSMENT	QUALITATIVE ASSESSMENT
Uses field surveys and monitoring programs to gather data on natural asset condition.	Relies on principles of landscape ecology to establish condition metrics that can be assessed remotely, provided sufficient data on the natural assets are available.	Relies on local knowledge and expertise to identify or rate natural assets that are in need of management actions.

Regardless of the approach taken, outcome of the condition assessment should be the establishment of a condition score for natural assets that aligns with the condition approach the local government is using as part of their asset management program. In Annex B of CSA (2023), a sample rating scale with definitions is provided and included here (Table 7) for reference. As noted above, a qualitative approach may result in a more simplistic rating scale. However, the general objective remains the same.

Table 7: Sample condition rating scale definitions (Source: CSA (2023)

RATING	EXPLANATION
Very Good	Well-maintained, good condition, no signs of deterioration in ecological conditions. Natural asset service provision is high.
Good	Ecological conditions appear to be sufficient; some minor localized (or isolated) impacts noticeable, which might be a warning sign of possible decline. Natural asset service provision is acceptable.
Fair	Clear signs of deterioration in ecological function and service-influencing factors. Natural asset service provision, while still functional, is at risk of failing.
Poor	Condition is below standard with large portion(s) of the system exhibiting significant deterioration in ecological function. Natural asset service provision is impacted, and some services might be non-functioning.
Very Poor	Widespread signs of advanced deterioration; unlikely that the natural asset is providing any functional service.

TIP: Before embarking on developing a specific condition assessment process, consider what work is already being done to understand the ecological conditions of natural areas. Many local governments are already doing similar work that is simply not framed in asset management terms. For instance, the City of Barrie in Ontario has undertaken forest health assessments. The results provide an indication of condition for woodlots. Their facilities, parks, and outdoor recreation asset management plan (2023) noted that this program can be adapted to inform condition ratings more directly for asset management purposes.[13] Local governments can also draw on the knowledge of condition documented by local experts in the community, such as Indigenous communities, community groups, non-profit organizations, local environmental organizations, universities, colleges and Conservation Authorities.

How the ratings are established and allocated to specific assets is flexible. Regardless of in-field or desktop-based assessments, it will be important to engage local ecological experts to help define the specific conditions that equate to each rating score to ensure condition ratings are appropriate and the scoring acceptably aligns with landscape ecological principles. While the specific conditions are likely to vary based on local context, existing guidelines can help inform the categorization of the condition indicators such as Environment Canada's *How Much Habitat is Enough*.[14]

2.4 Establish Replacement Costs for the Natural Assets

In the context of asset management, a replacement cost is intended to measure the cost of replacing an asset. For natural assets, this can be more challenging since natural assets owned or managed by a local government are not generally purchased or constructed. As a result, natural assets are unlikely to have any historical or capital construction costs. Furthermore, once lost, many natural assets cannot actually be replaced in an ecologically meaningful sense, or fully restored in relevant timeframes — their intrinsic values are inherently irreplaceable. However, some natural assets can sometimes be restored when significantly degraded or lost.[15]

Therefore, replacement costs for some natural assets can be based on an anticipated best estimate of what it would cost to restore the natural asset (e.g., forest, wetland, native grassland) if it was in a highly degraded state or create the natural asset if it was lost (e.g., cleared for agriculture). In either case, the

13 See SLBC (2023). Asset Management Plan for Facilities, Parks, and Outdoor Recreation. City of Barrie.

14 Bryan, G., & Henshaw, B (2013). See *publications.gc.ca/site/eng/9.652667/publication.html*

15 Ecological restoration is the process of repairing disturbed or degraded ecosystems. It aims to repair an existing natural area's structure, function, and composition returning it to a more undisturbed state. The term naturalization is also sometimes used in an urban context which involves planting trees and shrubs to restore cleared land to a natural state.

cost of afforestation can be used as a proxy for the replacement cost. However, the approximate nature of this estimate, its potential lack of suitability to some cases where restoration cannot be achieved (e.g. a contaminated aquifer), and the fact that restoration may not restore pre-existing biodiversity and connectivity, must be emphasized.

At a basic level, an average restoration cost can be estimated based on the natural asset type. For instance, if the average cost to restore 1 hectare (ha) of forest is $X, then a 5 ha forest asset can be applied a replacement cost of $5X. For this basic level, average replacement costs can be based on high-level estimates from credible sources.

At a more advanced level, average replacement costs can be based on credible sources such as historical restoration costs from comparable local projects, or estimated based on the specific work anticipated to restore the natural asset as determined by restoration and naturalization specialists. These costs can also be 'appreciated' using forest age or basal area. This helps account for the many years it will take a newly-planted forest to achieve 'like for like' levels of service with an older forest. Cost estimates should consider:

- Restoration planning
- Site preparation
- Labour
- Plant and materials
- Equipment
- Maintenance and monitoring

Average restoration costs vary depending on the natural asset type; it can be useful to organize restoration cost data around the asset hierarchy. For instance, replacement cost at the asset type level should be sufficient for basic estimates (e.g., forest, wetlands, grasslands, etc.). More advanced approaches might consider specifying unique values to replace the different asset components (e.g., coniferous forest, deciduous forest, marsh, bog, etc.).

If restoration costs are not readily available, there are numerous government and non-government organizations that specialize in natural feature restoration and naturalization that may have data or expertise to help (e.g., Conservation Authorities in Ontario, Ducks Unlimited Canada, etc.). See *Appendix D* for guidance from a Conservation Authority perspective. In the absence of locally available restoration costs, it may be possible to find average costs in the literature (see Kimball et al., 2015 or Zentner et al., 2003).

While approximating replacement costs is useful for informing and prioritizing natural asset management, it is imperative to recognize that:

(a) Some natural features and functions may be irreplaceable, meaning when the natural assets are lost, some ecosystem services will be lost forever; therefore, any replacement cost for such assets would be an underestimate.

(b) In cases where natural features and functions can be reasonably restored through restoration and naturalization practices, it may take many years, or decades, for a restored or constructed natural asset to provide the same level of service as the original undisturbed natural feature.[16]

(c) Not all natural assets deliver the same type or number of services, so a loss of assets in one location is unlikely to be compensated for with restoration or protection of natural assets in another location.

Replacement Cost of the Asset Versus the Service

There is an important distinction to be made between using a replacement cost approach to measure a service value (**e.g., estimating the cost to replace stormwater services provided by a forest**) and establishing the replacement of a specific asset (**e.g., estimating the cost to restore a forest**). As noted above, for the purpose of establishing a replacement cost for a state of the natural assets report, the replacement cost should focus on what it would cost to replace the asset itself (**e.g., the forest**). This is fundamentally different than the cost of replacing the service. Estimating the replacement cost of a natural assets service (**e.g., stormwater service**) can be very useful in demonstrating the importance of natural assets to a community. It can be a powerful message to articulate the financial liability a local government is exposed to if natural assets are not properly monitored, protected, and managed. However, **service** values should not be positioned as the replacement cost of the natural asset (**e.g., the forest**) **for the purposes of a natural asset management plan**.

Note that a valuation of a single service provided by natural assets, such as stormwater services provided, does not account for the value of all other ecosystem services and benefits the assets provide to the community. For example, the Grindstone Creek Watershed in Ontario is estimated to provide over $2 billion in stormwater services in terms of the value of engineered infrastructure replacements, not including operational costs. The watershed also provides an annual service value of approximately $34 million in co-benefits, including recreation, erosion control, habitat biodiversity, atmospheric regulation, and climate mitigation (MNAI, 2022).

In summary, replacement costs should generally be understood as a low-end and incomplete estimate.

16 This concern can be somewhat addressed using the basal area method mentioned above.

2.5 Document the State of Natural Assets

The final step is to summarize the results in a state of natural assets report. The level of detail can vary based on each local governments' natural asset management objectives and scope. For local governments that are unsure of how and where to start, some examples and ideas of what to summarize in a state of natural assets report include:

- Map of natural assets
  - By asset type
  - By condition score
  - By replacement cost
- Table and chart demonstrating area (and/or percent) of each asset type or asset component
- Condition ratings
  - Area of asset types by condition rating for each condition metric used
  - Area of asset types by condition rating based on a combined overall condition rating
  - Percent of each asset type by their condition rating
- Replacement costs of assets
  - Replacement cost by asset type differentiating between the cost of replacing forests, grasslands, wetlands, and meadows, for example (cost per hectare and total cost)
  - Replacement cost of asset by condition rating showing the cost of replacing the sub-set of assets in poor and/or very poor condition

3 Levels of Service

Natural assets provide a wide array of ecosystem services to a community. As noted, ecosystem services help local governments to manage the costs of and risks to service delivery. For instance, natural areas have pervious surfaces and subsurface soil structures that allow the infiltration of water and hence reduce the amount and speed of surface water runoff thereby reducing the overall burden on a local government's stormwater management infrastructure and helping to avoid or minimize flooding.

> Ecosystem services are aspects of ecosystems that provide benefits to people, which may be outcomes of a municipal service that protects the environment (i.e., air quality, biodiversity, habitat, pollination, carbon storage, cooling, shading, temperature regulation, water quality, etc.). **Source:** *Asset Management BC Community of Practice, LOS template.*

A key aspect of asset management planning is to assess the levels of service (LOS) that assets provide and define expected, or desired LOS that balance the LOS provided with risk and lifecycle management costs. O. Reg 588/17 requires risks be considered when assessing the costs to maintain current, or achieve target, LOS.

This section explores how LOS can be defined for natural assets and provides options for local governments to consider risks in the context of managing LOS. It can be read in conjunction with the NAI guidance on this topic.[17]

3.1 What are Levels of Service?[18]

LOS are objectives and performance measures that define the expected performance of assets and related services. They are an essential pillar of asset management. They represent the service delivery commitment of a local government, inform asset management and financial plans, and help local governments to prioritize capital and operational spending decisions.

Defining LOS enables local governments to link strategic organizational objectives with technical and operational requirements of infrastructure management, and is a way to steer a local government towards optimal investments.

17 See Defining Levels of Service for Natural Assets (2022) at *mnai.ca/media/2022/01/MNAI-Levels-of-Service-Neptis.pdf*

18 This explanation of levels of service draws heavily on the Institute of Public Works Australasia's globally acclaimed *International Infrastructure Management Manual*, which is aligned with the ISO 55000 Asset Management Standards.

It is the responsibility of a local government's council to approve and monitor progress on LOS. Doing so enables them to be transparent and accountable for their decisions regarding service delivery. When LOS are well-documented in asset management plans, councils are better able to communicate the social, environmental, and financial impacts of improving or reducing services and engage the community on their 'willingness to pay' for changes in service levels. If councils choose not to fully fund their asset management plans, then staff are able to communicate the costs and risks of failing to achieve the desired LOS documented in the plans.

3.2 Types of Level of Service Measures

There are two main types of LOS that, taken together, show how day-to-day operational activities for infrastructure will align with and support a local government's strategic objectives. Specifically, there are community[19] and technical LOS, described below. *Figure 4* provides some examples.

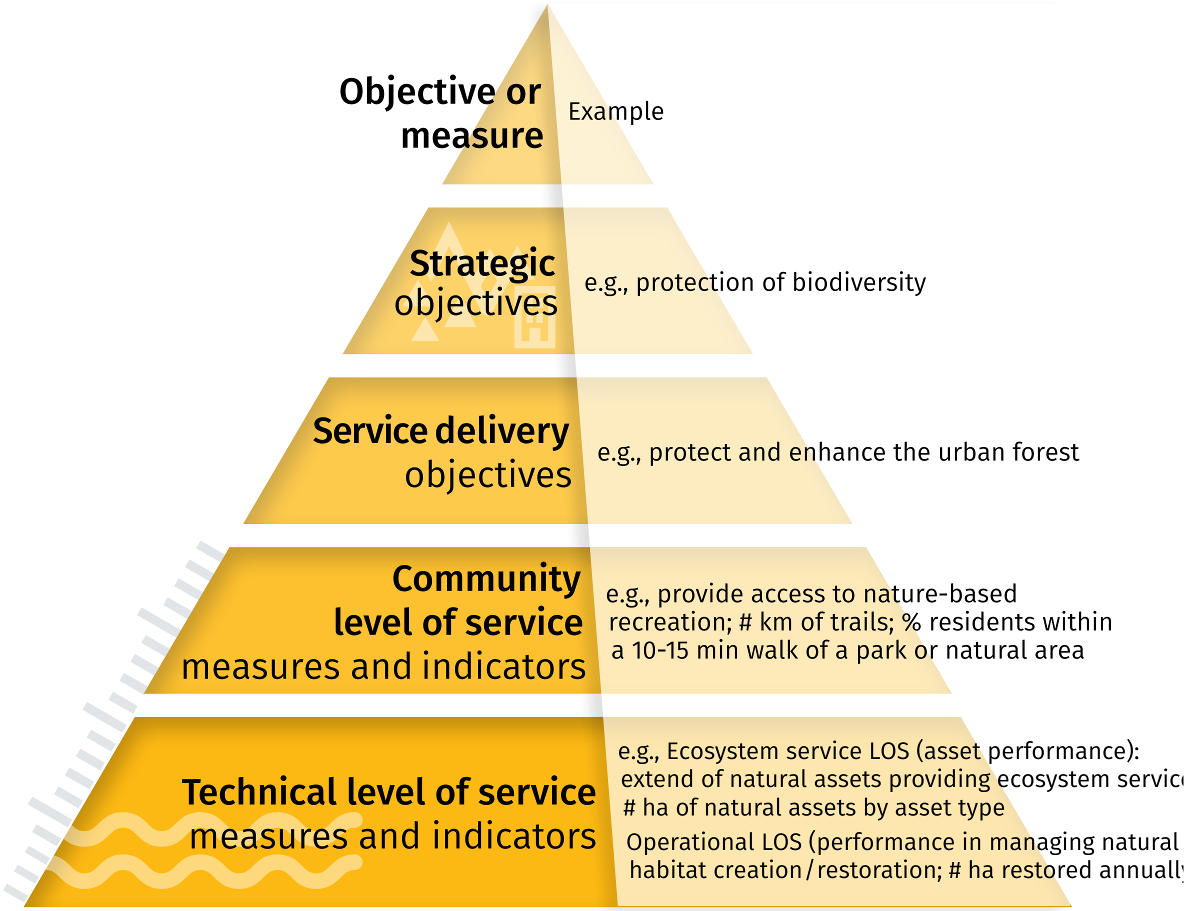
1/ **Community LOS Measures and Indicators:** These are performance measures that describe the service the community should expect to receive, expressed in terms that make sense to them. These measures usually refer to specific aspects of the service such as its accessibility to the community, its capacity to meet the community's expectations, its reliability, its safety, etc.

2/ **Technical LOS Measures and Indicators:** These are performance measures that describe the performance of the asset in relation to the service, or the operational requirements to manage the assets such that they achieve the expected LOS. In the case of natural assets, technical LOS related to asset performance focus on the ability of natural assets to provide ecosystem services to the community.

Knowledge about the ecosystem services that natural assets provide is needed to determine some technical LOS. For example, local governments may wish to assess the degrees of heat reduction contributed by natural assets, tonnes of carbon sequestered, or their ability to store water or provide habitat for flora and fauna. When local governments build an understanding of the current LOS natural assets provide for ecosystem services of interest to them, they will be able to define the expected or desired LOS they aim to achieve through natural asset management (e.g., how much to grow the urban forest, where to focus restoration efforts, what natural areas to conserve or protect, etc.).

19 Also referred to as customer LOS in standard asset management practices. Some local governments prefer not to identify the community as customers of a service, and therefore use the term community LOS instead.

Figure 4: Hierarchy of Decision-Making in a Local Government as it Relates to Level of Service Measures



***Source**: Adapted from Developing Levels of Service for Natural Assets: A Guidebook for Local Governments (NAI, 2022).*

3.3 Why Develop Levels of Service for Natural Assets?

When local governments develop LOS for natural assets, it helps ensure that:

- Natural assets' role in service delivery is recognized and there is accountability for their management.
- Lifecycle management activities (e.g., monitoring, maintenance, restoration) are included in budgets and long-term financial plans.
- Progress on natural asset management informs continuous improvement objectives to protect and manage natural assets when strategic plans and policies, including land use plans, are updated.
- The multiple services provided by natural assets are understood, which helps build a business case for their protection.

3.4 Steps to Establishing Levels of Service for Natural Assets

There are four steps to establishing LOS measures for natural assets. They are: **1)** prioritize which natural asset services to manage; **2)** define service delivery objectives for natural assets [corporate LOS]; **3)** scope community and technical LOS measures; and **4)** define community and technical LOS measures and indicators. Each of these steps is described in detail below. The subsequent section of this report considers how to incorporate risk into the LOS framework.

3.4.1 Step 1 – Prioritize which Natural Asset Services to Manage

The first step to establish LOS measures for natural assets is to identify the services the assets provide that are relevant to the local government. Different natural assets will provide different services and many natural assets will provide multiple services.[20]

The natural asset inventory demonstrates the spatial distribution of the natural assets and will help inform which services natural assets are delivering to the community. For example, urban forests can reduce urban heat, improve air quality, and provide aesthetic benefits for residents. Forest complexes will provide opportunities for nearby residents to realize social and cultural gains, recreation, and water retention and filtration. The expert opinion of staff and local conservation/nature groups can be useful to identify the services provided by natural assets; Some commonly identified services relevant to local governments are briefly described below (note this list is not exhaustive).

Stormwater management (core municipal service) — Natural assets can play an important role in stormwater management. Wetlands and riparian vegetation, for example, can be very effective in storing water, controlling peak flows, supporting groundwater recharge, and controlling erosion.

Drinking water management (core municipal service) — Natural assets play a role in the provision of drinking water. They are effective at storing and filtering water both in the context of ground or surface water supply.

Recreation (municipal service/co-benefit) — Recreational opportunities help to foster healthy, engaged, and socially cohesive communities and is a primary service offered by most local governments. In addition to urban parks, many types of green infrastructure such as urban and nearby forests, tree-lined streets, and other types of natural assets (e.g., a naturalized stormwater management facility), can support nature-based recreation.

20 There is some variation in how local governments refer to the ecosystem services natural assets provide. Some link some ecosystem services (e.g. infiltration, water storage) to a direct municipal service (e.g. stormwater management), while other ecosystem services are referred to as co-benefits (e.g. carbon sequestration, which is related to climate mitigation and not a direct municipal service). For the purpose of this guidance, we refer to all ecosystem services generally as "services provided by the natural assets".

Habitat (co-benefit) – Healthy natural assets support the provision of habitat to improve and maintain biodiversity. Biodiversity is essential to support functioning ecosystems. Changes in biodiversity can influence the supply of ecosystem services, just as changes in the quantity and condition of natural assets in an ecosystem can influence biodiversity.

Climate resilience (co-benefit) — Ecosystems and the natural assets contained in them are vital to the climate system through their role in the carbon cycle, the water cycle, and the maintenance of biodiversity. Soils, forests, wetlands, and grasslands all assist in carbon sequestration and storage. These natural assets also play an important buffering role by reducing the severity of climate change impacts, including through services such as flood attenuation, urban heat island reduction, and storm surge protection.

Public health (municipal service/co-benefit) — It is increasingly understood that proximity and access to greenspace leads to improvements in physical and mental health and wellbeing, reduced mortality, and reduced health care costs.

Culture and heritage (municipal service/co-benefit) — Nature plays an important role in maintaining community culture and heritage. A cultural landscape is any geographical area that has been modified, influenced, or given special cultural meaning by people.

Local economic development (municipal service/co-benefit) — Natural assets are foundational to local economies through their provisioning services for agriculture, forestry, fishing, and resource extraction. Natural assets also contribute to local economies by providing opportunities for nature-based tourism and recreation activities. In addition, studies have shown that trees and nature located close to residential and commercial properties increase their property value.

TIP: Local governments starting out in natural asset management will likely want to consider a small number of services that are critical for managing costs of, and risks to, service delivery. In NAI's experience, the services of interest that tend to rise to the top for local governments relate to stormwater management, the provision of drinking water, biodiversity and habitat protection, recreation, and climate mitigation and adaptation. Once the services of interest are scoped, the local government can define relevant service delivery objectives. See Step 2.

3.4.2 Step 2 – Identify Service Delivery Objectives for Natural Assets

The second step involves the identification of service delivery objectives to help prioritize natural asset management activities and budgets. Local governments should define these objectives so they are aligned with the content of existing strategic documents such as climate action plans, climate change resilience strategies, biodiversity strategies, urban forest management plans, official plans, master plans, or any other policy documents or plans where objectives for natural assets may be defined. Some examples of service delivery objectives are shown in Table 8. Local governments generally define a small number of service delivery objectives for natural assets.

***Table 8**: Service Delivery Objectives and Associated Natural Assets*

SERVICE DELIVERY OBJECTIVES [21]	RELEVANT NATURAL ASSETS THAT PROVIDE THE SERVICES [22]
Promote the use of naturalized methods to support stormwater management.	Forests, wetlands, and other pervious land covers provide infiltration, canopy interception, reduced runoff, and peak flow attenuation.
Protect and enhance natural assets to support biodiverse natural habitats and ecosystems.	Forests, wetlands, grasslands, and riparian areas provide habitat.
Leverage natural areas to mitigate and adapt to climate change.	Forests, wetlands, and other natural asset types sequester and store carbon, provide shade to reduce heat island effect and buffer the impacts of extreme weather events
Protect source water quality and quantity by sustaining hydrological and hydrogeological characteristics of watercourses, aquifers, and wetlands.	Forests, watercourses, wetlands, and riparian areas support aquifer recharge, filter water, etc.
Provide access to nature for passive recreation and cultural activities.	Parks and natural areas support trail networks, outdoor recreation, social and cultural opportunities.
Protect the community from natural hazards such as wildfires, flooding, storm surge and erosion through both land use planning and proactive management of natural areas, in consideration of current and future climate conditions.	Proactive natural asset management to manage service delivery risks — applies to all natural asset types.

