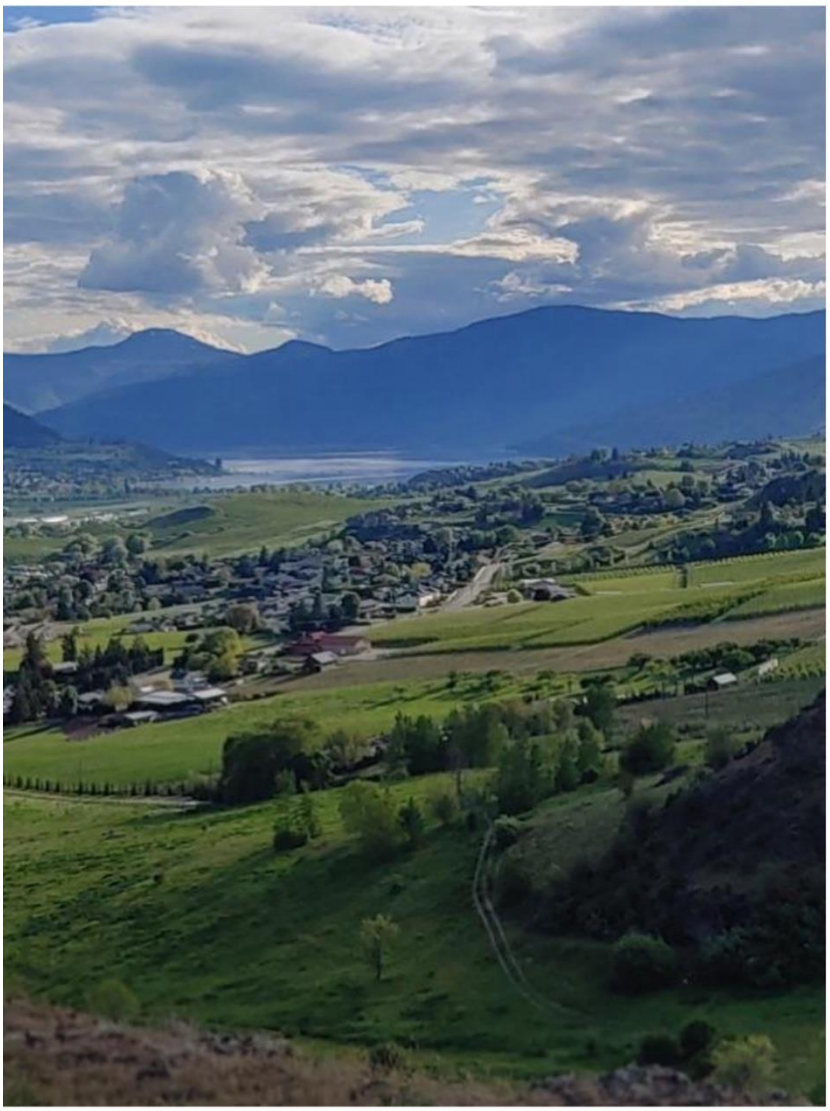
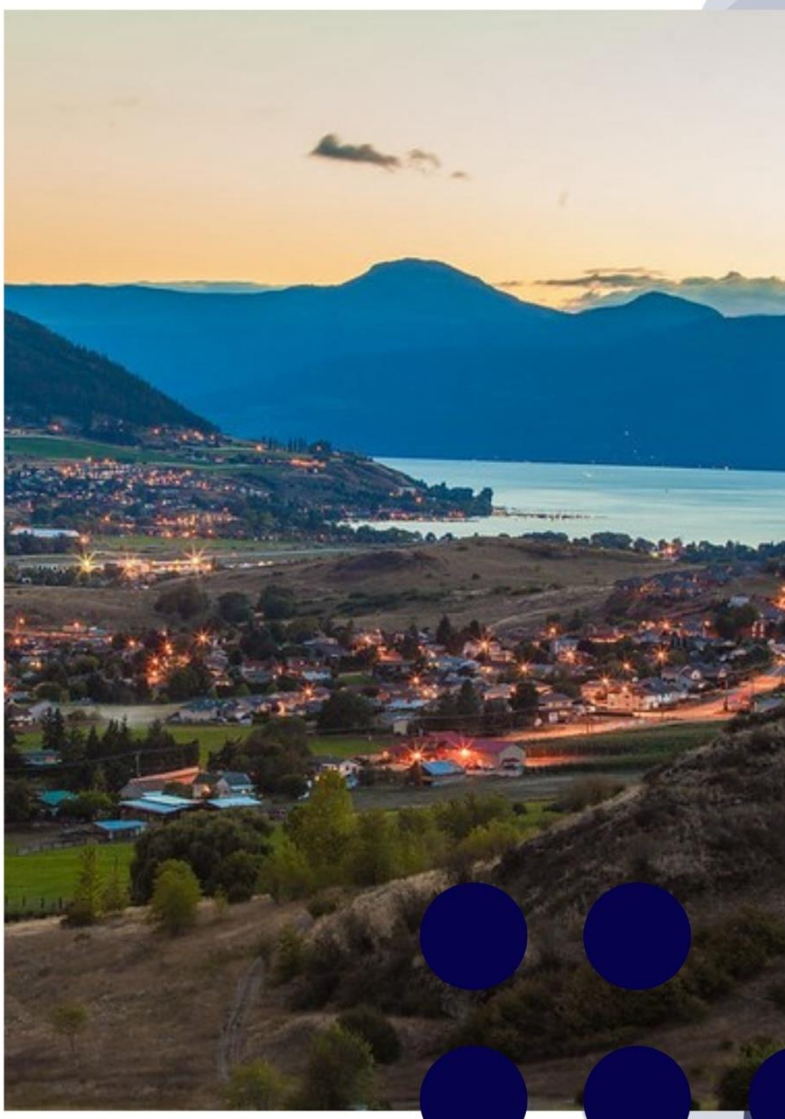
green ANALYTICS





City of Vernon
State of Natural Assets Report

January 2025

Executive Summary

Natural assets provide a cost-effective, resilient, alternative to some built infrastructure in terms of the services that they provide for local governments. Indeed, when managed properly, natural assets provide several valuable services such as stormwater management, urban heat reduction, air quality improvements, and recreation. Natural asset management, including the creation of a natural asset inventory that quantifies the natural assets within municipal boundaries along with the services those assets deliver, provides a framework for measuring and monitoring the ways people depend on and benefit from nature. In so doing, natural asset management helps ensure the services provided by natural assets are maintained or enhanced over time.

The City of Vernon is an area with significant natural assets, such as forests, grasslands, wetlands, and open water, that provide multiple benefits to Vernon residents. Natural asset management, like asset management for built infrastructure, provides an avenue for the City of Vernon to understand the location, extent and type of natural assets within the municipal boundary. It provides a foundation for identifying and implementing management actions to help ensure continued or enhanced service delivery in the future while also informing land use planning decisions. The purpose of this project was to complete a natural asset inventory and condition assessment for the natural assets within the Vernon municipal boundary. The inventory and condition assessment are foundational aspects of natural asset management and as such they position Vernon to continue to advance natural asset management over time.

The following results were derived from the inventory and condition assessment of the City of Vernon's natural assets.:

- **Inventory Approach**: An asset inventory for the City of Vernon was created using GIS. The inventory describes the type, location, and extent of assets within the municipal boundary. Assets are defined as either natural or enhanced according to the following:
    - Enhanced assets are assets that are designed and created to function like natural assets while incorporating human modifications. Examples include manicured greenspaces and urban trees.
    - Natural assets, sometimes called natural capital, are natural features that provide significant ecosystem services. Natural assets include forests, wetlands, and grasslands.
- **Asset Inventory**: Within the City of Vernon:
    - Enhanced and natural assets cover 9,188 ha within the municipal boundary (77% of the total area within the municipal boundary), including Canoe Bay (the Vernon Arm of Okanagan Lake).
    - Without Canoe Bay included, the enhanced and natural assets cover 7,075 ha of the City (60% of the total area within the municipal boundary).
    - Natural assets cover 7,411 ha or 81% of the asset area.
    - Enhanced assets cover 1,777 ha or 19% of the total area of assets.
    - There are 154 km of water flow routes. Of these, 137 km (89%) are ephemeral (seasonal or intermittent) and 17 km (11%) are constant flow.
    - Dominant natural asset types include forest assets, grassland assets and open water assets (when Canoe Bay is included in the open water area calculations).
    - Less dominant natural asset types include wetlands, riparian areas, and sparsely vegetated land.
    - The city owns 8% of the natural and enhanced assets within Vernon's municipal boundary.
- **Condition Assessment**: Natural assets in the City of Vernon were evaluated using indicators such as interior habitat, road density, and permeability of surrounding lands. The assessment ranked assets on a scale from very good to very poor. Results revealed most assets to be in very good or

good condition:

- The majority of the City's assets were rated as very good or good, with approximately 77% and 19% of the assets, respectively falling into these categories.
- Grassland and woodland assets have the highest percent of assets in very good condition with over 70% of these assets rated as such.
- Riparian and wetland assets have the highest portion of assets rated as fair condition. Of the 186 ha of riparian assets, 57 ha (30.3%) rated as fair condition. Of the 36 ha of wetland assets, 10 ha (29%) rated as fair condition.
- Riparian and sparsely vegetated lands were the only assets that included assets rated in poor condition. Of the 186 ha of riparian assets, 3 ha (1.3%) rated as poor condition. Of the 218 ha of sparsely vegetated assets, 0.7 ha (0.3%) rated as poor condition.