21 Not an exhaustive list of service delivery objectives. Service delivery objectives should be defined based on the local government's specific context.

22 Not an exhaustive list of natural asset types that provide related ecosystem services.

3.4.3 Step 3 – Scope the Community and Technical Level of Service Measures for Natural Assets

There are numerous factors that can and should be considered when establishing community and technical LOS for natural assets. Ultimately, the number of community and technical LOS measures that local governments track needs to be realistic. To scope them effectively, asset managers will want to consider:

Regulatory frameworks – the regulatory requirements of a local government may be relevant in establishing and prioritizing LOS measures. It may be appropriate, for example, to prioritize LOS measures that allow the local government to track progress against a regulatory requirement. Along these same lines, where clear performance targets have been established, prioritizing LOS measures that track progress against those targets can be helpful. Local governments typically describe the policy and regulatory requirements up front in the level of service section of their asset management plans, and their technical levels of service must meet the minimum requirements.

Community priorities and expectations for services – select measures that align with the services that are of interest to the community. For example, if access to green space is a community priority, then establishing LOS measures that evaluate access to nature (e.g., approximate walking time to the nearest greenspace) by neighbourhood would be appropriate.

Capacity of the local government — consider the capacity of the local government to track these measures over time. Budget and human resource limitations will need to be considered. In some cases, data pertaining to LOS measures may be readily available. In such cases, tracking the associated LOS measures may be immediately feasible. In other cases, the level of effort required to track the LOS measures may be minimal and thus justifiable in the short-term. LOS measures beyond those that can be tracked with existing data or with minimal additional effort will need to be evaluated for their importance relative to the cost of obtaining the needed data. Local governments with resource constraints can start with readily available data and prioritize future data collection to build out a full suite of LOS measures over time.

Priority assets – it may not be feasible to establish LOS measures for all of the natural assets within the municipal boundary. When capacity is constrained due to data, budget, or human resource limitations, asset managers may find it useful to focus initially on a sub-set of high priority assets. That may mean focusing on a particular type of asset (e.g., terrestrial, urban forests), assets within a particular area (e.g., within a certain proximity of residential units), or assets with specific designations (e.g., parks or protected areas). When identifying priority assets, practitioners can also think about the degree to which some assets may already be captured in other asset management plans. The idea here is to establish LOS for the assets that are highest priority for management in the short-run and in doing so ensure the number of LOS measures that are established can realistically be tracked over time.

Level of service attributes – there are some key service attributes that are important to consider when developing technical LOS for natural assets related to asset performance. These include the capacity and use, quality and reliability, and the function of the natural assets which enables them to provide ecosystem services.

- **Capacity and Use:** Natural assets have enough capacity to deliver ecosystem services
- **Quality and Reliability:** The quality of the natural assets meet community needs while limiting impacts to ecosystem health (e.g., their condition)
- **Function:** Natural assets perform their intended functions (e.g., peak flow attenuation) and are sustainable

The attributes above are the ones most commonly employed in asset management. Additional LOS attributes to consider when developing community and technical LOS encompass the universal values of service delivery[23], including:

- **Safety:** Natural asset services are safe and risks are managed (e.g., hazard trees are removed)
- **Regulatory:** Natural asset services meet all regulatory requirements (e.g., riparian buffers)
- **Reliability:** The service is reliable (e.g., frequency of trail closures)
- **Accessibility:** The service is accessible (e.g., all residents have access to greenspace)
- **Sustainability:** The service is sustainable (e.g., natural assets are protected from development)
- **Cost/Affordability**[24]**:** The service is affordable (e.g., cost of maintaining natural assets in good health to deliver services)
- **Customer Service:** The local government is responsive to questions or concerns about the service

In addition to the scoping considerations described above, when establishing LOS measures it is useful to consider the general rule-of-thumb for developing good performance measures, which is that they adhere to the following "SMARTER" principles[25]:

S: Specific, meaning they define results to be accomplished for a specific aspect of the service objective.

23 International Infrastructure Management Manual (2015), Institute of Public Works Engineering Australia

24 Note that this service attribute is used by some local governments but is not included in the International Infrastructure Management Manual (2015)

25 International Infrastructure Management Manual (2015), Institute of Public Works Engineering Australasia

M: Measurable, meaning they define a quantity, cost or quality.

A: Achievable, meaning the target should be realistic (not a stretch target or easy target).

R: Relevant, meaning it supports an organizational goal and provides a clear picture of whether the service is being provided. A customer LOS should also be relevant and meaningful to the community.

T: Timebound, meaning the measure specifies the frequency of action or a due date. Long-term targets should be stated along with annual or short-term targets that measure progress to be achieved over time.

E: Evaluation, meaning that there will be ongoing evaluation of the appropriateness of the measure/target.

R: Re-assess, meaning that LOS will be reviewed and updated to reflect the changing business environment.

Ideally, a local government will include the following when establishing community and technical LOS:

- Current (baseline) LOS being provided
- Desired trend (increase or decrease)
- Desired LOS (target, if possible)

Depending on a local government's data availability and resources to assess and track LOS, it may not be feasible to establish current and desired LOS for all LOS measures it is interested in tracking. **Establishing current community and technical LOS in priority areas is a good first step for local governments**. Expected or desired LOS can be established as part of continuous improvement efforts.

3.4.4 Step 4 — Define Community and Technical Level of Service Measures and Indicators

Community LOS measures typically relate to the direct benefits the community receives from natural assets, such as passive recreation opportunities, local economic development, climate resilience, etc.

Below (Table 9) are some examples of community LOS measures and indicators that local governments across Canada have included in LOS frameworks for natural assets.[26]

26 NAI has worked with the following communities to develop LOS frameworks for natural assets: City of Saskatoon, SK, Town of Pelham, ON, the Districts of Saanich and Nanaimo, BC, the Resort Municipality of Whistler, BC. Some measures are also being used by the City of Markham and York Region, ON.

Table 9: Examples of Community Levels of Service Measures and Associated Indicators and Attributes

COMMUNITY LOS MEASURES	INDICATORS [27]	SERVICE ATTRIBUTE
Provide access to parks	% of residents who have access to a local park, regional park, or publicly accessible greenspace within 0.5 km or 5-10 min walk	Accessibility
	% residents who have access to a local park within 0.5 km or 5-10 min walk	Accessibility
Provide physical and mental health benefits of the urban forest and resilience to climate change	annual # of trees planted per capita[28]	Quality
	% tree canopy cover provided by the urban forest	Quality
	% of neighbourhoods achieving the 3:30:300 standard.[29]	Accessibility
Provide passive nature-based recreation opportunities (includes cultural activities)	% of citizens satisfied with nature-based passive recreation	Quality
	# km of publicly accessible trails in natural areas	Accessibility
Access to community gardens.	# hectares of public land dedicated to community gardens	Accessibility
Protect the community from natural hazards	% of population living within xx metres of an identified natural hazard area	Safety
	# of residents impacted by natural hazards annually, broken down by hazard type (i.e., flooding, wildfire, erosion, extreme weather event)	Safety
Mitigate the cost of damages from natural hazards	Annual cost of insured and uninsured damages from natural hazards, broken down by hazard type	Cost
Protect and enhance biodiversity	Reporting on change in biodiversity every 5 years[30]	Quality

27 There may be some overlap with community performance indicators and technical performance indicators. The indicators reported publicly tend to be part of broader reporting on the organization's key performance indicators. Community level of service measures may also be described qualitatively and communicated to the public using maps or visual aids. An example is: We will provide access to a network of trails that are safe, accessible, maintained year-round, with public washrooms and water stations. Maps of the trail system provided, with daily updates on trail closures.

28 Annual trees planted per 100,000 population is a supporting indicator in the ISO 37120 Standard, World Council on City Data.

29 This is a guiding principle of urban forest management that proposes that everyone should be able to see 3 trees from their home, all neighbourhoods where people live should have at least 30% canopy cover, and all homes should be within 300m of a park or greenspace to ensure urban forest benefits are sufficient and accessible to all. This principle was approved by the District of Saanich, BC Council in 2021.

30 The ISO 37120 Standard (World Council on City Data) has specific requirements for tracking biodiversity of native species. Many local governments do no have sufficient data to track progress on this standard.

The examples of technical LOS below are broken down into the categories of asset performance (Table 10), which measures the ability of natural assets to deliver ecosystem services, and operational performance (Table 11), which measures the performance of the local government in managing natural assets. The indicators below reflect that large, intact natural areas in good condition are better able to deliver ecosystem services. The extent and condition of natural assets are therefore key asset performance measures to track.

***Table 10**: Technical Levels of Service (Natural Asset Performance) Measures and Associated Indicators and Attributes*

TECHNICAL LOS MEASURES (Natural Asset Performance)	**INDICATORS**	**SERVICE ATTRIBUTE**
Extent of the natural assets that provide ecosystem services	# of hectares of natural assets, broken down by asset type and by location within or outside the urban area.	Function
Extent of protected natural areas	# of hectares of natural heritage system under public ownership	Function
Ecological condition of the natural assets	% of natural assets in very good or good condition, broken down by asset type in the inventory[31]	Quality
Biodiversity of native species	Use data from available local biodiversity monitoring programs.[32]	Quality
	% area where invasive species are dominant	Quality
Annual carbon sequestration	a) # kg/m³ of carbon sequestered, broken down by natural asset type	Capacity
	b) Value of carbon sequestered annually, broken down by natural asset type	Cost
Watershed protection: riparian buffers	% of watercourse length and wetlands with required buffer of natural riparian cover as per regulatory requirements	Function/ Regulatory
Stormwater services provided by natural assets	Reduced peak flows from natural asset sub-catchments;	Capacity
	Reduced runoff depth from natural asset sub-catchments	Capacity
	# m³ of water storage capacity of wetlands	Capacity
	% pervious cover	Capacity
Source water quality[33]	% times annually source water quality reported as below regulatory thresholds	Function/ Regulatory
Source water quantity	# days water use restrictions exceeded level x	Capacity

31 Requires the local government to establish the methodology it will use to determine condition and develop a condition rating system. See *Section 2* of this guidance document for approaches to condition assessment.

32 The ISO 37120 Standard (World Council on City Data) has specific requirements for tracking biodiversity of native species. Many local governments do no have sufficient data to track progress on this standard.

33 Depending on the context there may be interest in tracking both surface source water and groundwater quality.

***Table 11:** Technical Levels of Service Measures (Operational Performance) and Associated Indicators and Attributes*

TECHNICAL LOS MEASURES (Operational Performance)	**INDICATORS**	**SERVICE ATTRIBUTE**
Monitor extent of natural assets	Inventory updates every xx years	Function
Monitor condition of natural assets	As per established condition rating system, every xx years.	Quality
Monitor extent of native species and biodiversity	As per established monitoring framework	Quality
Monitor prevalence of invasive plant species	As per established monitoring framework, sometimes included in an invasive species management plan	Quality
Monitor surface and groundwater quality	Establish indicators using existing monitoring programs, when available.	Quality
Monitor surface and groundwater quantity	Establish indicators using existing monitoring programs, when available	Capacity
Monitor extent of natural hazards	As per established monitoring protocol	Safety
Local government-managed restoration in priority areas.	# ha restored (can be broken down by type of restoration/ habitat creation; by location)	Function/ Sustainability
Annual spending on restoration in priority areas.	$/hectare restoration, broken down by funding source	Cost
Targeted management of invasive species	Annual spending on invasive species management	Cost
	% change area where invasive species are dominant	Quality
Natural areas stewardship programs	Annual spending on education, awareness and stewardship programs; results, where possible, e.g., # hectares maintained, restored or created	Quality
Land securement	# hectares protected through land securement	Function

4 Incorporating Risk and Criticality

A key asset management principle is to manage risk while meeting service levels and minimizing lifecycle costs. A local government can provide lower service levels, which typically results in lower immediate costs. However, this usually is associated with higher risk and potentially higher costs in the long term. The primary goal of understanding the risk exposure from natural assets is to inform a local government on which projects to prioritize across asset classes and service areas.

Before engaging in a formal risk assessment, local governments should consider work already undertaken that might inform or provide a foundation for a risk assessment. For example, many local governments have completed climate change vulnerability assessments; many of which have incorporated risk assessments and some of which might be relevant to natural assets. At a minimum, these studies can provide an excellent launching pad for a natural asset risk assessment.

The concept of asset criticality can also be useful in helpful for prioritizing assets and focusing management efforts.

Criticality refers to the importance or significance of an asset to a local governments' operations or objectives. It reflects the degree to which an asset is essential for achieving desired outcomes and can provide a sense of relative importance.

Generally, assets that have the greater consequences of failure will be the assets that are considered the most critical. Another important variable for identifying critical natural assets is whether the asset is replaceable. For example, a drainage ditch is easily substituted by grey infrastructure, whereas an aquifer may not be replaced with grey infrastructure (or may entail costs that are too high). Identifying which natural assets are critical helps prioritize which ones should be the focus of deeper risk consideration and lifecycle management activities. *Section 4.4* explores this further.

There are many ways to approach assessing risk associated with natural assets. Below are three approaches to provide direction to local governments as they begin asset management for natural assets. It is important to remember that a range of options exist; it is not just a choice between the options that follow. Any chosen risk approach can and should be tailored to the context of each specific local government. The approaches, described further in this section, are:

1/ Qualitative risk assessment that relies on local knowledge and expertise to identify anticipated risks and describe how the asset management plan attempts to address or mitigate those risks.

2/ A threats-based approach that examines the range of potential threats to natural assets. In this context, the term threat (i.e., something that is dangerous or likely to cause damage) is intended to capture the range of issues that could damage natural assets and impact the flow of services over time (e.g., overuse, extreme weather events, pollution, etc.).[34]

3/ A probability and consequence of asset failure approach, more commonly used for traditional asset management. This approach has the advantage of being more directly comparable with what most local governments are doing for their built assets. This approach can also be combined with the threats-based approach.

4.1 Addressing Risk Qualitatively

At the most general level, the purpose of risk consideration in an asset management plan is to help prioritize where to invest limited lifecycle management dollars. In this context, consideration of risk can be as simple as a qualitive assessment of key risks framed around LOS and required investments in lifecycle management costs. For instance, in Ontario, O. Reg 588/17 requires local government to consider:

- The cost associated with maintaining the current levels of service considering risks associated with lifecycle management activities.
- That risks are considered when assessing options for lifecycle activities that could be undertaken to achieve proposed LOS.
- An "explanation of how the local government will manage the risks associated with not undertaking any of the lifecycle activities identified."
- For local governments with a population greater than 25,000, an "overview of the risks associated with implementation of the asset management plan and any actions that would be proposed in response to those risks."

For communities outside Ontario, the O. Reg 588/17 requirements provide a reasonable minimum level of effort for considering risk. The baseline approach should be to define the current and target LOS and to ensure risks are considered when developing management plans. This consideration of risk can be as simple as a qualitative description of the range of risks associated with the lifecycle management plan and anticipated consequences for the assets should those risks be realized. In other words, the consideration of risk can be achieved without completing a formal risk assessment approach. However, some local governments may be well-positioned to complete a more sophisticated

34 It is important to note that the threats-based approach is different from the standard of practice commonly applied to built assets. Where the standard asset management approach focuses on probability and consequence of an asset failing, the threats based approach focuses on the likelihood of a threat occurring and the impact that threat could have on natural assets if it did occur.

risk assessment. Those local governments can consider either of the approaches presented in *sections 4.2* and *4.3* to considering risk.

4.2 Threats-based Approach to Considering Risk

One way to consider the risk to LOS provided by natural assets is to assess the range of threats[35] natural assets are exposed to. Natural assets can withstand a certain amount of stress and, in many cases, can "self-repair" when damaged over time, as long as the damage is not too severe or sustained, and as long as the asset is not subject to a succession of stressors or already in a poor condition. Within this context, degradation or damage to one component of a natural asset may not have a significant impact on the overall LOS (e.g., loss of one tree will likely have a minor impact on overall forest or canopy cover and the associated services). This resiliency is one of the many reasons natural assets have been identified as a critical part of the solution to deal with certain infrastructure and climate change-related challenges. Nonetheless, cumulative effects and/or exposure to multiple stressors can cause even the most resilient natural assets to reach tipping points, causing cascading or widespread failure of the assets. Therefore, one approach to assessing risks to natural assets is to consider the range of threats to which natural assets may be exposed. Such an assessment examines the exposure of natural assets to a range of threats that, taken together, could have the potential of triggering tipping points or thresholds beyond which LOS can be significantly impacted.

An assessment using this approach considers the range of threats or issues that natural assets might be subject to along with the relative impact and likelihood of those threats. Specifically, such an assessment involves the following steps:

1/ Identify relevant threats
2/ Assign impact rating to each threats
3/ Assign likelihood rating to each threats
4/ Calculate the risk score
5/ Allocate the risk scores to the relevant natural assets

These steps are elaborated on in the sub-sections that follow.

4.2.1 Identify Relevant Threats

A threats-based assessment begins with the identification of threats that are relevant to the natural assets within the geographic area under consideration. These are threats that could negatively impact the natural assets and hence their ability to deliver services. Table 12 contains a set of common threats to natural assets that can act as a starting place in identifying relevant threats.

35 This approach could also be referred to as a hazards-based approach however, for this Guidance Document a decision was made to refer to threats rather than hazards to avoid confusion with hazards in the context of hazard trees or the use of this term in the context of the mandate of Conservation Authorities where hazards has a well-defined defined and disparate meaning.

Additional threats can be added, or threats removed from the list, based on what is most relevant for the area under consideration.

Table 12: *Potential Threats to Natural Assets*

POTENTIAL THREATS TO NATURAL ASSETS	DEFINITION
Invasive species*	Invasive plant species able to negatively impact a natural asset such that its ability to provide the services for which it is being assumed/maintained is impaired.
Pests and disease*	Pests (primarily insects) and diseases negatively impact a natural asset such that its ability to provide the services for which it is being assumed/ maintained is impaired.
During construction impacts	Impacts resulting from activities during construction within or adjacent to natural assets able to negatively impact the natural asset such that its ability to provide the services for which it is being assumed/maintained is impaired.
Encroachments / disturbances	Impacts resulting from inappropriate and unauthorized activities adjacent to and within natural assets (post-construction) able to negatively impact the natural asset such that its ability to provide the services for which it is being assumed/maintained is impaired.
Overuse / inappropriate use	Impacts resulting from excessive and overuse of natural assets causing negative impacts.
Flooding*	Naturally occurring threat exacerbated by both urbanization (i.e., reduced permeable surfaces with inadequate stormwater management controls in some areas of the city or upstream) and climate change (i.e., increased frequency and intensity of storm events).
Erosion and sedimentation*	Naturally occurring threat exacerbated by flooding, urbanization (i.e., reduced permeable surfaces with inadequate stormwater management controls in some areas of the city or upstream) and climate change (i.e., increased frequency and intensity of storm events).
Extreme Wind*	Naturally occurring threat exacerbated by climate change (i.e., increased frequency and intensity of extreme wind events).
Ice Storms*	Naturally occurring threat exacerbated by climate change (i.e., increased frequency and intensity of ice storm events).
Extreme heat*	Heat stress to vegetative communities caused by extreme heat events.
Drought*	Naturally occurring threat exacerbated by both urbanization (i.e., changes in drainage and infiltration) and climate change (i.e., increased frequency and intensity of heat events).
Contamination	Introduction of pollutants and/or chemicals to the asset that can seriously impair the function of, or kill, the asset.
Fire*	Fire of natural or human origin that occurs within the asset able to negatively impact the natural asset such that its ability to provide services is reduced/ eliminated.

** Threat is anticipated to become more likely or more severe in the context of climate change.*

To refine the list of relevant threats it is useful to connect with knowledgeable stakeholders and subject matter experts. As part of the threat identification exercise, the threats can be defined in the local context. For example, extreme wind events might be defined as hurricane events in coastal areas or downburst/tornado events in other regions of the country.

Climate change-related threats are identified in *Table 12* (marked by an *). These climate-related threats are likely to increase in intensity and frequency over time. To the extent that a community is prone to significant climate-related threats, threats-based assessments should be carried out more frequently. The assessment gives practitioners a picture of the risk profile to their natural assets at a point in time. Frequent updates are needed to ensure that the increased intensity and frequency of climate-related threats are reflected in the results and thus taken into consideration when planning and prioritizing management activities.

4.2.2 Assign Impact Rating

Once the list of relevant threats is confirmed, the next step is to assign a relative impact rating to each threat. The impact rating describes the degree of damage to the natural assets from the occurrence of the particular threat. The impact rating can be informed by existing data and information, past experience with threat events, and subject matter expertise.

As noted above, impact scores are commonly assigned based on a five-point scale. Table 13 contains sample impact rating definitions. These or similar definitions can be used to assign impact ratings to the various threats. **When defining the scale for the relative impact of threats, local governments may find it useful to consider the scale used for built assets**.