Recognizing natural assets and the range of services they provide to local governments and their residents is essential to ensuring these assets are effectively managed to avoid the deterioration of the services they provide. The natural asset inventory and condition assessment summarized in this report provide the foundation from which the City of Vernon can continue to advance in the field of natural asset management.

Table of Contents

1 Introduction

Municipalities across Canada provide services to local citizens through use of built assets. This includes, for example, stormwater management, transportation and parks. Local governments manage these assets through asset management practices that track the location, type, condition and risks to the assets. Like built infrastructure, natural assets provide services to local residents. The term "municipal natural assets" refers to the stock of natural resources or ecosystems that is relied upon, managed, or could be managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more local government services. Natural assets provide a cost-effective, resilient, alternative or complement to some built infrastructure. Indeed, when managed properly, natural assets provide several valuable services including stormwater management, urban heat reduction, air quality improvements, and recreation.

Despite their ability to deliver services the adoption of natural asset management is not widespread in Canada. A key factor contributing to this limitation is the lack of information and data pertaining to the assets and the services that they provide. To overcome this, there is a need to undertake natural asset management that parallels the approach used for built assets. 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 and benefits associated with service delivery and to manage such costs appropriately, while also adequately addressing associated risks. If natural assets are not managed properly, their value can depreciate and their ability to provide services diminishes. Indeed, the outcomes of natural asset management include reduced risks, enhanced services, increased climate resilience and climate change mitigation.

Figure 1-1 depicts steps in natural asset management that culminate in a comprehensive natural asset management plan. The process largely parallels the approach typically applied to built assets as part of a City's corporate asset management plan. The process begins with obtaining spatial data layers that depict the location, extent and type of the various assets (Step 1). This information is structured into a registry that is a tabular representation of the assets where each asset is a row in the registry and a series of columns contain asset attributes, such as land ownership and watershed (Step 2). Using GIS, the amalgamated data is used to delineate and quantify the type, location and extent of assets (Step 3). The resulting inventory forms the basis of all subsequent asset management steps. The assets in the inventory are assessed for condition and rated on a scale from very poor to very good to align with such scales used for built assets (Step 4). The condition is assessed through a series of indicators that proxy the ecological health of the assets on the assumption that assets in good ecological health are able to deliver good ecological services. Paralleling the asset management approach applied to built assets, replacement costs are assigned to the assets in the inventory (Step 5). The steps taken to this point are summarized in a State of the Infrastructure report (Step 6). In the next phase of work, the focus is on identifying (Step 7) and quantifying (Step 8) relevant services from natural assets. This might include drinking water provision, recreation opportunities, stormwater management and/or urban heat reduction. The risks that might impair the ability of assets to deliver priority services are then identified and assessed (Step 9). Lifecycle activities intended to ensure continued or enhanced delivery of services in the face of relevant risks are then identified (Step 10) and costed (Step 11) to inform budget allocations and identify potential budget shortfalls. The results of all the steps are collectively presented in an asset management plan (Step 12). For a more detailed description of the key steps associated with natural asset management, refer to Appendix A.

Figure 1-1. Overview of steps associated with natural asset management (see Appendix A for brief descriptions of each step).

While a natural asset management plan is the ultimate goal of natural asset management, the pursuit of any of the steps identified above has merit as each will provide asset managers with additional information for land-use planning and management decisions. The focus of the current project for the City of Vernon is on creating an inventory (Steps 1 – 3 in Figure 1-1) and undertaking a condition assessment (Step 4 in Figure 1-1). This study is a significant opportunity for the City to join other leading municipalities undertaking natural asset management in Canada. The scope of work provides the foundation for a more wholistic approach to land management and urban planning.