Table 13: *Potential Impact Ratings and Associated Criteria*

SCALE	IMPACT	FINANCIAL	SOCIO-ECONOMIC	ENVIRONMENTAL
5	Very high	Cost of remediation is significant and difficult to recover.	Permanent loss of related services.	Potential to cause long-term environmental damage to the condition of the natural assets over a large area.
4	High			
3	Moderate	Cost of remediation is considerable and requires budget revisions.	Temporary loss of related services.	Potential to cause medium-term repairable environmental damage to the condition of the natural asset.
2	Low			
1	Very low	Cost of remediation falls within annual budget.	Little to no effect on related services.	Potential to cause non-lasting damage to environmental assets.

4.2.3 Assign Likelihood Rating

The next step is to allocate a likelihood rating on a scale of 1 to 5, where 1 is rare and 5 is almost certain. Table 14 demonstrates some likelihood ratings that can be considered for the threats to natural assets. As with the impact ratings, local governments can use a likelihood rating scale comparable to the one used for built assets.

***Table 14:** Likelihood Ratings*

LIKELIHOOD RATING	DESCRIPTION	ANNUAL PROBABILITY	RETURN PERIOD
Rare (1)	Likely to occur once every 50 years or more	Less than or equal to 2%	1:50 or less
Unlikely (2)	Likely to occur between once every 21 years and once every 50 years	More than 2% and less than 5%	1:21 to 1:50
Possible (3)	Likely to occur between once every 5 years and once every 20 years	More than 5% and less than 20%	1:5 to 1:20
Likely (4)	Likely to occur between once every 2 years and once every 5 years	More than 20% and less than 50%	1:2 to 1:5
Almost certain (5)	Likely to occur annually or several times a year	More than or equal to 50%	1:1 or more

4.2.4 Calculate the Risk Score

With the impact and likelihood scores established for each threat, the next step is to calculate the risk score. The risk score is the product of the impact rating and likelihood rating. By multiplying the impact rating by the likelihood rating, an overall risk score is derived (*Figure 5*).

***Figure 5:** Standard Asset Risk Rating*

		IMPACT				
		Very Low 1	**Low 2**	**Moderate 3**	**High 4**	**Very High 5**
LIKELIHOOD	Almost Certain 5	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
	Likely 4	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
	Possible 3	Low 3	Moderate 6	High 9	High 12	Extreme 15
	Unlikely 2	Low 2	Moderate 4	Moderate 6	High 8	High 10
	Rare 1	Low 1	Low 2	Low 3	Moderate 4	Moderate 5

4.2.5 Allocate the Risk Scores to Relevant Natural Assets

With the risk scores established for each threat, the next step is to determine which natural assets are most likely to be impacted by those risks. This can be done by first identifying the type of natural asset that will be subject to the particular risk, and then identifying the specific assets (of that type) that the risks would apply to. Existing documentation or information, including for example, vulnerability assessments and expert knowledge can inform the allocation of risks to natural assets. A set of risk allocation criteria can also be useful in this regard.

Table 15 provides a sample of allocation criteria by risk. The table links the risks with the relevant asset types and then within those asset types, the allocation assumptions that will determine the specific assets that will be subject to the risks. For example, while a broad range of asset types have the potential to be subject to encroachment, those that are located within 20 metres of private properties will ultimately be subject to this risk. Where allocation criteria are required, distribution assumptions and selection criteria can be established in consultation with relevant stakeholders and subject matter experts. The goal is to establish the most reasonable and sensible allocation assumptions for each risk based on the best available information. Over time, allocation assumptions can be updated and refined.

***Table 15**: Sample Spatial Distribution and Selection Criteria for Assigning Risks to Natural Assets*

POTENTIAL THREATS TO NATURAL ASSETS	APPLICABILITY BY NATURAL ASSET CLASS			SPATIAL DISTRIBUTION ASSUMPTIONS	SELECTION CRITERIA
	WETLANDS	FORESTS	GRASSLANDS		
Invasive species	Y	Y	Y	All relevant asset classes	All relevant asset classes
Pests and disease	N	Y	N	All relevant asset classes	All relevant asset classes
Encroachment	Y	Y	Y	Buffer around existing private property areas	20 m
Overuse or inappropriate use	Y	Y	Y	All assets with known access	Assets with trails
Extreme wind event	Y	Y	Y	All relevant asset classes	All relevant asset classes
Drought	Y	Y	Y	All relevant asset classes	All relevant asset classes
Contamination	Y	Y	Y	Buffer around roads and industrial areas	15 m buffer
Fire	Y	Y	N	All relevant asset classes	All relevant asset classes

Once all the risks have been allocated to the appropriate assets, a total risk score can be developed for each asset based on the number of risks that asset is prone to.

The results of this assessment can be added into the asset inventory as an asset attribute. It will also inform the LOS measures and ultimately lifecycle management strategies. In this way, management strategies can be targeted towards those assets that provide significant services that are also exposed to greater risks.

4.3 Probability and Consequence of Failure Approach

For built assets, the common standard of practice is to rank risks to assets based on the probability and consequence of the given asset (or asset type) failing. These are typically defined as:

- **Probability of Failure (PoF):** The chance, or likelihood that the asset will fail.
- **Consequence of Failure (CoF):** The impact to the local government if the asset does fail.

An overall risk score for each asset (or asset type) can be generated by multiplying the PoF by the CoF score. For example:

Asset *a* risk score = CoF x PoF

Taking this approach local governments can assess natural asset risk by conducting an exercise that follows these steps:

1/ Establish probability of failure
2/ Establish consequence of failure
3/ Calculate the risk score

Currently, there have not been any published approaches, or accepted norms, developed on how to apply the CoF and PoF approach to natural assets. Local governments who want to use this approach are encouraged to engage internal (or if necessary, external) expertise to help identify the best way to apply this approach to natural assets in the context of the government's available information on natural assets.

Given the resilience of most natural assets, the idea of a natural asset "failing" may not be overly obvious. A natural asset can certainly become significantly degraded, but the point of asset failure may be difficult to determine. For this reason, when considering the consequence and probability of failure it may be helpful to frame those assessments around different modes of failure. For instance, drawing from some recent thinking from the Toronto and Region Conservation Authority, three modes of failure can be considered:

1/ **Functional failure –** occurs when a natural asset physically fails or stops performing intended functions (e.g., loss of soil or vegetation, excessive sedimentation buildup in a wetland, excessive water pollution leading to a dysfunctional aquatic ecosystem, invasive species causing widespread tree mortality).

2/ **Capacity failure –** occurs when a natural asset is functioning but does not have the capacity needed (e.g., precipitation exceeding drainage capacity, visitor density exceeds the forest capacity causing degradation).

3/ **Service failure –** occurs when a natural asset is no longer providing the desired service level (e.g., natural asset lacks adequate biodiversity, compacted soils preventing infiltration).

4.3.1 Establish Probability of Failure

The PoF in the context of built assets is often directly linked to the overall condition rating of an asset. As outlined in Table 16, establishing a PoF score for each asset is a matter of inverting the condition score.

***Table 16**: Probability of Failure*

CONDITION RATING		PROBABILITY OF FAILURE	
5	Very Good	**1**	Very Low
4	Good	**2**	Low
3	Fair	**3**	Moderate
2	Poor	**4**	High
1	Very Poor	**5**	Very High

The challenge with this approach for natural assets is that a natural asset is not likely to degrade over time unless negatively impacted by threats such as those described in the previous section. Thus, in the context of natural assets, it may be more appropriate to establish a PoF that is based not only on the condition of the assets (which may be accomplished through a desktop condition assessment or a fields-based assessment as articulated in *Appendix D*) but also the results of a threats-based risk assessment as articulated in the previous section. The rationale for using the condition results is based on the premise that the resilience of a natural asset is going to be higher for an asset in excellent condition, therefore its probability of failure would be lower. Table 17 provides an example for how a threats-based risk assessment and condition ratings can be combined to generate a PoF score.

Note that Table 17 is provided as a guide for local governments to see how this approach can be executed and should not be interpreted as direction on how the PoF scores should be allocated.

Table 17: *Combining Condition and Risk Scores to Estimate Probability of Failure*

CONDITION RATING	THREAT BASED RISK RATING				
	Very Low	**Low**	**Moderate**	**High**	**Very High**
Very Good	PoF = 1 Rare	PoF = 1 Rare	PoF = 2 Unlikely	PoF = 3 Possible	PoF = 3 Possible
Good	PoF = 1 Rare	PoF = 2 Unlikely	PoF = 3 Possible	PoF = 3 Possible	PoF = 4 Likely
Fair	PoF = 1 Rare	PoF = 2 Unlikely	PoF = 3 Possible	PoF = 4 Likely	PoF = 5 Almost Certain
Poor	PoF = 2 Unlikely	PoF = 3 Possible	PoF = 3 Possible	PoF = 4 Likely	PoF = 5 Almost Certain
Very Poor	PoF = 3 Possible	PoF = 3 Possible	PoF = 4 Likely	PoF = 5 Almost Certain	PoF = 5 Almost Certain

The advantage of this approach is that PoF integrates an asset's current condition and the anticipated exposure of the asset to a series of known threats. This means an asset that is in very poor condition with has high risks associated with it would have a higher PoF. In contrast, natural assets in excellent condition can be anticipated to be more resilient and have a lower or moderate PoF, even in the face of high risk from threats.

4.3.2 Establish Consequence of Failure

The CoF is generally based on a scoring system defined by each local government. For instance, CoF scores might be defined as outlined in Table 18 (adapted from the Municipal Finance Officers Association of Ontaio, 2018).

***Table 18**: Consequence of Failure*

CONSEQUENCE OF FAILURE	COST CONSEQUENCES	SOCIAL CONSEQUENCES	ENVIRONMENTAL CONSEQUENCES	SERVICE DELIVERY CONSEQUENCES
Insignificant	Negligible	No injury	No impact	No interruptions
Minor	Small or minor costs within budget allocations	Minor injury	Minor, short-term and fixable impact	Minor interruptions
Moderate	Considerable costs, requires budget revisions	Moderate injury	Medium-term and fixable impact	Moderate interruptions
Major	Substantial costs, multi-year budget impacts	Major injury	Long-term and fixable impact	Major interruptions
Significant	Significant costs, difficult to recover	Significant injury	Long-term and permanent impact	Significant interruptions

The example in Table 18 is general enough that it can reasonably apply to natural assets. However, many local governments have developed more specific criteria and definitions for the asset management process. Local governments can refer to their asset management plans for built assets and develop a comparable scale for natural assets. To apply the CoF to natural assets, a local government should engage subject matter experts to help adapt the criteria used for built assets into something comparable and applicable to natural assets.

4.3.3 Calculate the Risk Score

With the CoF and PoF scores established, the next step is to calculate the risk score. The risk score is the product of the CoF and PoF rating (Table 19).

***Table 19**: Standard Asset Risk Rating*

		CONSEQUENCES				
		Insignificant 1	**Minor 2**	**Moderate 3**	**Major 4**	**Significant 5**
PROBABILITY	Very high 5	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
	High 4	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
	Moderate 3	Low 3	Moderate 6	High 9	High 12	Extreme 15
	Low 2	Low 2	Moderate 4	Moderate 6	High 8	High 10
	Very low 1	Low 1	Low 2	Low 3	Moderate 4	Moderate 5

Using this approach, the scores would get allocated to each natural asset based on a range of factors. The PoF would get assigned to each natural asset based in its condition rating, and (if available) an assessment of its exposure to threats. The CoF can be assigned to natural assets in a way that best suits the local government context. However, when assigning CoF based on the defined scoring system (e.g., Table 19), consideration of spatial variation in asset or sub-asset type and service provision is recommended.

4.4 Natural Asset Criticality

Further to the specific approaches described above, the concept of asset criticality can be used to help narrow or target the focus of risk considerations and lifecycle management to assets deemed to be the most critical. Natural assets with the largest CoF would be considered to have higher criticality. For instance, natural assets are essential for mitigating urban heat impacts. Therefore, natural assets near residential or commercial areas could be considered more critical from the perspective of mitigating urban heat impacts. The challenge with natural assets is that they provide a wide range of beneficial services, which means an asset's criticality will vary depending on the service(s) of interest. There are a couple ways this can be addressed:

- Criticality can be based on an aggregation of ecosystem services provided, where assets that provide the most services are considered more critical.

- Specific ecosystem services can be considered to have varying degrees of criticality, and those natural assets that are providing critical service can be prioritized.
- A combination of the above.

Criticality might also be considered based on a natural asset's condition. In some highly urbanized communities, natural areas have become highly fragmented and isolated with limited potential for improvement. In such cases, focusing efforts on the remaining natural assets that are in better condition with greater connectivity and likelihood that their condition can be maintained or improved may be deemed critical. In other words, those assets in better condition would be considered the most critical since they are providing greater LOS and would have a greater consequence if damaged or lost.

Regardless of how criticality is ultimately determined, the concept can be used to focus risk mitigation efforts.

4.5 Risk Mitigation

With an understanding of the risks facing natural assets, a risk response or mitigation strategy can be established. The strategy should include specific risk mitigation activities tailored to the natural assets under consideration. The City of Edmonton's Urban Forest Asset Management Plan (2021) defines risk responses as planning and implementing actions to mitigate or avoid unacceptable risks. Depending on the types of natural assets and associated risks, risk mitigation actions can include restoring natural habitats to improve resilience against climate changes, implementing sustainable land use practices, and engaging in regular monitoring and maintenance of natural resources. In Table 20, current and future risk responses as articulated in Edmonton's Urban Forest Asset Management Plan are identified.

Table 20: Example Risk Mitigation Responses to High Priority Risks from the City of Edmonton's Urban Forest Management Plan Risk Mitigation Measures (partial)

RISKS	CURRENT RESPONSES	FUTURE RESPONSES
Climate change risks to Maintained Trees: • Insect and disease • Hail / Freezing Rain / Unseasonal Snow • Drought • Lightning Strikes • High winds / tornado • Warmer Annual Temperature • Flooding • Higher annual total precipitation	• Visual inspection from the ground every two years • Removing dead, hazardous, and diseased infested trees (through inspections) and compliance with elm bylaw requirements • Identification, monitoring, surveillance, and management of pests (insects and disease) following Integrated Pest Management Plan • Phytosanitary inspections of nursery stock • Training City of Edmonton staff to recognize pest and general public education and awareness • Increasing biodiversity of trees species when planting • Systematic pruning cycles of trees including disease prone trees • Implementing plant health care strategies to improve pest resistance and reduce secondary pest problems • Investigating and utilizing natural control agents • Proactive and reactive cabling and bracing identified through pruning and inspections • Responding to storm 24/7 including storm damage, rigging training for Arborists • Watering established trees identified as stressed or declining during drought by water truck technician • Low impact development	• Increasing routine structural pruning cycles on young trees to improve their resilience to storms, lighting strikes and heavy winds • Increasing frequency of inspections and risk assessments • Removing insect or disease infested trees that are high risk to the forest & injecting nearby & feature trees with insecticide or fungicide • Identifying inventoried / volunteered elm and ash trees on City properties (back alleys) and maintaining and removing as necessary • Improve soil and drainage conditions during planning and building stages to increase resilience to droughts • Construct soil cells for hardscape trees and medians to grow healthier more fit trees that will be less susceptible to drought • Improve drainage designs to increase resilience to flooding • Improving / increasing tree species diversity to improve resilience and sustainability of the Urban Forest
Human Activity risks to Maintained Trees: • Construction and maintenance activities	• General public education and awareness • Dedicated landscape technicians completing regular inspections • Air excavations for compaction • Increased watering • Building relationships with the building, design and construction industries to continually improve regulations and industry requirements for working around trees • Building of Public Tree Bylaw	• Increased inspections and risk assessment • Implement proposed public tree bylaw • Education and workshops • Investigate possibilities of a private tree bylaw or other incentives to sustain overall canopy

***Source:** City of Edmonton Urban Forest Asset Management Plan (2021)*

4.6 Residual Risk

After implementing risk reduction strategies, it is essential to evaluate the remaining, or residual, risk. Residual risk is the level of risk that remains after all mitigation strategies have been applied. This step is crucial for understanding the effectiveness of the risk mitigation measures and for identifying any gaps in the management plan.

Monitoring activities are helpful in assessing the level of residual risk and ensuring it remains within acceptable bounds. Monitoring activities can consider the effectiveness of the management strategies in place. This can be done through field surveys, remote sensing technologies, and data collection. Periodic risk assessment updates in light of new information and/or changing conditions, such as climate change projections or demographic shifts, can also be helpful.

Recognizing that residual risk exists, it is helpful to articulate a risk response plan. This plan should outline specific actions to be taken when encountering unavoidable risks to minimize impacts. Table 21 is a partial risk response plan taken from the American Water Research Foundation (2021).

***Table 21**: Example Risk Response Plan*

RISK LEVEL	LEVEL	MANAGEMENT ACTION	TIMEFRAME	
			CORPORATE	PROJECT
Very High	Intolerable	Immediate action to eliminate risk or reduce to acceptable level	Implementation: **immediate** Review: **Weekly**	
High	Conditional tolerable	Conditional tolerable if all cost-effective measures to treat the level of risk are implemented. Where cost-effective measures can be applied, additional action is required to reduce level of residual risk.	Implementation: **6 months** Review: **Quarterly**	Implementation: **3 months** Review: **Monthly**
Medium	Conditional tolerable	Conditional tolerable if all cost-effective measures to treat the level of risk are implemented, maintain watching brief, quarterly review by management. Where cost-effective measures can be applied, longer term additional action required to reduce level of residual risk.	Implementation: **12 months** Review: **6 months**	Implementation: **6 months** Review: **Quarterly**
Low	Tolerable	Broadly acceptable, cost-effective measures to reduce level of risk unlikely.	N/A	N/A

5 Lifecycle Management Strategies

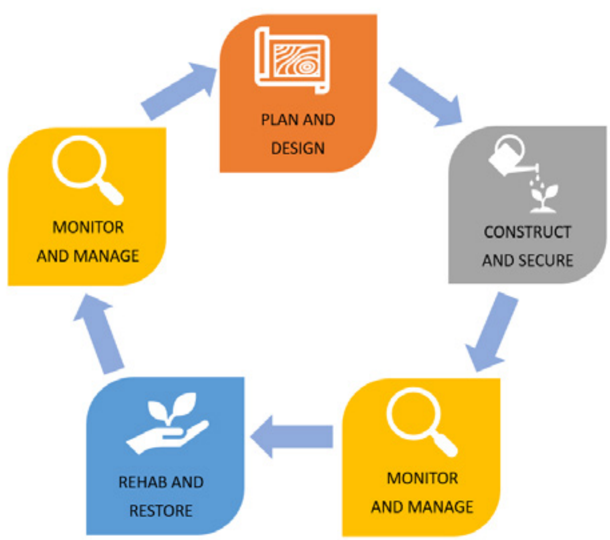
A key component of a natural asset management plan is the articulation of lifecycle management strategies. Lifecycle management strategies ensure the delivery of services over time while managing risks and costs. More specifically, **the objective of lifecycle management is to identify and cost the planning, operations, maintenance, and renewal activities needed to maintain required LOS in the face of relevant risks**. Ultimately, the lifecycle approach balances the need to provide continuous and reliable services within budget constraints (MFOA, 2018).

This section describes the application of lifecycle management strategies to natural assets. It begins with an articulation of the lifecycle stages of natural assets. Management actions associated with each stage are then described. Guidance is provided on how to cost the activities identified for each stage along with an overview of potential funding mechanisms. Examples of lifecycle management activities and their costs are provided where possible.

5.1 Natural Asset Lifecycle Stages

The lifecycle stages of built assets have been well defined. However, the application of such stages to the natural asset context is less established. Figure 6 demonstrates the lifecycle structure of natural assets. The main difference between the natural assets' lifecycle and that of built infrastructure is that natural assets have no end of useful life.[36]

***Figure 6**: Lifecycle Management Stages that are the Focus of this Guidebook*



36 To explore how natural assets can be applied to the lifecycle management strategy portion of an asset management plan, a number of lifecycle management frameworks were reviewed, described in *Appendix C*. While the stages and specific terminology used in this guidance differ slightly from the lifecycle examples described in *Appendix C*, the cycles largely align with respect to the main components of a natural asset's lifecycle.

The activities associated with the lifecycle stages of natural asset management are described below, with some examples. The following section shows how to estimate the lifecycle costs associated with these activities.

Non-infrastructure Solutions

Non-infrastructure solutions refer to strategies that municipalities can employ to meet service needs without relying on the construction or enhancement of physical infrastructure (MFOA, 2018). These solutions encompass a variety of approaches such as policy changes, demand management, and operational improvements. The key advantage of these solutions lies in their ability to provide effective service outcomes in a more cost-effective, and often faster, manner than traditional infrastructure projects.

These types of approaches can be particularly beneficial for natural assets. Since the levels of service provided by natural assets to a given community are generated by the complete integrated system of natural features across the landscape (regardless of who owns the assets), lifecycle management strategies that focus only on municipally owned natural assets ignore the potential implications for the broader system of natural assets. Local governments have some influence over those assets through non-infrastructure-based approaches, such as establishing land use planning rules that protect natural heritage features, or investing in strategic stewardship and community outreach programs that foster better collective stewardship of the communities' natural assets. While most local governments' primary focus will be on publicly owned and managed natural assets, non-infrastructure solutions can be an important mechanism to achieve levels of service provided by natural assets on private land.

Other non-infrastructure solutions can be helpful in offsetting or avoiding certain operations and maintenance activities, such as leveraging demand management techniques to control access to overused areas, or use of signs and other communication tools to build awareness of negative impacts of inappropriate uses of natural assets.

The City of Guelph is pursuing non-infrastructure solutions to incentivize its citizens to support stormwater management. Specifically, the City introduced a series of incentive programs including a rebate for rain gardens, a subsidy for backyard tree planting, a seasonal outdoor rainwater harvesting rebate, and subsidies for rain barrels. Such incentives can play a significant role in managing and delivering LOS even though they do not directly involve lifecycle management activities. For this reason, non-infrastructure solutions such as those pursued by Guelph are often incorporated into asset management plans.

5.2 Plan and Design

As articulated in *Figure 6*, the lifecycle for natural assets includes four main stages, namely plan/design, construct/secure, monitor/manage, and rehabilitate/restore. The plan/design stage informs the subsequent stages with the specific planning activities varying depending on whether local governments are planning for monitor/manage, rehab/restore or construct/secure. Regardless, a principle objective of the plan/design stage is to set local governments up for subsequent life cycle stages. Thus, at a minimum the plan/design stage should involve data and information collection to understand the type, location, and extent of natural assets under the management of the local government. It should also take into consideration the service delivery objectives for natural assets and key risks to be managed (see *Section 4*).

5.3 Construct / Secure (New Assets)

In the context of constructing or securing new assets, the focus is on either securing/acquiring assets that already exist, or creating/constructing assets through restoration or naturalization. The first thing to do at this stage is to undertake the necessary planning activities. As articulated by the Credit Valley Conservation Authority (CVC, 2020), planning activities associated with the creation of new natural assets can include:

- Planning for the acquisition of existing natural assets:
  - Defining the geographic area to be acquired based on criteria established by the local government (e.g., biodiversity hotspots, protection from natural hazards, resilience to flooding, expansion of trail networks, etc.)
  - Mapping the assets present in the acquisition area
  - Negotiating acquisition terms and conditions
  - Establishing allowable uses of the acquired assets
- Planning for the creation of new natural assets on lands already owned by the municipality:
  - Developing conceptual and detailed designs
  - Defining planting regimes
  - Defining species composition
  - Order seeds, saplings and materials as needed
  - Contracting
- Acquiring necessary permits and approvals
- Engaging with Indigenous groups, as well as consulting with other agencies, the public, or other rightsholders and stakeholders

After planning is complete, constructing/securing new assets may involve a range of other activities, including:

- Land acquisition
- Site preparation
- Materials, equipment, and supplies
- Planting and vegetation establishment

This stage of the lifecycle could also include some basic maintenance activities associated with asset creation to ensure the successful survival and establishment of the natural features, such as watering and mulching.

5.4 Monitor and Manage

An effective maintenance strategy for natural assets can significantly improve the assets' long-term resilience ensuring they continue to provide the desired LOS. A well-structured maintenance plan serves as a proactive measure to manage resources effectively and ensures their reliability and performance. By prioritizing regular and strategic maintenance (i.e., monitoring and management) activities, municipalities can minimize service disruptions and avoid the higher costs associated with emergency repairs or premature asset replacement.

To start, local governments will want to undertake plan/design activities related to the monitor/manage life cycle stage. Activities that might be undertaken when planning for monitor/manage include:

- Identifying the types of activities that are to be undertaken
- Identifying the frequency and timing of activities
- Identifying the level of effort required for the activities

Activities that should be undertaken during this stage in the lifecycle for natural assets include:

- Maintenance activities that will help the natural assets become (if recently established) or stay self-sustaining and resilient.
- Monitoring of assets for key indicators of hydrologic and ecological functions which can inform condition assessments.
- Well-established assets that have not been subject to negative impacts or a catastrophic event may not require much maintenance work. Activities for such assets should focus on longer-term monitoring and pre-emptive management needs (e.g., pruning, invasive species management, human use management).

In partnership with NAI, the Town of Gibsons, BC, carried out the Source to Sea project, which focused on evaluating and managing the natural assets within the Gibsons' Aquifer 360 Watershed. Part of that project entailed the articulation of operations and maintenance needs for the wetland and forest assets within the watershed. Table 22 provides an example of activities that would fall within the monitor/manage stage of the lifecycle. For each activity the associated frequency, time period, and level of effort is specified.

***Table 22**: Town Of Gibsons' Operations and Maintenance Activities for Natural Assets*

ASSET TYPE	ACTIVITY	FREQUENCY	TIME PERIOD	LEVEL OF EFFORT
Wetlands (natural and constructed)	Ensure there is no ponding in the pre-treatment device	Min 2x/year after storm events > 1 in 2-year storm event	Within first 6 months	1-2 hours
	Check for evidence of clogging in pre-treatment device and/or in any conveyance structures	Min 2x/year after storm events > 1 in 2-year storm event	Within first 6 months	1-2 hours
	Check that water is moving as intended through the wetland. Identify and fix any stagnant zones.	As needed	During first 2 months	4 hours
Forests (urban)	Pruning of immature trees and newly planted trees to develop structural integrity	Once, 1 year after planting	Winter/ Summer	High
	Planting [of new trees, and trees to restore native plant communities	As needed	Fall/Winter	High
	Removal clean-up of failed tree limbs and other debris following severe weather	As needed	Anytime	Medium

The City of Edmonton's Urban Forest Asset Management Plan (2021) also demonstrates a range of activities that can be included as a part of monitoring and management. The plan organized and summarized the activities into four work categories:

1/ **Inspections:** these can vary from checking that the asset is functioning as expected to measuring and assessing condition or performance.

2/ **Operations:** these are routine activities necessary to maintain natural assets' function and resilience.

3/ **Preventative maintenance:** these are regularly scheduled activities to maintain condition and avoid deterioration of a natural asset.

4/ **Corrective maintenance:** these are activities or interventions associated with a natural asset that has been significantly impacted by an external impact (e.g., extreme weather, invasive species, damage caused by overuse of people).

Within these categories, Edmonton's plan identifies specific activities across the range of urban forest assets. Some of the operations and maintenance activities for grassland naturalization and naturally wooded assets are summarized in Table 23.

Table 23: Edmonton's Urban Forest Asset Management Plan — Operate/Maintain Activities for Natural Assets (partial)

ASSET TYPE	INSPECTIONS	OPERATIONS	PREVENTATIVE MAINTENANCE	CORRECTIVE MAINTENANCE
Grassland Naturalization	• Inspection in years 2 and 5 as part of asset creation.	• Mowing along curbs, trails, and property lines.	• Noxious weed control 2 years after naturalization.	• Unscheduled inspections and actions in response to customer service requests including removing unauthorized bike trails, litter, and safety hazards.
Naturally wooded stands	• Inspect Stands acquired from developers to confirm if area will be accepted into the City's inventory. • Annual inspections for noxious wees and unauthorized activities. • Insect monitoring. • Tree risk assessment along maintained trail network annually for stationary targets like picnic tables and playgrounds, every 10 years for other areas. • Fire risk mitigation inspections every 1 to 10 years to assess fuel load. • Viewpoint inspections every 5 years for vista pruning. • Ecological health monitoring.	• Clearance pruning along maintained trail edges. • Hazardous tree removal. • Noxious and prohibited noxious week control.	• Viewpoint vista pruning every 5 years including clearing and disposal of vegetation. • Fuel load reduction by applying recommended treatment and removing and disposing of material. • Tree risk mitigation along maintained trail network annually for stationary targets like picnic tables and playgrounds, every 10 years for other areas.	• Unscheduled inspection and actions in response to customer service requests including removing bike trails, litter, and safety hazards. • Storm response including inspections and removing hazardous trees and branches. • Restoration of disturbed stands.

When identifying monitor/manage activities, it may be necessary to prioritize some activities over others. Several factors can help inform the prioritization. One such consideration is LOS. A local government may want to prioritize or target management actions in locations of greater human traffic where LOS are more important. The City of Edmonton (2021) relates maintenance activities to technical and customer LOS. For example, their "tree risk assessments are completed more frequently in areas close to human activity such as picnic tables, playgrounds, and along transportation corridors and pathways."

A prioritization strategy for natural asset operation and maintenance efforts might also consider variations in the criticality of natural assets' contribution to core services provided by the municipality, because operation and maintenance activities should be strategically allocated to critical assets when resources are limited. Priority activities can be communicated in the lifecycle management strategy. This can be helpful in allocating resources when facing staff or budgetary constraints. The City of Edmonton's 2021 plan defined operation and maintenance activities into three categories: urgent work, essential work, and less essential or desirable work (Table 24).

Table 24: Prioritizing Operate/Maintain Activities in Edmonton's Urban Forest Asset Management Plan

ASSET CATEGORY	URGENT WORK	ESSENTIAL WORK	LESS ESSENTIAL OR DESIRABLE WORK
All Assets	• Storm response including inspections and removing hazardous trees and branches. • Hazard tree removal • All notification and call are responded to within 24 hrs depending on the size of the storm and volume of calls.	• Inspections and actions in response to customer requests concerning safety hazards and sightline concerns. Customer requests are responded to within 5 days.	• Inspections and action in response to customer requests concerning non-safety issues. Customer requests are responded to within 5 days. Work may not necessarily be scheduled or completed within 5 days.
Natural Wooded Areas	• None in addition to storm response and hazard tree removal.	• Annual inspections for prohibited / noxious weeds and unauthorized activities. • Mechanical control of prohibited / noxious weeds. • Insect monitoring • Tree risk assessment and mitigation along trail network. • Clarance pruning along formal trail edges. • Fire risk mitigation (e.g., fuel load reduction by applying recommended treatment and removing and disposing of material).	• Inspect stands acquired from developers to confirm if area will be accepted into the City's inventory. • Viewpoint maintenance every 5 years including vista clearing and disposal of vegetation. • Restoration of disturbed stands. • Ecological health monitoring.

5.5 Rehabilitate and Restore

To understand activities associated with rehabilitate/restore, it is useful to distinguish between monitor/manage and rehab/restore. Monitor/manage is focused on preserving the existing condition and functionality of an asset, ensuring its continued operation at current levels. Rehab/restore, by comparison, involves significant repair to extend the life and enhance the performance of existing assets (MFOA, 2018). Substantial rehabilitation and restoration can be expected in response to specific impacts or damage due to unmitigable risk events or from cumulative long-term degradation causing the asset's functioning to be significantly impaired. This would be the case, for instance, when a natural asset has been either impacted by an extreme event (e.g., forest fire) or is in a degraded condition that requires intervention more significant than typical operation and maintenance activities.

As with the other life cycle stages, there are planning activities that will take place as part of rehab/restore; the goal of these activities is to improve asset condition, improve an assets resilience to anticipated risks, or to respond to certain extreme hazard events that require reactive rehabilitation. Within this context, planning activities for rehab/restore could include:

- Assessing restoration needs for the targeted site(s)
- Developing site plans and designs for the restoration activities
- Acquiring necessary permits and approvals
- Determining which assets maybe more susceptible to certain risks
- Engaging with Indigenous groups, as well as consulting with other agencies, the public, or other stakeholders and rightsholders

Table 25 summarizes how rehab/restore was factored into Edmonton's (2021) Urban Forest Asset Management Plan for some of Edmonton's natural assets.

***Table 25**: Rehab/Restore Activities in Edmonton's Urban Forest Asset Management Plan*

<table>
<tr><th>ASSET CATEGORY</th><th>REHABILITATION OPTIONS</th></tr>
<tr><td>Grassland naturalization</td><td rowspan="2">• Renewal of areas by planting smaller native trees, shrubs, and wildflowers to create a healthy ecosystem providing added benefits, beauty, biodiversity, and to provide resources for wildlife to flourish and re-establish.
• Restoring damaged areas</td></tr>
<tr><td>Natural Wooded Areas</td></tr>
</table>

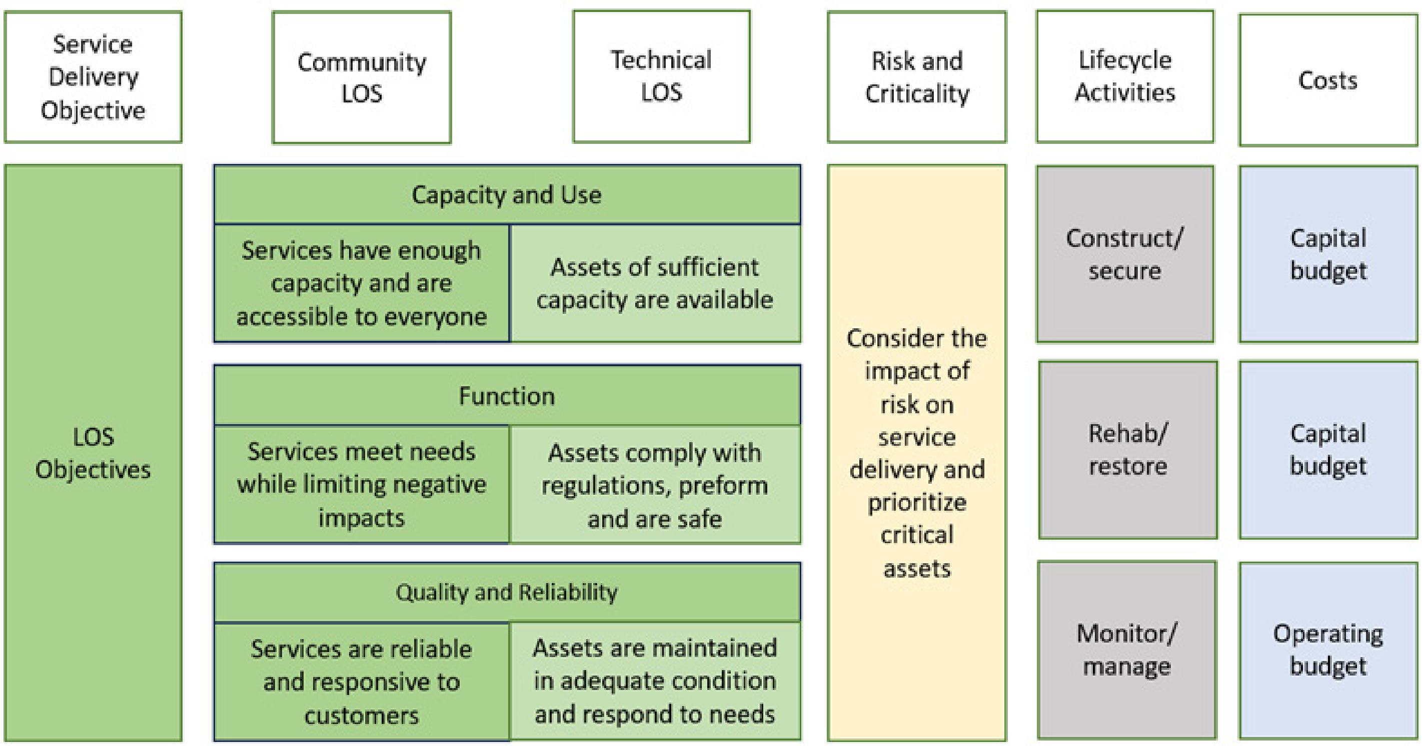
6 Financial Strategy

Once the lifecycle management activities have been established for each lifecycle stage, the next task in developing an asset management plan is to consider the lifecycle costs associated with those activities. The costs can then be assessed against the available budget and new funding sources considered to the extent necessary. This section focuses on how to estimate lifecycle management costs, linking the costs to target levels of service, and establishing a long-term funding strategy.

6.1 Establishing Lifecycle Management Costs

The lifecycle management costs should include the cost of all identified activities for each stage of the lifecycle (construct/secure, operate/maintain, rehabilitate/restore). This should be done in the context of LOS and risk and criticality as per Figure 7.

***Figure 7:** Establishing Lifecycle Costs in the Context of Levels of Service and Risk*



As is described in Figure 7, lifecycle management costs are driven by the lifecycle management activities (across the lifecycle stages) that, when considered in the context of risk and criticality, will deliver the established community and technical LOS to ensure corporate LOS are achieved. The link between cost, lifecycle activities, risk and criticality, and LOS are described in the following sub-sections, along with other important lifecycle cost considerations, specifically demand forecasting and life cycle management scenarios. In addition to these factors, consideration should be given to the following:

- The time period over which estimates will be established. The lifecycle costs should be estimated over a predefined timeline that is relevant to the municipality's asset management planning horizon.
- Assumptions related to inflation rates and projecting costs into the future. Historical data can be helpful in informing expected future costs and inflation rates. Variables should be periodically updated to reflect the most recent historical data available.

6.1.1 Linking Lifecycle Management Costs to Levels of Service

As is depicted in *Figure 7*, when establishing lifecycle management cost, it can be helpful to organize the assessment around identified LOS categories. For each LOS, local governments should consider the metric as well as the current and target performance. They should then assess what the management cost would be to maintain the current performance and/or to achieve the target performance. More specifically, consideration should be given to:

- Capacity and use related LOS that inform the need for expansion activities (i.e., the need to construct and secure new natural assets).
    - *Table 26* provides examples of capacity LOS related to the amount of owned natural assets and the percent of canopy cover. In this example, to assess the lifecycle management cost, local governments should consider what the associated capital cost would be to achieve the desired increase in natural asset ownership or canopy cover. The table also contains a capacity and use example related to restoration to add natural assets (i.e., restore land that is not currently in a natural state). Here, consideration should be given to the capital costs associated with the restoration.
- Functioning related LOS inform the need for upgrading activities (i.e., the need to rehabilitate or restore natural assets).
    - Table 26 provides an example of a function LOS related to restoration activities associated with restoring an existing asset that has degraded. In this example, to assess the lifecycle management cost, local governments should consider what the associated operating cost would be to achieve the desired restored area per year.
- Quality and reliability LOS inform the need for operation and maintenance activities (i.e., to monitor and maintain natural assets).
    - Table 26 provides examples of quality LOS related to ecological condition and biodiversity. In this example, to assess the lifecycle management cost, local governments should consider what the associated operational cost would be to achieve the desired increase in the state of good repair, or the percent of area dominated by invasive species.

***Table 26:** Hypothetical LOS Measures, Indicators, and Associated Lifecycle Management Cost*

TECHNICAL LOS MEASURES	SERVICE ATTRIBUTE	INDICATORS	CURRENT LOS	DESIRED LOS	LIFECYCLE COST
Extent of protected natural areas	Capacity	# of ha of natural heritage system under public ownership	50 ha	65 ha	Construct and secure action, associated with capital budget
Urban heat reduction benefits of the urban forest	Capacity	% tree canopy provided by the urban forest	20%	35%	Construct and secure action, associated with capital budget
Local government-managed restoration of existing degraded assets	Function	# of ha restored per year	5 ha per year	10 ha per year	Restore and rehab actions, associated with operational budget
Local government-managed restoration to create new assets	Capacity	# of ha restored per year	5 ha per year	10 ha per year	Restore and rehab actions, associated with capital budget
Local government-managed restoration in priority areas.	Function	# of ha restored per year	5 ha per year	10 ha per year	Restore and rehab actions, associated with capital budget
Ecological condition of the natural assets	Quality	% of natural assets in very good or good condition, broken down by asset type in the inventory[37]	70%	80%	Monitor and maintain actions, associated with operational budget
Biodiversity of native species	Quality	% area where invasive species are dominant	20%	15%	Monitor and maintain actions, associated with operational budget

37 Requires the local government to establish the methodology it will use to determine condition and develop a condition rating system. See *Section 2* of this guidance document for approaches to condition assessment.

Estimating the lifecycle management costs to maintain current performance or achieve target performance should consider the range of anticipated activities noted in *Section 5*. Cost estimates can be based on historical cost information or data on hand related to historical activities. Alternatively, *Table 27* (adapted from CVC, 2020) contains sample lifecycle costs for a range of natural assets according to the lifecycle stages identified in the associated report. These costs should be considered illustrative and would need to be vetted for each local government. Nonetheless, CVC (2020) provides a framework that municipalities can follow or use as a template to help anticipate what typical life cycle management costs might be for their own natural assets.

Table 27: Lifecycle Costs for the Lifecycle Stages Identified in the Credit Valley Conservation Authority's Lifecycle Framework for Natural Assets

ASSET TYPE	ASSET SUB-TYPE	PLAN, INVENTORY AND ASSESS – YEARS 1-2	SECURE AND CREATE – YEARS 3-5	INSPECT AND MAINTAIN – YEARS 6-10	MONITOR AND MANAGE – YEARS 11-50	TOTAL MODERATE LIFE CYCLE COST
Lawn	Manicured Lawn – creation (1 ha)	$1,313	$202,575	$79,800	$693,579	**$977,267**
Stream Corridors	Stream Corridor Rehabilitation – small system (500 m x 20 m)	$109,100	$741,000	$58,500	$206,000	**$1,114,600**
	Stream Corridor Rehabilitation – large system (500 m x 30 m)	$145,050	$1,050,500	$83,500	$306,000	**$1,585,050**
	Stream Corridor Erosion Control – small system (100 m x 20 m)	$54,502	$195,020	$58,500	$206,000	**$514,022**
	Stream Corridor Erosion Control – large system (100 m x 30 m)	$74,920	$349,200	$83,500	$306,000	**$813,620**
Wetlands	Wetland Meadow Marsh – creation (1 ha)	$27,863	$357,250	$13,750	$254,000	**$652,863**
	Wetland Meadow Marsh – acquired (1 ha)	$11,675	$67,000	$11,250	$262,000	**$351,925**
	Wetland Thicket Swamp – acquired (1 ha)	$11,775	$71,000	$11,250	$278,000	**$327,025**
Upland Meadows	Cultural Meadow – creation (1 ha)	$15,935	$168,700	$15,250	$127,500	**$327,385**
	Cultural Meadow – acquisition (1 ha)	$8,540	$41,600	$15,250	$127,500	**$192,890**

ASSET TYPE	ASSET SUB-TYPE	PLAN, INVENTORY AND ASSESS – YEARS 1-2	SECURE AND CREATE – YEARS 3-5	INSPECT AND MAINTAIN – YEARS 6-10	MONITOR AND MANAGE – YEARS 11-50	TOTAL MODERATE LIFE CYCLE COST
Upland Forests	Deciduous or Mixed Forest – creation (1 ha)	$22,439	$192,520	$63,000	$198,000	**$475,959**
	Deciduous Forest – acquired (1 ha)	$20,450	$84,500	$20,050	$98,000	**$223,200**
	Cultural Plantation managed as Mixed Forest 0 acquired (1 ha)	$21,080	$90,800	$24,750	$120,000	**$256,630**

Note that the table above does not show costs associated with implementing non-infrastructure solutions. Non-infrastructure solutions do typically impact a local government's operating budget and should also be included in the financial strategy. For example, the cost to deliver an educational and awareness-building program to enable households to manage source water onsite needs to be adequately planned and budgeted for, even though it does not involve direct management of natural assets.

6.1.2 Accounting for Risk

Lifecycle costing should also consider risk management and include appropriate contingencies. Indeed, an important risk treatment is allocating funding for contingencies. Lifecycle management strategies and their associated costs can be impacted by several factors beyond the control of the asset manager. It can therefore be prudent to consider such possibilities and factor in contingencies when articulating the lifecycle management costs. Risk factors that can influence lifecycle costs include:

- Extreme weather events that divert resources away from planned operation and maintenance activities.
- Drought and heat stress that impact the survival of newly planted natural assets.
- Human resource constraints.
- Legislation and regulations (e.g., species at risk) that could restrict activities to certain locations or times of the year.

6.1.3 Lifecycle Management Activities

Driven by established LOS and considering risks, lifecycle management activities are then identified and costed. This includes the cost of all identified activities for each stage of the lifecycle (construct/secure, monitor/manage, rehabilitate/restore:

- Construction and securing costs should be linked to a local government's planned development or expansion of their natural asset portfolio. This should consider estimating costs associated with securing new natural assets as part of the development process, or other securement mechanism as well as afforestation or any activities required to bring the asset up to the local government's standards and LOS.
- Monitoring and management costs are regularly scheduled costs associated with the inspection and maintenance of assets. To establish operate/maintain costs, assumptions can be made about the frequency of inspections, and preventative, and corrective maintenance activities. Such assumptions can be grounded in the need to maintain the condition of the natural assets to ensure the required LOS continues.
- Rehabilitation and restoration costs can be more challenging to estimate for natural assets relative to built assets as the lifecycle of natural assets is not tied to an end-of-life the in the way built assets are. For instance, as noted in *Section 5.5* it is not possible to predict rehabilitation costs since they are not necessarily correlated with age. If a municipality has identified priority areas for restoration activities, assumptions related to the timing of those activities can be built into the lifecycle management cost forecast. While Edmonton's Urban Forest Asset Management Plan notes possible rehabilitation options associated with natural assets, it states that these options are not included in the lifecycle cost forecasts due to insufficient data available to determine the frequency of their occurrence, or their unit costs. This is indeed a challenge for costing the lifecycle management for natural assets since the need for rehabilitation or restoration activities are not as predictable as with built assets. With natural assets the need for rehab/restore arises periodically due to random external events, or as a result of many years of neglect, which should be avoidable through ongoing preventative and corrective maintenance. Communities that have invested in restoration activities can leverage that work to inform and cost this stage of the lifecycle management strategy.

6.1.4 Demand Forecasting

Demand forecasting is an important consideration when assessing lifecycle management costs. Demand forecasting in the context of asset management is the process of predicting future demand for assets and their associate services. It is a crucial step in infrastructure and asset management, as it aids in decision-making and planning for future needs, and allocates resources efficiently to maintain, replace, or expand their asset base. Lee et al. (2004) highlights the importance of demand forecasting in infrastructure asset management, outlining its significance in effective planning and resource allocation.

Demand Forecasting and O. Reg 588/17

In Ontario, O. Reg. 588/17 outlines requirements with respect to LOS that every municipality, with a population over 25,000, shall prepare an asset management plan and develop demand forecasting for every asset class. While the literature on natural asset demand forecasting may currently be limited, there exists a valuable opportunity to draw upon the well-established methodologies employed for built infrastructure demand forecasting and to adapt them to the unique context of natural asset by leveraging the transferable aspects of these methodologies.

The process of demand forecasting encompasses various considerations. A report from the UK's National Infrastructure Commission (2017) highlights that economic growth significantly influences the demand for infrastructure services. The report emphasizes GDP and income as critical factors in demand forecasting. As population and wealth increase, there is typically an increase in the demand for infrastructure services, including heightened consumption of energy and water, and increased waste generation (National Infrastructure Commission, 2017). In the context of natural assets, expansion of traditional infrastructure, increased urban development, and population growth can all put additional pressure and demand on natural assets. Therefore, the financial strategy for natural assets should also consider anticipated changes in demand for natural assets and their associated services.

Using forest assets as an example, predicting future demand for such an asset is vital for sustainable forest management. Economic growth can significantly influence the demand for services provided by forest assets. As population grows, there may be increased demand for recreational opportunities and higher interest in ecosystem services like clean air and water, or urban heat reduction.

Another aspect of increased demand for natural assets that may need to be considered is the potential for increased damage to natural assets. One significant concern is the risk of overuse, which can result in heightened operations and maintenance costs related to preserving and maintaining natural ecosystems. As demand for nature-based recreational activities grows, there is potentially a corresponding need to balance conservation objectives with the use of natural resources. Moreover, the increasing demand for natural assets could expose them to a heightened risk from invasive species. With greater human activity and movement between different regions, the likelihood of introducing non-native species into natural ecosystem rises. As a result, managing invasive species may become a critical component of natural assets operations and maintenance efforts as demand increases.

The City of Edmonton's Urban Forest Asset Management Plan (2021) provides an example of how to incorporate demand forecasting into natural asset management planning. It provides a comprehensive overview of the demand drivers for urban forest assets, focusing on growth and future demand. This plan outlines key demand drivers, including population growth, legislative changes, climate shifts, public awareness, quality of life, economic factors, and technological advancements, and their anticipated impact on urban forest services. Understanding the factors that influence the natural assets and associated services is crucial for adapting to a dynamic world. An excerpt of the demand drivers for urban forest assets and their anticipated impact on services are shown in Table 28.

Table 28: Example of Demand Drivers in the City of Edmonton's Urban Forest Asset Management Plan

DEMAND DRIVER	PRESENT STATE	ANTICIPATED TREND	IMPACT ON SERVICES
Population	~1 million	Increase of 23,000 people per year reaching 1.5 million in 20 years	• Less land available for natural areas • More maintained trees to beautify new roads and parks • With new neighborhoods built there will be more open space areas and trees • Higher demand for natural areas and related maintenance services (e.g. litter pickup, monitoring for prohibited activities) • More customer calls and longer travel times for crews to access sites. Additional yards may be required for operational staff and equipment as the city continues to grow
Climate	• Average daily temperatures range from -11.7°C in January to 17.6°C in July • Yearly precipitation values range from 466 mm to 536 mm • Growing Season of 178 days	• Average temperatures 5 to 7°C warmer by 2080s • More rain, less snow, drier summers • Increased summer climatic moisture deficits • Potential changes in frequency and intensity of extreme weather events • Growing season increase to 243 days by 2080	• Demand for increased canopy coverage as temperatures increases • Increased demand for natural and naturalized areas to abate stormwater and prevent erosion • Increase in the number of hazards due to storm damage • Seasonal changes may change or impact the levels of service, extend planting season, require a shift in the types of species planted, and more maintenance including watering and inspections for insects and disease

The final step in demand forecasting is to establish a comprehensive and adaptive response to the forecasted demand. The City of London, Ontario's Corporate Asset Management Plan (2023) offers dynamic responses to forecasted forest demand, encompassing strategic planning, innovative planting solutions, efficient resource management, and public awareness initiatives. Given the constraints posed by urban growth and the specific impacts on street trees and tree canopy cover, the response prioritizes innovative planting strategies that extend beyond traditional urban spaces. A notable example is the collaboration between the Rapid Transit team and Parks and Forestry, where alternative planting sites near main Rapid Transit corridors were identified, both offsetting tree loss and improving the urban environment. The initiative to plant 600 – 700 trees along the Wellington and East Link corridors reflects a proactive effort to preserve tree canopy cover. Despite constraints like limited space, London's commitment to a 1:1 tree replacement ratio is key, as shown by its goal to plant a minimum of 3,000 trees annually to meet the 2065 tree canopy cover goals. The City of Edmonton's Urban Forest Asset Management Plan (2021) projects a significant expansion in its urban forest assets, categorized by maintained trees, natural areas, and naturalized areas. Edmonton anticipates an annual net increase of approximately 7,500 maintained trees, factoring in both additions and losses due to urban development, resulting in an addition of 375,000 maintained trees over the next 50 years. Regarding natural areas, Edmonton established the goal of owning 6,400 ha of natural areas, including 3,200 ha of naturally wooded areas. This goal involves acquiring an average of 28 ha of naturally wooded areas per year over the next 50 years, while ensuring no loss of current natural areas to development. The plan also forecasts a substantial increase in naturalized areas, from 745 ha to 3,100 ha, through a combination of planting and natural growth.

6.1.5 Lifecycle Management Strategy Scenarios

Developing and assessing lifecycle management scenarios can help ensure balance and weigh the trade-offs between costs and service levels. The specific scenarios will likely vary by local government and their individual strategic priorities and local context. However, some possible scenarios to consider might include:

- Variations in anticipated future demand
- Differences between maintaining current LOS and meeting desired LOS
- Exploring differences between improving the overall state of natural assets, versus maintaining the current state of such assets

6.2 Long-term Financial Needs Assessment

The ultimate objective of lifecycle management strategies and costing is to assess the long-term financial needs for natural asset management. Specifically, the financial needs assessment should address whether the current level of funding is sufficient to meet the current and target LOS. Questions a financial needs assessment should attempt to answer include:

- What lifecycle activities are required to meet the target LOS?
- Does current funding level provide enough resources to achieve target LOS?
- Is there a funding gap, and if so, how much additional funding is needed?
- If the funding gap is not able to be addressed, what is the impact on the desired LOS?
- Does the current funding enable sufficient reserves to account for future needs (intergenerational equity)?

The financial needs assessment should draw on and summarize the information and analysis described in Section 6.1. The results of the lifecycle management costs needed to meet target LOS should then be compared with current capital and operating budget funding to draw attention to any anticipated funding gaps.

7 Funding Sources

Once a long-term financial needs assessment has been completed and funding needs have been compared against available funding, a local government should have a general sense of whether the available funding is suitable to achieve the target LOS. When available funding is not sufficient, funding sources will need to be considered to help close the funding gap. This section reviews a range of potential funding sources local governments might consider in the process of closing the funding gap.

Natural asset management funding sources refer to the various approaches and mechanisms used to fund the conservation and sustainable management of natural assets. Common types of funding sources are identified in Table 29. These funding sources can be leveraged to help ensure lifecycle management strategies are sufficiently financed. This section provides a general overview of potential sources and is not intended to be comprehensive or prescriptive. Rather, the purpose is to provide an overview and examples as a starting point or source of inspiration for local governments.

***Table 29**: Funding Sources Available to Support Lifecycle Asset Management Strategies*

TYPES OF COMMON FINANCING STRATEGIES	DESCRIPTION
Direct Financing	This strategy involves covering capital costs through **taxation**, imposed **user fees**, or issuing **debt** at the time of acquiring assets or project kickoff. Debt repayments including principal and interest become part of the municipality's future operating expenses. This method is suitable for assets with shorter lifespans or lower values. High interest rate environments significantly affect the attractiveness of this method.
Dedicated Funds	Municipalities can transfer a portion of the operating budgets annually to a dedicated capital fund. This practice aims to accumulate funds for future capital projects and can earn interest, amplifying the contributions made. **Self-sustaining (Revolving fund)**: A dedicated fund that replenishes itself through the revenue or savings it generates from its investments. This model allows for continuous funding of projects without the need for additional external capital, promoting long-term financial sustainability.
External Grants	Municipalities can obtain grants from other levels of government or government bodies. It is essential for municipalities to stay informed about these programs, understand the criteria for approving capital projects, and have a formal asset management plan in place. Being proactive and prepared in meeting the acceptance criteria helps ensure compliance and avoid delays. It is crucial to only include grants as funding sources if there is a reasonable assurance of approval and receipt, as listing unconfirmed grants can create an overly optimistic financial strategy.

TYPES OF COMMON FINANCING STRATEGIES	DESCRIPTION
Beneficiary Contributions	This approach involves financing capital projects by collecting contributions from taxpayers who directly benefit from them. Charges can be collected over multiple years with favorable interest rates and the municipality should evaluate whether the projects primarily benefit specific landowners or have a broader community benefit.
Community Fundraising	In some cases, citizen groups may have an interest in fundraising for community projects, such as recreation centers, libraries, park equipment, etc. Caution should be exercised in projecting anticipated funding from this source. Unless firm agreements are in place, with guaranteed amounts of funding identified, a conservative approach should be taken to quantifying donations as part of the financing strategy.

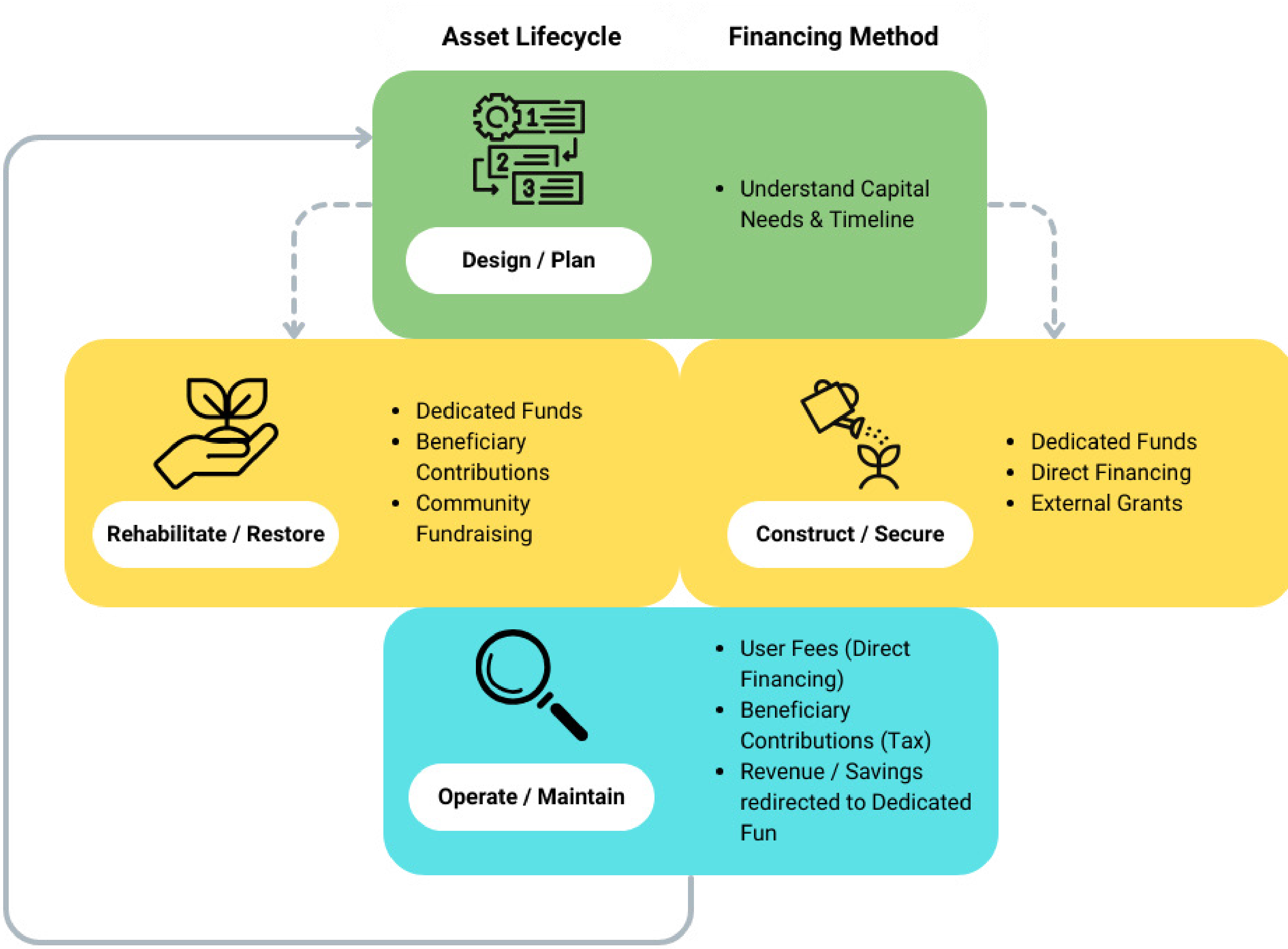
Development cost charges (DCC) are frequently cited as potential funding sources to support the rehabilitation of natural assets. In British Columbia, for example, DCCs are instrumental in facilitating the rehabilitation of natural assets, provided the initiative aligns with the criteria of a capital expenditure that supports a qualifying service. Additionally, this is contingent upon the restoration and enhancement activities directly or indirectly benefiting the development on which the charge is levied. Collaborative agreements between local governments and First Nations regarding service provision can be significant for natural asset protection strategies. These partnerships are beneficial in minimizing infrastructure redundancy, sharing both capital and operation expenses, and capitalizing on economies of scale.

In the context of acquiring operational funds, a notable example is the Environmental Reserve Fund established by the District of West Vancouver, BC.[38] The fund's primary application is to support initiatives that preserve and safeguard the natural environment. The fund is also used to address climate change through dedicated response strategies, mitigation efforts, and adaptive measures.

Some funding sources are more amenable to specific lifecycle stages. The Municipal Finance Officers' Association (2018) presents a framework that aligns various funding sources with different asset lifecycle stages. An adapted version of the MFOA framework is presented in *Figure 8*. While the MFOA's framework was developed for built assets, it is also suitable for the management of natural assets.

38 See *westvancouver.ca/government-administration/bylaws-licensing/find-bylaw/environmental-reserve-fund-bylaw*

Figure 8: Financing Sources and Lifecycle Stages



Faced with the pressures of climate change, aging infrastructure, and significant budget constraints, local governments in Canada are pursuing a range of funding options to finance natural asset management and ensure the continued delivery of LOS. The City of Kitchener, ON, for example, implemented stormwater user fees to support natural assets for stormwater management.[39] Kitchener previously relied on property tax revenues to fund its stormwater services. However, this approach places stormwater management in competition for funding with other municipal services such as parks, transportation, and social services. In response, Kitchener introduced stormwater charges, creating a stable and dedicated funding source specifically for maintaining, operating, and upgrading its stormwater infrastructure. The stormwater user fee is based on how much stormwater runoff a property owner creates. The stormwater runoff is determined by how much of the property is covered in impervious surfaces (i.e., buildings, driveways, and parking lots). Non-residential properties, which typically have larger areas of these impervious surfaces, generally incur higher stormwater fees, reflecting their larger contribution to stormwater runoff. The

39 See *www.kitchener.ca/en/water-and-environment/stormwater-utility.aspx*

monthly charges vary according to property type, with rates starting at $11.24 per month for small, detached homes with a building footprint of 105 m^2 or less and escalating up to $3,818.29 for non-residential properties with more than 39,035 m^2 of impervious area.

The City of Toronto introduced the Green Debenture Program to fund natural asset management activities.[40] Green or conservation bonds are increasingly popular as a financing option for municipalities to fund major projects. The program leverages advantageous borrowing rates to finance environmental capital projects. The program, which has successfully raised $630 million across three investment rounds, demonstrates this strategy in action. The proceeds are dedicated to various eco-friendly projects, including the Port Lands Flood Protection project[41], a critical initiative for rehabilitating natural assets.

40 See *www.toronto.ca/city-government/budget-finances/city-finance/investor-relations/green-debenture-program/*

41 See *portlandsto.ca/about/*

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Appendix A: Natural Asset Management and Conservation Management Plans

A natural asset management plan refers to the application of public asset management planning to natural assets. This is typically a high-level plan intended to guide investments in infrastructure asset management at the corporate level over a minimum 10-year time frame, factoring in key information related to criticality of the assets and associated risks to the provision of services. This should be considered distinct from a detailed conservation, natural heritage, or site-specific management plan, which is akin to an operations and maintenance plan for built assets. If such detailed management plans exist, they can be used to inform the broader natural asset management plan. However, it is not the intent of an asset management plan to provide prescriptive site-specific plans for natural assets. The table below compares asset management plans with conservation management plans.

ASSET MANAGEMENT PLAN FOR THE NATURAL ASSETS' ASSET CLASS OR GROUP (ORGANIZATION-WIDE)	CONSERVATION MANAGEMENT PLAN OR NATURAL HERITAGE MANAGEMENT PLAN (SITE SPECIFIC)
A long-term investment plan (10+ years) that outlines the current or desired LOS for natural assets, organization-wide, the risks to be managed, and the estimated costs to implement the lifecycle management strategy for the assets.	A management plan for a natural heritage system or protected area. May comprise most natural assets of significance within the local government jurisdiction or may focus on a specific natural area.
May include non-infrastructure solutions that seek to influence stewardship of natural assets on private lands.	Focus is on management of publicly owned assets, within the local government`s direct sphere of influence.
May consider core services and co-benefits derived from natural assets outside of the local government`s jurisdiction (e.g. watershed scale), such as stormwater services, source water quality and quantity.	Focus is on conservation to sustain ecosystem health.
May require collaboration with neighbouring jurisdictions, provincial or federal governments, private landowners, Indigenous Nations, and the broader community.	May require collaboration with stakeholders and rightsholders that influence conservation outcomes in the plan area.
Represents one over-arching, high level investment plan for the whole organization.	Multiple management plans for natural areas throughout the local government`s jurisdiction may be needed. May identify restoration priorities in specific areas and include a detailed operations and maintenance plan for the specific plan area.
Should align with existing master plans, studies, heritage system management plans, Official Community Plans, etc.	Should align with levels of service articulated in organization-wide asset management plans and policies.

Appendix B: Guidance Materials

ALBERTA MUNICIPAL AFFAIRS

Getting started: Toolkit User Guide. Quick start tools and templates for building an asset management program. (2015) *open.alberta.ca/publications/getting-started-toolkit-user-guide-for-building-an-asset-management-program*

ASSET MANAGEMENT BC

Asset Management for Sustainable Service Delivery: A BC framework. (2019) *www.assetmanagementbc.ca/wp-content/uploads/Asset-Management-for-Sustainable-Service-Delivery-A-BC-Framework-.pdf*

Integrating Natural Assets into Asset Management: A sustainable service delivery primer. (2019) *www.assetmanagementbc.ca/wp-content/uploads/Integrating-Natural-Assets-into-Asset-Management.pdf*

MUNICIPAL FINANCE OFFICERS' ASSOCIATION OF ONTARIO

Asset Management Framework: A guide to asset management for municipalities in Ontario. (2018). *mfoa-amp.ca/*

NATURAL ASSETS INITIATIVE

Defining and Scoping Municipal Natural Assets. (2018) *mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf*

Advancing Municipal Natural Asset Management Through Professional Planning: Twelve action steps — Decision-Maker Summary. (2019). *mnai.ca/media/2019/07/SP_MNAI_Report4_June2019.pdf*

Managing natural asset to increase coastal resilience: Guidance document for municipalities. (2021). *mnai.ca/media/2021/11/MNAI-Coastal-Asset-Guidance-Doc-cover-101-combined.pdf*

Now what? Guide to next steps in natural asset management. (2022) *mnai.ca/media/2022/04/what-next-document-104.pdf*

The Federation of Canadian Municipalities also provides a wealth of resources, training, and funding to help municipalities strengthen their asset management practices. *fcm.ca/en/programs/municipal-asset-management-program*

Value of Nature to Canadians Study Taskforce.

Completing and Using Ecosystem Service Assessment for Decision-Making: An interdisciplinary toolkit for managers and analysts. (2017). Ottawa, ON: Federal, Provincial, and Territorial Governments of Canada. (En4-295-2016-eng.pdf (*publications.gc.ca*)

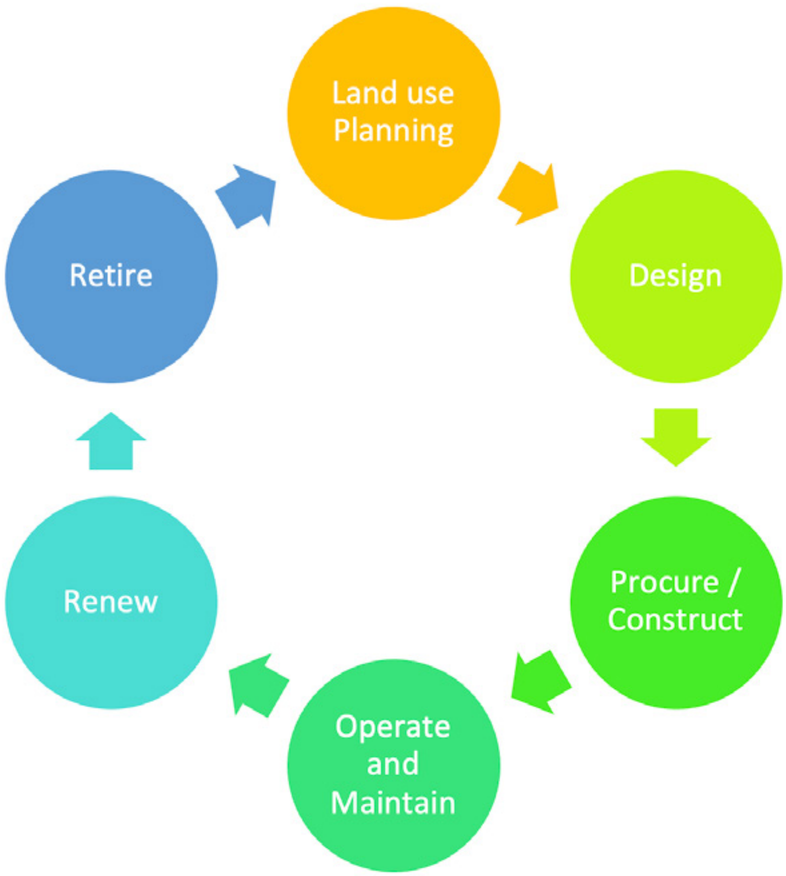
WATER RESEARCH FOUNDATION

Asset Management Framework for Forested and Natural Assets. (2020). *gibsons.ca/wp-content/uploads/2021/03/American-Water-Foundation-4727-Final-Report-March-2021.pdf*

Appendix C: Review of Life Cycle Management Stages

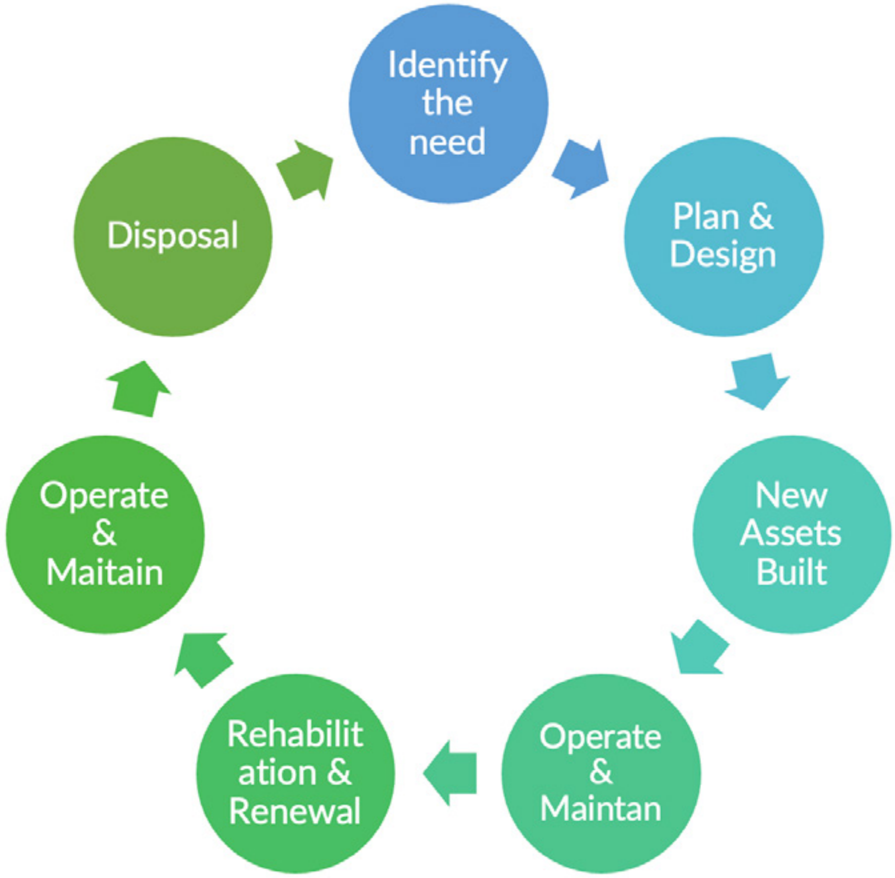
Asset management BC (2019) presents a 6-stage asset management lifecycle, shown in Figure 9. The first stage, land use planning, sets the direction for the type and scale of infrastructure that will be needed in a community. Subsequent lifecycle stages consider asset design, procurement and construction, operation and maintenance, renewal, and finally retirement of assets.

Figure 9: Asset management lifecycle stages, adopted from Asset Management BC (2019).



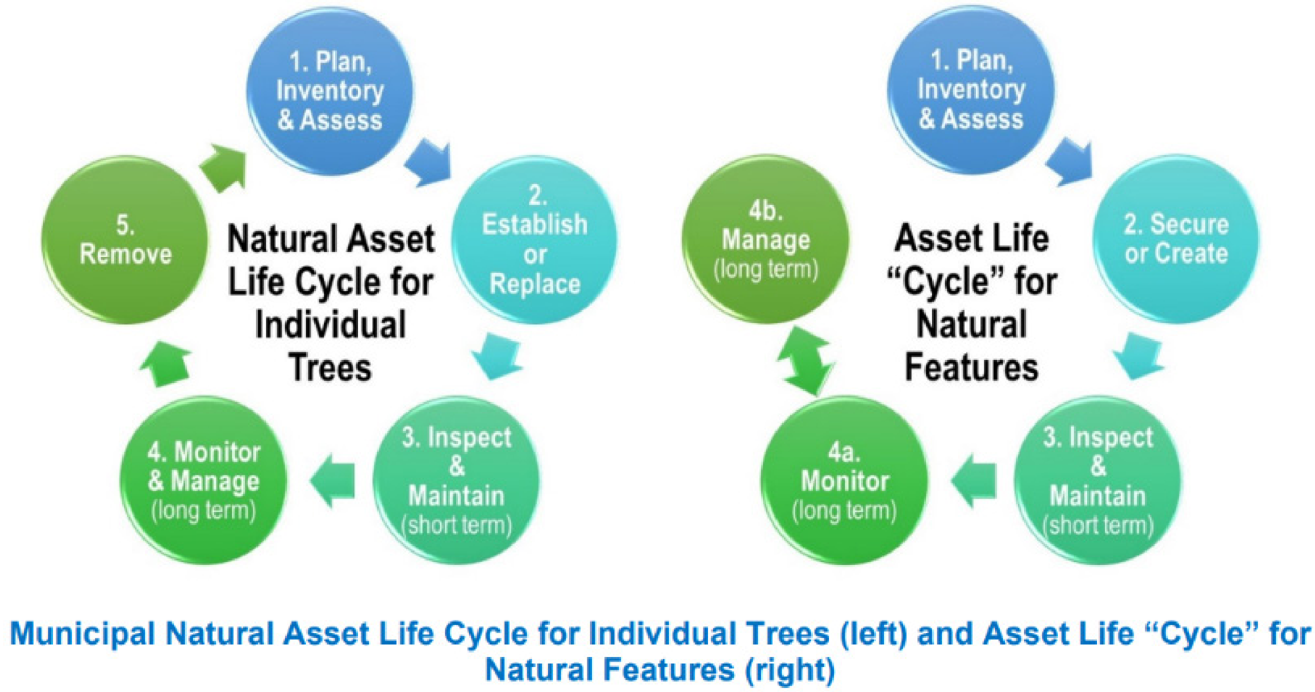
The City of Edmonton, through their Urban Forest Asset Management Plan, articulates a lifecycle for natural assets as outlined in *Figure 10*. The lifecycle components identified in Edmonton's Urban Forest Asset Management Plan largely align with those articulated by Asset Management BC, although the defined stages and specific language employed differ slightly.

***Figure 10**: Asset Lifecycle, Adopted from Edmonton's Urban Forest Asset Management Plan (2021)*



A lifecycle framework for natural assets was developed for the Credit Valley Conservation Authority (CVC, 2020). This framework recognizes two lifecycle management cycles for the municipalities in Peel region, as depicted in *Figure 11*. As is shown in the figure, the lifecycle of assets that have an end of life (e.g., street trees) differs from those that don't (e.g., forest or wetland areas). The CVC lifecycle is similar to that of Asset Management BC (2019) and City of Edmonton (2021) in a number of ways. It starts with a 'plan, inventory, and assess' phase, which encompasses strategizing for existing natural assets or planning the development of new assets. This is followed by an 'establishment' phase, which involves the creation, establishment, or replacement of the asset. The subsequent phases focus on monitoring and management, both in the short and long term. Finally, for assets with a finite lifespan there is a 'removal' phase.

Figure 11: Municipal Natural Asset Lifecycle for Assets with Limited Life (Left) and Asset Lifecycle for Assets without a Removal Phase (right). Obtained from CVC, 2020



Appendix D: Ontario Conservation Authorities Expertise and Support on Natural Asset Management

The Role of Conservation Authorities in Natural Asset Management

1.0 Introduction to Conservation Authorities in Ontario

Conservation Authorities (CAs) are distinctive organizations specific to Ontario, responsible for managing water and other natural resources at the watershed scale, rather than within political boundaries such as municipalities. The mandate of CAs is to undertake watershed-based programs to protect people and property from flooding and other natural hazards, and to conserve, restore and responsibly manage natural resources for economic, social and environmental benefits. There are 36 CAs in Ontario and they collectively oversee the watersheds encompassing 95% of the province's population.

Although CAs are charitable or non-profit organizations, they are legislatively mandated by Ontario's Conservation Authorities Act, 1946. Historically funded by the Province, in the 1990s most CAs transitioned to being funded primarily by the municipalities within their respective watersheds. Consequently, many of the services provided by CAs are intricately linked to the needs and resources of the municipalities they serve.[1]

2.0 The Importance of the Watershed Scale

CAs operate at the scale of entire watersheds, aligning with both ecological and hydrological processes, and allowing for more comprehensive environmental management. Initially designed to address erosion and sedimentation, flooding, drought and degraded water quality, the watershed scale also proves instrumental in safeguarding drinking water sources, undertaking effective ecosystem restoration, and implementing adaptive management strategies for water resources and natural heritage systems. Managing at this scale ensures that the entire catchment area is considered together in decision making, reducing the downstream impacts of poor upstream conditions, and fostering a holistic approach to environmental conservation.

1 For further information on the history of Conservation Authorities, see: "Ontario Conservation Authorities: Myth and Reality" by B. Mitchell & D. Shrubsole (1992), and "Conservation by the People: The Story of the Conservation Authorities in Ontario" by A.H. Richardson (1974).

Municipalities retain ownership and management responsibilities for many natural assets within their jurisdictions. Therefore, to operate at the watershed scale, collaboration is essential. Multiple CAs often exist within the boundaries of a single municipality and most CAs concurrently serve multiple municipalities. This highlights the intricate network of relationships necessary to implement effective watershed governance in Ontario.

3.0 The Role of Conservation Authorities in Managing Natural Assets

CAs in Ontario play a crucial role in managing and protecting natural resources, including water, land, and biodiversity. Their responsibilities are diverse and vary across different authorities, but common roles and functions include watershed planning, natural hazard management, floodplain management, conservation area management, and biodiversity conservation.

CA roles vary due to several factors, including regional differences in population density, economic contexts, and land use patterns. CAs adapt their programs and initiatives to address the specific challenges and opportunities presented by their respective watersheds, ultimately working towards the common goal of sustainable natural resource management.

CAs have been at the forefront of managing natural assets for decades. They work to prioritize conservation across southern Ontario and help empower municipalities to make informed decisions regarding the management of natural assets. This occurs through a wide variety of work, but six examples are outlined below.

1/ **Natural Heritage System Planning:** Mapping and strategic management of interconnected natural areas, aiming to improve the conservation of biodiversity and ecological integrity within a region. This planning process considers habitat connectivity, species protection, and landscape-scale conservation to sustain a resilient and functioning natural ecosystem.

2/ **Restoration:** Rehabilitating ecosystems that have been degraded or damaged, aiming to enhance biodiversity, ecosystem functionality, and overall environmental health. Restoration activities may include reforestation, wetland rehabilitation, and the removal of invasive species.

3/ **Environmental Monitoring:** Collecting and analyzing data to track changes in environmental conditions over time. This process helps assess the effectiveness of conservation and management efforts, identify emerging issues, and provide a foundation for evidence-based decision-making in environmental management.

4/ **Ecosystem Research and Valuation:** Researching ecosystems to understand their structure, functions, and the services they provide to human well-being. Valuation includes assessing the economic and non-economic benefits of ecosystems.

5/ **Offsetting Guidelines:** Some CAs have developed ecosystem offsetting guidelines to help determine the amount of offsetting required to replace lost or altered ecosystems. Where this has been done, it is under the principle that offsetting must be considered only as a last resort within a mitigation hierarchy of: Avoid, Minimize, Mitigate, Offset (Compensate).

6/ **Water Resource Systems:** Integrated management of water-related assets, including rivers, lakes, wetlands, and aquifers.

3.1 MANAGING NATURAL ASSETS VS. NATURAL ASSET MANAGEMENT

An important distinction exists between managing natural assets and natural asset management. Natural asset management is a prescribed process focused on making decisions about the collective set of assets in a municipality. It requires strategic planning and prioritizing actions across the entire system. Whereas managing natural assets is making decisions about individual asset types – for example, how do we maintain our forests. This involves considering the most effective and efficient management activities for each individual asset type. Both are vital and connected, but it is important to understand the difference between them. CAs have a long history of managing natural assets, but natural asset management is a relatively new process that is still evolving.

3.2 RELATIONSHIP WITH MUNICIPALITIES

CAs have a distinctive governance model that helps creates a critical and unique relationship between CAs and municipalities. CAs operate as corporate bodies with a reporting relationship to the Ontario Ministry of Natural Resources and Forestry (MNRF). However, it is the municipalities, located wholly or partially within a watershed, that are one of the main financial supporters of the associated CA and actively participate in decision making. The Board of each CA is formed with council representatives from member municipalities making the CA directly accountable to its municipalities. This unique partnership requires collaboration and coordination to effectively share responsibility for preserving the natural systems of southern Ontario.

Additionally, CAs often act as natural asset experts for a wide variety of municipal initiatives. They also support the many experts within municipalities with specific applied research needs.

4.0 How Conservation Authorities Support Natural Asset Management

4.1 INTRODUCTION

CAs provide leading-edge science and expertise to support evidence-based municipal decision making. This experience makes them well positioned to leverage their expertise managing natural assets to help further the field of natural asset management. Their role can be broadly defined in the following areas, though exact roles will vary between difference CAs:

- **Leadership:** CAs can be leaders in natural asset management, leveraging their historical role in conservation to guide the integration of natural assets into asset management processes.
- **Subject Matter Experts:** Drawing on years of experience, CAs can contribute specialized knowledge to shape natural asset management initiatives, ensuring a comprehensive and effective approach to natural asset management.
- **Asset Managers:** CAs actively manage and protect natural assets within their jurisdictions, they can employ natural asset management to optimize the ecological, social, and economic benefits of these assets aligned with their mandate.
- **Data Collectors and Managers:** As stewards of environmental data, CAs play a pivotal role in providing the necessary information for informed decision-making in the natural asset management process.
- **Educators:** Leading natural asset management CAs can act as educators, providing training and raising awareness among municipalities, CAs, and other stakeholders about the importance of natural assets, the benefits of natural asset management, and specific details on how to undertake natural asset management.

The Conservation Authorities Act establishes three categories of programs and services provided by Conservation Authorities: mandatory, municipal, and other. The mandatory programs and services ("Category 1") are established by O. Reg. 686/21 under the Conservation Authorities Act. CAs may also agree to provide specific programs and services on behalf of municipal partners under a Memorandum of Understanding or other such agreement ("Category 2"). Through Category 2 services, CAs can provide support for municipal natural asset management to one or more municipal partners. Natural asset management work could also occur under other programs and services ("Category 3"). This would be a situation where a CA seeks funding from other sources and the CA board supports the work. This additional funding (outside municipal funding) could support monitoring, natural asset inventories etc.

The following section provides some additional context and guidance on natural asset management specific to Ontario's governance structure. It also provides some useful examples of CAs work. It is organized to align with the main Guidance Document's structure. The examples show the breadth of CA expertise and may be helpful to communities across Canada.

4.2 ESTABLISH THE STATE OF NATURAL ASSETS

4.2.1 Geographic Scope

Defining the geographic scope of natural assets in southern Ontario includes considering some additional complexity. The options from *section 2.1.2* of the Guidance Document are reiterated below, with additional considerations for municipalities in southern Ontario. A more detailed explanation of context-specific considerations accompanies each option.

1/ Focus on municipally owned and/or managed natural assets;

Municipalities own and manage natural assets on their lands. Many of these assets are open to the public, but some exist on public land that is not accessible (e.g., wastewater treatment facilities). All natural assets within a municipality should be included in asset management processes. An added consideration for municipalities within CA jurisdictions is determining whether there are lands managed by a municipality but owned by the CA. The reverse circumstance can also occur, though is less common. In these situations, it is important to build strong collaborative relationships and work together to decide which organization should include the natural assets in their asset management plan. There may be situations where a natural asset type makes sense to be included in both the municipal and CA plans. This is feasible if it is clear who is responsible for which management and/or budget activities. Clear and open communication and collaboration is key to managing these situations effectively.

2/ Focus on Conservation Authority owned and managed natural assets;

Conservation Authorities typically own and manage a variety of land, often substantial, for the purposes of environmental conservation, public recreation, and education. In 2022, CAs reported they collectively own a total of 205,739 hectares across Ontario. This land is distributed across the watershed(s) in a CA's jurisdiction and often exists in multiple municipalities. CAs should be working to include natural assets in their asset management plans. And, by nature of their jurisdiction, natural asset management focused on CA lands will occur at the watershed scale.

3/ Include all natural assets within the municipal boundary (regardless of ownership); or

The jurisdictions of municipalities and CAs include natural assets that are privately owned by individuals, corporations, or non-governmental organizations. These assets often provide important services, but their management is the responsibility of the private owner or organization. Private owners may choose to sell or develop the natural areas, therefore they are not necessarily protected. Natural asset management can include privately-owned natural assets, but it is important to determine clear objectives for including private land.

4/ Include the natural assets that provide a service to the community (e.g., the watershed boundary that provides drinking water services).

If there is interest in undertaking a watershed scale natural asset management plan, it is important to set clear objectives within the context of other watershed scale planning in Ontario. CAs develop and implement watershed plans to address issues related to water quality, quantity, and overall ecosystem health. These plans typically involve collaboration with various stakeholders including municipalities, Indigenous Communities, businesses, and the public. Ontario also has the Clean Water Act, 2006, which has enabled significant source water protection initiatives and planning focused on promoting clean, safe, and sustainable drinking water for Ontarians. Undertaking a watershed scale asset management plan needs to be completed in collaboration with the relevant CA and should ideally by linked closely with CA watershed planning. Asset management and watershed planning are complementary processes that can benefit each other (See *page 102* for an example).

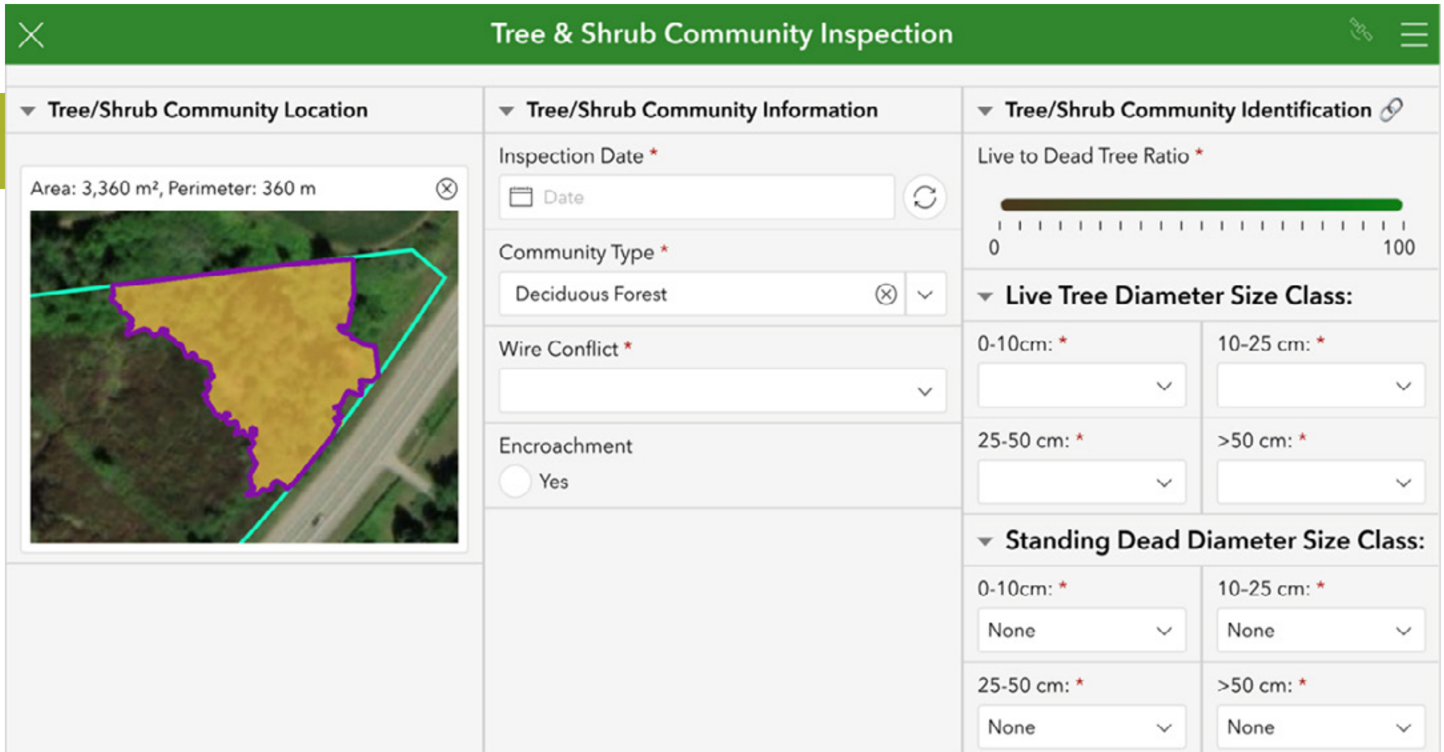
4.2.2 Inventory

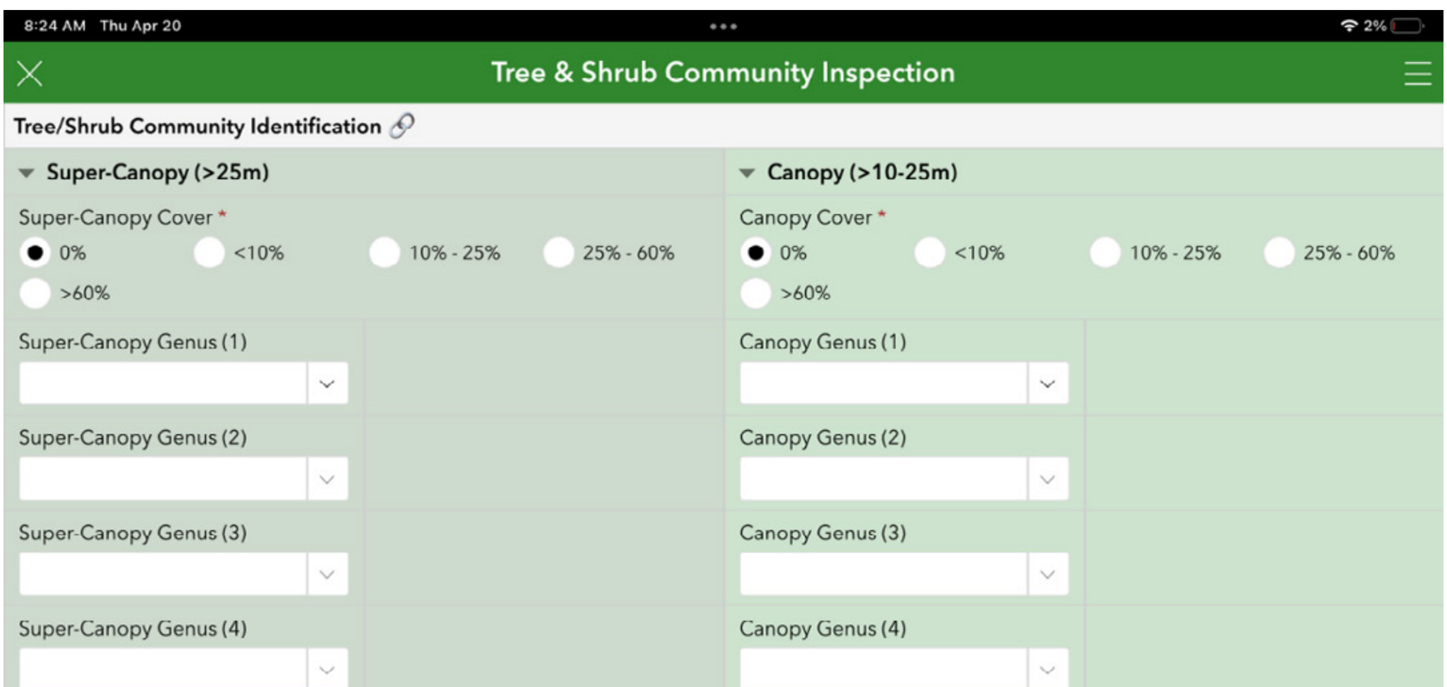
The Guidance Document summarizes a variety of potential data sources for a natural asset inventory. It mentions Ecological Land Classification (ELC) mapping, which is an Ontario provincial standard for classifying and mapping natural communities. It was developed by the Ministry of Natural Resources in 1998 and was intended to support planners and ecologists in organizing ecological information into logically integrated units. The structure of ELC mapping makes it easily transferable to a natural asset inventory. Many CAs, particularly the larger CAs, collect ELC data that is available through their open data portals. Typically, the data will cover a large portion of the land in their jurisdiction but will generally focus on natural features larger than 0.5ha. This mapping can be used to inventory different natural assets on municipal owned land, CA owned land, and private land.

4.2.3 Condition

Natural asset condition assessments will ideally occur in the field because direct observation of the actual ecosystem can provide valuable information that may not be reflected through remote sensing alone. While remote sensing can provide coarse information on asset condition, on-the ground field work can provide more details and information on causes of the condition. Field assessments allow for the detailed observation of habitat structures and complexities, risks (e.g., invasive pests), and noting of specific features that may impact the ecological condition of an asset (e.g., garbage dumping, unauthorized trails).

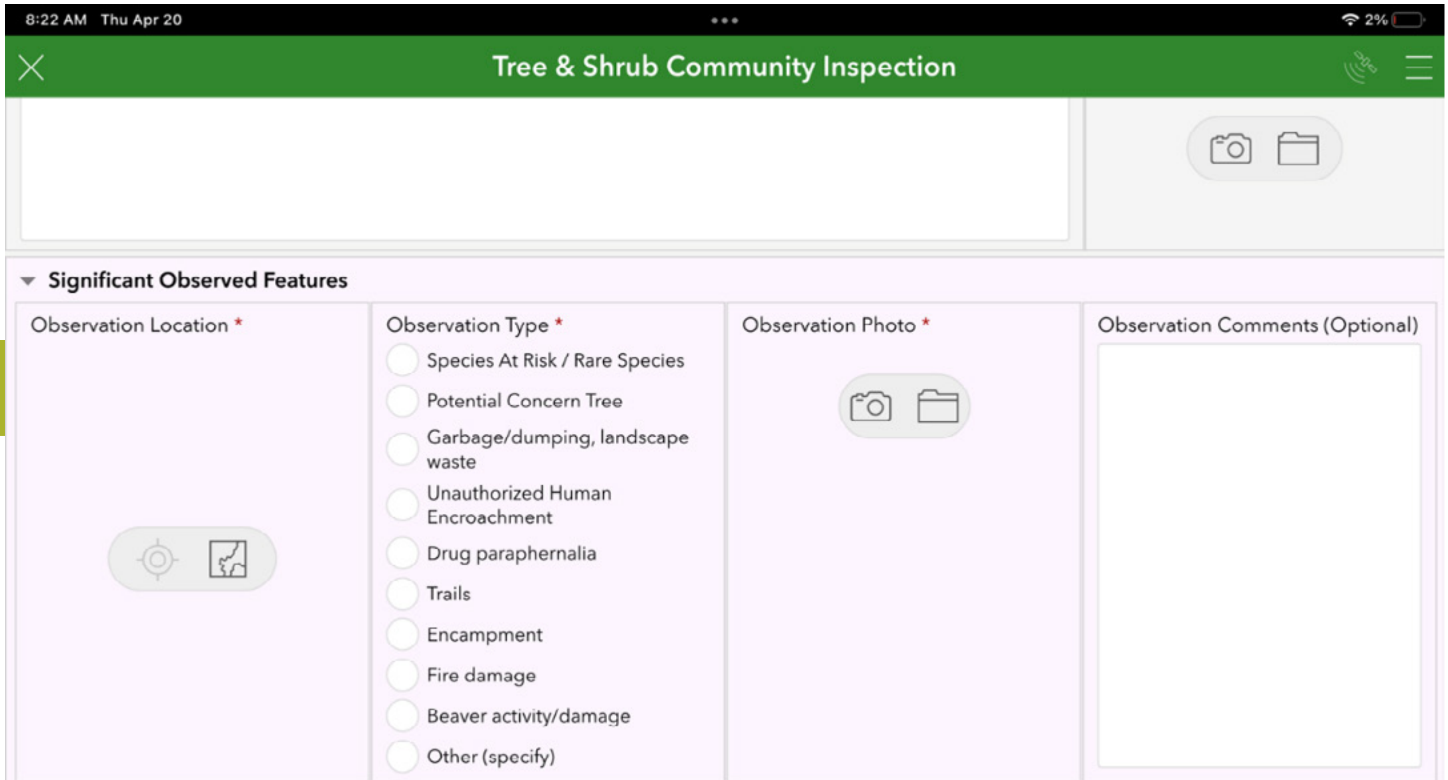
The Guidance Document references a Rapid Inventory and Condition Assessment Method (RICAM) for Natural Assets" developed by Credit Valley Conservation Authority (CVC) to help guide efficient collection of field data for natural asset management. The approach helps natural asset managers quickly inventory and assess the conditions of the natural assets in their jurisdiction or area of responsibility. RICAM provides a means to evaluate the condition of a natural asset through assessing its ecological structure and composition, and the intensity and extent of disturbances to the asset. Recently this method was used by CVC and Toronto and Region Conservation Authority (TRCA) to create a tree and shrub community (forest) inspection protocol for natural assets on municipal properties. The data was collected over one summer season with multiple field crews. The crews had strong tree identification skills but were a mixture of students and recent graduates without official forestry or arboriculture designations. They completed a high-level assessment to build the asset inventory, including condition information. Each field team was provided a GPS unit and a handheld device to collect data directly into a database. The data collection forms are provided below as an example of an application of the rapid assessment protocol for forests.






8:25 AM Thu Apr 20
2%
Tree & Shrub Community Inspection
Tree/Shrub Community Identification
Sub-Canopy (>2-10m)
Sub-Canopy Cover *
0%
<10%
10% - 25%
25% - 60%
>60%
Sub-Canopy Genus (1)
Sub-Canopy Genus (2)
Sub-Canopy Genus (3)
Sub-Canopy Genus (4)
Understory (>0.5-2m)
Understory Cover *
0%
<10%
10% - 25%
25% - 60%
>60%
Understory Genus (1)
Understory Genus (2)
Understory Genus (3)
Understory Genus (4)


8:26 AM Thu Apr 20
2%
Tree & Shrub Community Inspection
Tree/Shrub Community Identification
Groundcover (<0.5m)
Groundcover *
0%
<10%
10% - 25%
25% - 60%
>60%
Groundcover Genus (1)
Groundcover Genus (2)
Groundcover Genus (3)
Groundcover Genus (4)
Tree Tally by Species (Prism Factor 2x) | Averages 0 : 0
Tree Tally Genus *
Tree Tally Species *
Live Tree Tally *
0
Dead Tree Tally *
0
1 of 1

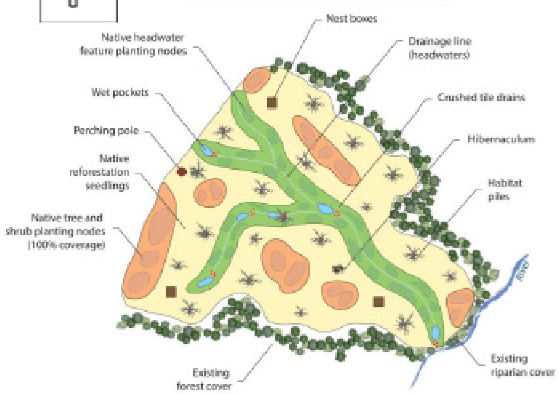


4.2.4 Replacement Costs

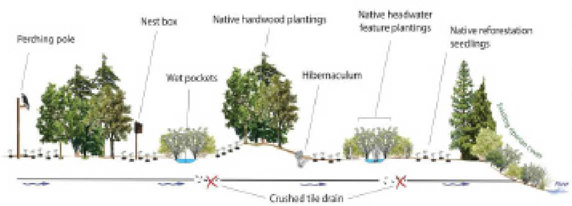
CAs play a crucial role in planning, implementing, and overseeing ecological restoration projects. These projects often focus on ecosystems that have been degraded, damaged, or were non-existent. CA staff may have local restoration costs for a variety of ecosystems that can be used for calculating current replacement cost in asset management. For example, TRCA annually updates a report of costs to replace different ecosystem types. Below is an excerpt showing reforestation costs for a mixed wood forest ecosystem, including project management, site preparation, tree planning, habitat installation, and monitoring.

F

ENHANCED REFORESTATION



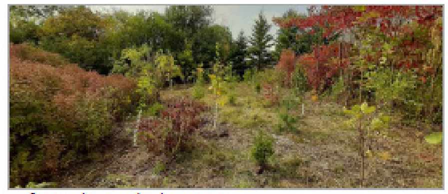
ENHANCED REFORESTATION TYPICAL PLAN



ENHANCED REFORESTATION TYPICAL CROSS SECTION

Details:

Project planning and development (detailed design and project management), site preparation, wildlife structures and/or bird box installation



Reforestation monitoring, year 1

Reforestation monitoring year 1

Reforestation monitoring year 5

Features to include in Design:

- Reversal of altered hydrology (crushed tile drains, decommissioning straightened ditches)
- Proper erosion and sediment control methods
- 20 - 30 Habitat structures (log perches, large woody debris, hibernacula, nest boxes)
- Site preparation and removal of invasive species
- 100% woody vegetation (native trees and shrubs, including bareroot seedlings) planted.
  - Shrubs planted in groups of 10 at 1 m spacing (1,000 pieces)
  - Bareroot trees scatter planted at 1.7 m spacing (1,000 seedlings)
  - Potted trees planted in groups of 10 at 2.45 m spacing (1,000 pots)
- 4 kg native meadow seed mix for disturbed soils
- 46 kg erosion and sediment control cover crop
- 1,500 m of deer fencing to mitigate or prevent predation of, and damage to, terrestrial plantings by wildlife

Project Goals:

- Restore ecosystem form and function
- Restore soil and soil processes
- Restore natural hydrologic processes
- Enhance and restore natural cover and essential habitat

Suggested plant species:

Planting early to mid-successional tree and shrub species based on specific site conditions and existing vegetation, species might include:

- Elderberry
- Sumac
- Dogwood
- Birch
- Eastern white cedar
- White pine
- Poplar
- Spruce

Enhanced Reforestation Planting Typical Cost Estimate (1 ha)		2023 Cost Year	
Project Management	**Notes**	**Cost ($)**	
Project Management	Initiating, planning, executing, controlling, and closing	$	5,065.64
	Subtotal	**$**	**5,065.64**
Contingency	10%	$	506.56
	Total	**$**	**5,572.21**
Site Preparation			
Equipment	4 days of equipment time for minor grading, tilling, seeding. (Truck, trailer, tractor, tractor Implements, ATV)	$	3,501.75
Materials	Herbicide application, (46 kg) cover crop, (4 kg) native seed	$	7,919.60
Labour	4 days of implementation for 2 staff	$	5,080.53
	Subtotal	**$**	**16,501.88**
Contingency	10%	$	1,650.19
	Total	**$**	**18,152.07**
Deer Fence			
Equipment	Truck, trailer, ATV	$	4,013.10
Materials	15 rolls of fencing (100m rolls), 675 T-bars (2.3 m), staples and flagging tape	$	18,033.75
Labour	7 days for installation, maintenance and removal for 4 staff	$	15,798.73
	Subtotal	**$**	**37,845.58**
Contingency	10%	$	3,784.56
	Total	**$**	**41,630.13**
Planting			
Equipment	Truck, trailer, ATV	$	5,590.20
Materials	1,000 tree seedlings, 1,000 potted (2 gal) shrubs, 500 potted (2 gal) coniferous, 500 potted (2 gal) deciduous, and (3 loads) mulch	$	32,863.95
Labour	8 days implementation for 5 staff	$	21,511.68
	Subtotal	**$**	**59,965.83**
Contingency	10%	$	5,996.58
Plant Replacement	25% replacement of material	$	16,894.53
	Total	**$**	**82,856.94**
Habitat Installation			
Equipment	4 days of equipment time for minor grading and structure installation. (Truck, trailer, tractor, tractor Implements, ATV)	$	3,829.35
Materials	4 bird boxes and (5 loads) wood/logs	$	5,691.00
Labour	4 days implementation for 2 staff	$	8,663.25
	Subtotal	**$**	**18,183.60**
Contingency	10%	$	1,818.36
	Total	**$**	**20,001.96**
Site Assessment	3 Rapid Restoration Assessment visits (year 1, 3 and 5) with reporting	$	5,633.59
	Total	**$**	**5,633.59**
	Project Management Subtotal	**$**	**5,065.64**
	Site Preparation and Planting Subtotal	**$**	**132,496.89**
	Contingency and Replacement Subtotal	**$**	**30,650.78**
	Monitoring and Assessment Subtotal	**$**	**5,633.59**
Note: Add 13% HST if applicable.	**GRAND TOTAL**	**$**	**173,846.90**

4.3 LEVELS OF SERVICE

As outlined in the Guidance Document, natural assets can provide multiple services and co-benefits. When a municipality aims to develop levels of service metrics related to biodiversity, habitat, water quantity/quality, or floodplain areas, engaging CA staff can be useful because they would bring specific scientific expertise. Due to the wide variety and large number of services provided by natural assets, defining levels of service necessitates substantial collaboration across municipal departments. This collaboration effort should extend to inter-organizational cooperation, where CAs and municipalities can work closely together to set and prioritize levels of service for natural assets.

One option that can help address the large number of potential levels of services metrics it to divide services into two categories: core and secondary. Core services would be the primary reason(s) a natural asset is conserved or managed. Secondary services would cover those additional co-benefits that are important to a municipality. The core services, rather than the secondary services, drive implementation or maintenance work and the later stages of asset management. Example levels of service for watercourse natural assets can be found below, these are an excerpt of a Green Stormwater Infrastructure Asset Management Toolkit written by TRCA for the Green Infrastructure Ontario Coalition. Please note that the storm return periods in the table are only provided as examples and there are different local regulatory events used across Ontario. It is also important to note that that climate change could be incorporated into this type of metric and this would likely involve using a longer return period.

Table 3 Examples of Level of Service for Streams

Core Services – Streams		
Service Attributes that Matter to Customers or Elected Leaders	**External LoS Performance Indicator**	**Internal LoS Performance Indicator**
Properties are **protected** from riverine flooding	Number of residential properties not flooded by nearby adjacent streams.	A floodplain capacity for 100-year return period storm
		Percent of the floodplain that is developed OR For small streams without floodplain mapping: Percent of development within 25 ft of riparian area on either side of the stream centreline
		Number of buildings prone to riverine flooding during a 100-year return period storm
It is **safe** to be in and around streams and trail/path/road infrastructure is **minimally damaged** during storm events	Percent of customers satisfied with how well streams are maintained	Percent of streams in good or very good condition
		Total spent on erosion damages and repairing stream degradation ($)
	Number of signs communicating risk to public	Percent of riparian area developed
		Date of urbanization surrounding stream
		Cost of repairs to damaged trails in the flood plain during storm ($)
		Cost of repairs to damaged sewer and water infrastructure within the stream valley ($)
	Number of visits to combined sewer overflow or warning websites	Percent effective impervious area of the watershed
	Percentage of length of trails closed due to erosion or flooding impacts	Number of indicators of erosion, e.g., number of uncontrolled outfalls
	Number of trail or road service requests relating to safety of watercourses	Number of bank stability projects undertaken to help prevent erosion
		Percent of bank stability projects that use natural approaches
Streams are **clean**	Percent of time stream water quality meets minimum standard for recreational use	Percent of community with stormwater quality control in place

Core Services – Streams		
Service Attributes that Matter to Customers or Elected Leaders	**External LoS Performance Indicator**	**Internal LoS Performance Indicator**
	Percent of public users satisfied with cleanliness of streams	Number of CSO events
Accessibility and Connectivity – streams are accessible to the public and there are stretches of uninterrupted natural stream landscapes	Percent of stream that is natural landscape	Number of road crossings
		Total length of stream piped or length of each piped section of stream
		Total length of stream channelized
		Number of aquatic migration barriers in the steam
		Stream connectivity to the floodplain (measure of entrenchment or incision – entrenchment and/or incision ratio)
	Kilometers (or miles) of trails along streams	Number of stream trail access points

Secondary Services – Streams		
Service Attributes that Matter to Customers or Elected Leaders	**External LOS Goal**	**Internal LOS Goal**
Streams are **aesthetically** appealing	Kilometers/miles of stream that are naturalized	Total length of stream restoration projects
		Median age of stream restoration projects
		Number of streams with restoration projects in the last x years
Streams provide **healthy habitat**	Number of streams where ecologically sensitive species are found	Number of bank and bed barriers to fish and amphibians
		Aquatic biodiversity index (fish, plants, benthic)
		Type of bank material (ranking scale)
	Number of educational signs along the watercourse	Number of residents reached by watershed/aquatic education programs
		Number of participants in "Adopt a stream" program
	Average grade of watershed report card	Riparian vegetation biodiversity
		Aquatic biology diversity
		Percent of vegetation planted that is native
		Land area impacted with invasive plant species

It can also be helpful to link levels of services to other planning documents, including those completed at the watershed scale. Below is an excerpt table on linking (Sub)watershed Management Plans to Asset Management and Master Planning. This table provides some additional examples of technical and customer levels of service metrics for natural assets and various services that can be applicable at different scales in asset management and other planning processes by municipalities and CAs.

Comprehensive (Sub)Watershed Study Component, Description and Recommendations	Flooding Example	Water Balance Example	Erosion Control Example	Water Temperature Example	Natural Heritage/ Natural Assets
Characterization and Issue Identification (Sub)watershed studies provide essential characterization of complex interconnections between built and natural infrastructure that can inform municipal infrastructure plans; for example monitoring analysis. For example, this should include: analysis of local climate stations and trends, Watershed-Wide Water Quality Model, Watershed-Wide Hydrogeological Model, and Watershed-Wide Fluvial Geomorphic Model, Risk and Return on Investment Tool (RROIT), i-tree, and Health and Well-Being: Cost Benefit Analysis of Restoration Actions Tool help to inform master plans.	The subwatershed characterization delineates the regulatory flood hazard and identifies undersized crossings and the number of structures in the floodplain. In this example, modelling indicates that the current regulatory flow rate in the main reach of the creek is 132 m^3/s. This flowrate results in 58 private structures, representing 3% of the total properties in the subwatershed being wholly or partially within the regulatory flood limit. Modelling indicates that a flowrate of 126 m^3/s is required in the main reach to completely eliminate the flooding of structures. Modelling has provided infiltration potential, including the delineation of ecologically significant groundwater recharge areas. Connecting Asset Value and Community Risk of Existing Conditions: The RROIT can quantify damages for varying storm events and help identify the cause of flooding issues (i.e., riverine, urban overland and areas in which the sanitary system may be at risk from stormwater inflow/riverine) to support municipal infrastructure programs and develop priority mapping of high contributing areas to facilitate the identification of management options. **Master Plan Connection:** Subwatershed characterization findings are integrated into the SWMP characterization to identify issues related to flood risk and stormwater infrastructure. Examples include areas of high flood risk and flood elevations for various return periods, which may be important for boundary conditions associated with urban stormwater models. **Asset Management Plan Connection:** The existing LOS is established for assets related to subwatershed features/processes. This example identifies the LOS associated with the regulatory flood event. **Existing Community LOS:** "I do not want my property to flood" **Existing Technical LOS:** "97% of properties are resilient to the regulatory flood event" "All buildings are protected at the 100-year design event level".	In this example, characterization data identifies the long-term percent of mean annual flow that is characterized as baseflow to be 6%. Historical records indicate that this number has been trending lower over the last 25 years concurrent with urban expansion in the subwatershed. Connecting Asset Value and Community Risk of Existing Conditions: The RROIT groundwater feature can be used to conduct a groundwater frequency analysis (event-based methodology). This analysis can identify areas with frequent high groundwater table in which infiltration techniques would not be suitable or where the sanitary system may be at risk of infiltration. **Master Plan Connection:** Subwatershed characterization findings are integrated into SWMP characterization to identify issues related to stormwater infiltration, including mapping of constraints and opportunities. The ESGRA mapping provides areas of opportunity for infiltration. **Asset Management Plan Connection:** The existing LOS associated with baseflow inputs to the stream is the focus of this example. The direct asset connection is infiltration-based low impact development practices owned and maintained by the municipality (e.g., in the municipal right-of-way and in parkland). **Existing Community LOS:** "The creek no longer supports healthy coldwater aquatic communities as a result of reduced groundwater flow contributions and corresponding increasing stream temperatures." **Existing Technical LOS:** % baseflow: is a performance indicator that is unique to each creek and/or reach in the subwatershed; may change based on short-term climatic factors; and requires long-term monitoring for characterization. The groundwater modelling and ESGRA mapping can provide insight with regard to infiltration processes as well as important infiltration areas. The local thermal regime is a closely related subwatershed health indicator, for which there is long-term data. For each reach of interest, the thermal regime will be used as key performance indictor. For example: "The current stream thermal regime is warm-cool". These conditions are typically reach specific.	Long-term fluvial geomorphic monitoring is needed to properly characterize fluvial processes and determine the location of erosion issues. Erosion is monitored through repeated visual assessments (e.g., rapid geomorphic assessments) and detailed cross-section surveys. Hydrologic modelling provides flow regime characteristics that are used in the evaluation of erosion potential through the consideration of flow energy and flow frequency duration curves. The results of this monitoring over the last 10-15 years have found urbanization to be the primary driver of erosion and stream instability. Connecting Asset Value and Community Risk of Existing Conditions: The RROIT can be used to identify the critical infrastructure that may be at risk of erosion for various storm events. This can support prioritizing emergency management plans, asset management planning, and location of erosion monitoring sites. **Master Plan Connection:** Subwatershed characterization findings are integrated into SWMP characterization to identify issues related to erosion sites and historical and/or ongoing erosion control projects. Erosion sites include sensitive stream reaches, as well as stormwater infrastructure discharge points and road crossings. **Asset Management Plan Connection:** The existing LOS is established for assets related to erosion control. This example identifies the LOS associated with stormwater controls. **Existing Community LOS:** "Local creeks banks are stable and do not pose a threat to me" or "My property/critical infrastructure is not impacted by erosion for a 2-year storm under historic climate conditions" **Existing Technical LOS:** "% of catchments that include erosion control per MECP Manual (i.e., detention of the 25mm event for a period of 48 hours)."	Typically within the watershed, a warming trend in stream water temperature at monitoring locations throughout the watershed has been observed from 2004-2016. This trend is observed in both rural and urban locations, and is consistent with trends across Canada, indicating that climate change may be responsible. Climate change is expected to exacerbate surface water quality degradation. In this example, characterization data consists of long-term instream temperature data dispersed throughout the watershed. Analysis determines the trends associated with daily maximum values as well as seasonal averages. The mechanism to manage and develop an approach to meet water temperature targets is directly linked to water balance, through the maintenance of the input of cooler groundwater. However, other tools are available through the use of riparian shading and cooling of stormwater discharges to the streams. **Master Plan Connection:** Subwatershed characterization findings are integrated into SWMP characterization to identify stream reaches that exceed temperature thresholds established for aquatic habitat maintenance. **Asset Management Plan Connection:** The existing LOS is established for assets related to subwatershed features and processes. This example identifies the LOS associated with stormwater thermal controls. **Existing Community LOS:** "The creek does/does not support diverse fish community" **Existing Technical LOS:** "Thermal stormwater controls in the form of infiltration-based low impact development practices are constructed on 5% of properties within an urban catchment" and "a 30-metre-wide naturally vegetated riparian area exists along 8% of urban watercourse within an urban catchment."	At a watershed scale, conservation authorities identify strategies as technical support to their municipalities and then, at a subwatershed characterization scale, the natural heritage system is refined based on a number of considerations, including policy, local opportunities, needs, and constraints in the area. The extent of the recommended natural heritage system can be a complex process. It is informed by natural heritage policy requirements, ecological health targets, groundwater conditions, water balance, water quality, and climate conditions. Natural heritage system design also considers social objectives, such trail network design, and access to parks and greenspace. The natural heritage system is made up of natural assets, for example, forests, which provide many services, such as cooling urban areas, performing stormwater management functions, removing air pollutants, filtering out pollutants and nutrients from runoff, and providing recreational opportunities. Characterization elements will typically include factors that include both coverage, measurements of the health of features, numbers and health of species, both aquatic and terrestrial. **Master Plan Connection:** Wetlands, forests, meadows, and other natural assets play a critical role in stormwater management (e.g., during rainfall events wetlands act like natural sponges that absorb water to prevent floods and can help buffer against drought). The stormwater management capacity of subwatersheds' natural assets can be a useful metric demonstrating their potential for flood mitigation and advocating for the need to maintain and restore natural assets (CVC (2021) Natural Asset Scaling Analysis (Internal Draft Report); CVC (2018) Municipal Natural Assets Initiative: Region of Peel Pilot (Environmental Protection Agency Stormwater Management Modeling report)). Reduced wetland and/or forest cover due to climate change and human impacts may affect hydrology/water balance, water temperature, and erosion. Maintaining and/or restoring natural assets to good condition is critical for meeting required LOS for stormwater management targets. Subwatershed characterization findings are integrated into SWMP characterization to identify which natural heritage systems/natural assets are at risk and require protection and/or restoration. This assessment is to be coupled with parks master plan requirements so that any overlap with recreational needs can be coupled with NHS characteristics. Similarly, the value of the NHS system to the community is to be considered. **LOS for Natural Assets** Specific targets and metrics for measuring LOS for natural assets will depend on the service being measured (i.e., whether it is stormwater management/flood protection, urban heat island reduction or recreation/general well-being). **Existing Community LOS:** "Woodland cover, wetland cover and % woodland interior are not sufficient to support ecosystem functions and features, including biodiversity." **Existing Technical LOS:** Different metrics are used for woodland cover, woodland interior, and wetland cover: Watershed woodland cover >40%. Where possible % net gain in urban areas, target based on feasibility and existing conditions. Watershed woodland interior is >10%. Where possible % net gain in urban areas, target based on feasibility and existing conditions. Watershed wetland cover >10%. Where possible % net gain in urban areas, target based on feasibility and existing conditions.

4.4 INCORPORATING RISK AND CRITICALITY

CAs implement and promote the use of natural assets to mitigate risks. This includes using natural features such as wetlands and forests to provide stormwater management, erosion control, and other ecosystem services. Many CAs possess substantial expertise in evaluating the risks affecting natural assets. In the context of risk assessment discussions, it is wise to involve CA staff, as they may possess specialized knowledge pertaining to specific types of natural assets.

Examining the distinctive feature of risks for natural assets is also crucial. Unlike traditional infrastructure, natural areas are particularly susceptible to cumulative risks, wherein adverse effects gradually accumulate over time due to persistent stressors. This vulnerability arises from the ecological complexity and sensitivity of natural areas to long-term pressures. While conventional infrastructure asset management often centres around event-driven risks, natural assets must navigate both cumulative and event-driven risks. Examples of both types of risks are provided below to underscore the diverse challenges associated with managing natural ecosystems.

Cumulative Risks

- **Climate Change:** Long-term shifts in temperature and precipitation patterns can impact natural asset health over extended periods. Changes in climate can affect tree growth, alter species composition, and contribute to the spread of pests and diseases.
- **Invasive Species:** The gradual spread of invasive species over time can have cumulative negative effects on natural asset ecosystems. Invasive plants, insects, or pathogens can outcompete native species, disrupt nutrient cycling, and compromise overall ecosystem health.
- **Fragmentation and Habitat Loss:** The ongoing fragmentation of natural areas due to urbanization or land development leads to the gradual loss of habitat and sensitive plant species.

Event-driven Risks

- **Wildfires:** Natural assets are susceptible to sudden and catastrophic events such as wildfires. These events, often triggered by lightning strikes or human activities, can cause rapid and extensive damage to vegetation and soil.
- **Windstorms and Ice Storms:** Sudden weather events, like severe windstorms or ice storms, can result in substantial damage to natural assets. High winds can uproot trees, break branches, and alter the structure of the forest canopy.
- **Disease Outbreaks:** While some diseases may have a cumulative impact, certain invasive pests can also spread rapidly, causing sudden outbreaks. For example, tree pathogens or fungi can lead to widespread mortality in a short period, impacting forest health.

To help assess both types of risk for a municipal natural asset project, CVC worked with Green Analytics to adapt the typical Probability and Consequence of Failure Approach to risk assessment (as described in *Section 4.3* of the guidance document) to be more tailored for natural assets. Rather than focus on "Consequence of Failure" they assess the "Severity of Impact" and when assessing the likelihood, they suggest focusing on "likelihood of occurrence" rather than likelihood of failure. They also suggest considering both recurrent impacts and single events to address the presence of cumulative risks. The tables below show their suggested 5-point rating scales to align with traditional asset management ratings.

Impact Rating	Description
Catastrophic (5)	Irrecoverable damage/irreversible impacts to the asset and/or major loss of its functions
Major (4)	Major, widespread impacts on the asset in the medium/long-term and/or severe and widespread loss of ecological functions. Damage that could be mitigated with intensive efforts.
Moderate (3)	Moderate impacts on the asset in the short/medium-term. Isolated but moderate instances of damage to the ecosystem functions that could be mitigated with intensive efforts.
Minor (2)	Minor, localized impacts on the asset in the short-term. Isolated but minor instances of damage to the ecosystem functions that could be mitigated.
Insignificant (1)	Appearance of threat but no real impacts on the asset or its functions.

Likelihood Rating	Recurrent Impact	Single Event
Highly Probable (5)	Could occur several times per year	More likely than not –probability greater than 50%
Likely (4)	May arise about once per year	50/50 chance
Possible (3)	May arise once in ~10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely (2)	May arise once in 10 years to 25 years	Unlikely not but not negligible –probability low but noticeably greater than zero
Improbable (1)	Unlikely during the next 25 years	Negligible –probability very small, closer to zero

4.5 LIFECYCLE MANAGEMENT STRATEGIES

As outlined in the Guidance Document, the goal of a Lifecycle Management Strategy is to identify the lifecycle phases and activities to help find the optimal level of maintenance and rehabilitation for municipal assets. This involves weighing the lifecycle costs against the potential improvement in condition, mitigation of risk, and movement towards expected service levels. This stage of asset management is the intersection of natural asset management and managing natural assets. It requires strategically planning and prioritizing actions across the system (asset management), while also considering the most effective management activities for each individual asset type as it proceeds through its life (managing assets). As outlined in *section 2.0*, CAs have decades of experience managing natural assets and can bring useful expertise and perspectives to help identify key natural asset management strategies. An example of CA guidance on this topic is available in *section 6.1.1* and *Appendix C*, which outlines CVC's Life Cycle Costing of Restoration and Environmental Management Actions.7.

4.6 WATERSHED SCALE

Collaboration is necessary for natural asset management to extend beyond municipal boundaries, and CAs or other watershed-level managers are ideal partners for such projects. An example of collaboration between municipalities, CAs, and a charity is the Grindstone Creek Watershed Natural Assets Management Project. Here, the Cities of Burlington and Hamilton, Conservation Halton, and the Royal Botanical Gardens worked together with Natural Assets Initiative (NAI) to begin the natural asset management planning process for their shared watershed. This project went above and beyond a standard natural asset management plan and shows what is possible when different parties' priorities align. Conservation Halton provided expertise in data, condition assessments, risk management, and modelling scenarios to support the work of the municipalities, nonprofit, and contractors such as NAI.

The purpose of this project was to identify, understand, and quantify the roles of natural assets as a component of services such as flood mitigation, stormwater management, and water quality control. To do so, the project partners created a natural asset inventory, assessed condition, identified risk, and defined levels of service. Additionally, they valued the ecosystem services provided by the assets.

The watershed scale was necessary in this study because natural assets upstream of the City of Burlington, outside of their political boundaries, for example, were still providing services for stormwater management within the City. Working together with neighbouring municipalities and CAs can align management and provide the resources necessary to maintain and enhance these natural assets. Going forward, the project team intends collaboratively manage and monitor the watershed.

4.6 FINANCIAL STRATEGY

Developing a financial strategy is a key stage in natural asset management. As with all stages, it is important that natural assets are considered in parallel to grey infrastructure assets. A final component of a financial strategy in asset management is dedicated to exploring financing approaches to address any overall funding gap across the system. This involves looking at existing and potential new funding sources. One of the next stages of advancing natural asset management in the Grindstone Creek watershed is a Watershed Financing Project to explore innovative financing models for ecosystem restoration and protection. It focuses on developing a conceptual financing model for sustaining and enhancing ecosystem services given the regulatory, institutional and coordination barriers that exist. This framework includes new economic tools, collaboration among multiple entities including Indigenous Communities and the private sector and builds on existing or enhanced governance structures. The study recognizes that a diverse model is needed because neither private nor public financing acting in isolation can address the issues of nature finance or the undervaluation of natural assets. The final product aims to include a recommended investment model and results of implementation.

5.0 Conclusion

This appendix underscores the pivotal role played by CAs in Ontario, emphasizing their unique position in managing water and natural resources at the watershed scale. Collaboration between CAs and municipalities is essential for effective watershed governance, recognizing shared responsibilities and distinct roles in environmental stewardship. Conservation Authorities, acting as natural asset experts, can contribute important expertise and perspectives to natural asset management projects at all scales. Good asset management incorporates long-term inter-departmental collaboration, and this extends to the important relationship between CAs and municipalities; they need to work closely together to achieve impactful natural asset management.

While the CA governance system is unique to Ontario, there are watershed organizations doing great work across the country. Some examples include:

- i/ **British Columbia:** Okanagan Basin Water Board, Fraser Basin Council
- ii/ **Alberta:** Watershed Planning and Advisory Councils
  E.g., North Saskatchewan Watershed Alliance, Bow River Basin Council
- iii/ **Saskatchewan:** Watershed Security Agency - Watershed Advisory Committees, Meewasin Valley Authority
- iv/ **Manitoba:** Watershed Districts
- v/ **Quebec:** Watershed Organizations
- vi/ **New Brunswick:** Watershed Caucus
- vii/ **Nova Scotia:** Clean Annapolis River Project
- viii/ **PEI:** Watershed Alliances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