Vernon, located in the North Okanagan region of British Columbia, is characterized by a diverse landscape of forests, woodlands, grasslands, and open water. The area's forests and woodlands consist primarily of mixed coniferous and deciduous trees, while the grasslands host unique plant species adapted to drier conditions. These natural areas provide important ecological benefits, such as supporting biodiversity, maintaining air and water quality, offering wildlife habitat, and contributing to climate regulation through carbon storage and temperature moderation. To ensure management of these areas and the continued provision of these services, the natural assets within Vernon need to be inventoried and assessed. Hence, the importance of this work for Vernon. This report presents Vernon's natural asset inventory and desktop (GIS-based) condition assessment. It is organized as follows:

- The **Asset Inventory** section describes the approach employed to quantify Vernon's assets along with the results of the inventory, which describes the type, location and extent of the range of assets within Vernon's municipal boundary.
- The **Condition Assessment** section describes the indicators used to assess the ecological condition of Vernon's natural assets as well as the results of that assessment, which rates the natural assets on a scale from very poor to very good.
- The **Conclusion** summarizes the project findings and identifies next steps for the City of Vernon to continue to advance natural asset management.

2 Asset Inventory

An overview of the approach and outputs for establishing an inventory of natural assets for the City of Vernon is provided in this section. The range of assets that may be managed by local governments, including various types of green infrastructure (highlighted in the green boxes) and grey infrastructure (highlighted in the grey box), is defined in Figure 2-1. Relationships between terms commonly used to describe green infrastructure, such as nature-based solutions, nature-based climate solutions, and low-impact development, are illustrated in the figure. Three sub-types of GI—natural assets, enhanced assets, and engineered assets—are distinguished, with examples provided for each. The asset inventory structure for the City of Vernon, focusing on natural and enhanced assets, is informed by this classification structure.

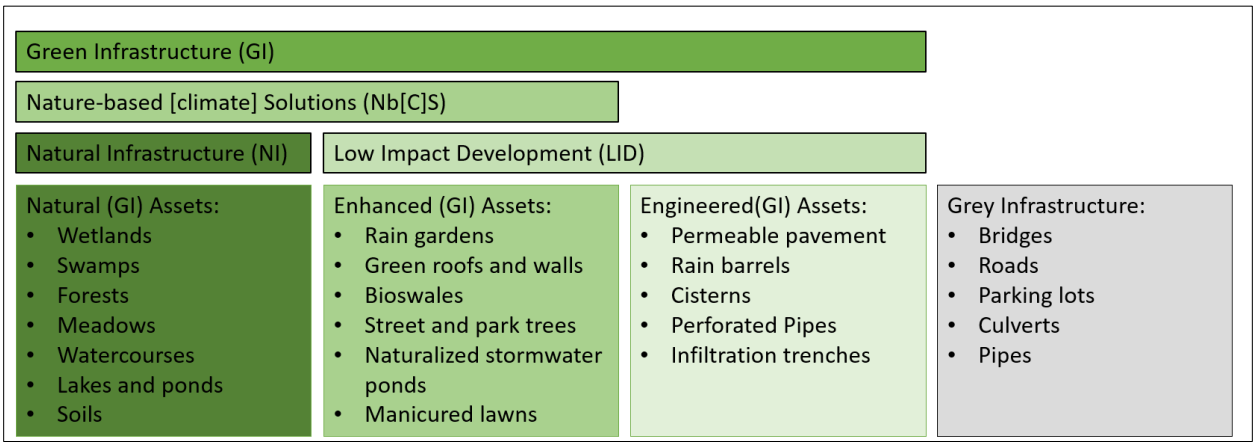


Figure 2-1. Defining natural and enhanced assets.

2.1 Inventory Approach

An asset inventory provides the foundation for all other asset management tasks. The approach aligns with Canada-wide standards and specifications for natural asset inventories (CSA-2022). The inventory is created in GIS, amalgamating relevant data to compile a complete picture of the type, location, and extent of assets within the municipal boundary. For the purposes of this report, the term “assets” refers to the two asset classes contained within the inventory:

1. **Natural assets**, which are comprised of natural features including forests, wetlands and grasslands.
2. **Enhanced assets**, which are comprised of semi-natural features that are more manicured and actively maintained such as urban trees and manicured greenspaces.

Figure 2-2 categorizes natural and enhanced asset classes into a series of asset types. Natural asset types include forests, grasslands, wetlands, riparian areas, open water, and sparsely vegetated areas, all measured as area-based assets in hectares (ha). Natural assets also include water flow route assets, measured as line features in kilometers (km) and further divided into constant flow routes and ephemeral flow routes.

Enhanced asset types include agriculture, urban trees, urban parks, and golf courses. Urban trees are identified as points (i.e., number of trees), while other enhanced assets are area-based and measured in ha. Agriculture assets are further classified into cultivated fields, cultivated orchards, cultivated vineyards, and other categories. Similarly, urban parks are subdivided into athletic parks, community parks, neighborhood parks, and urban parks and plazas.

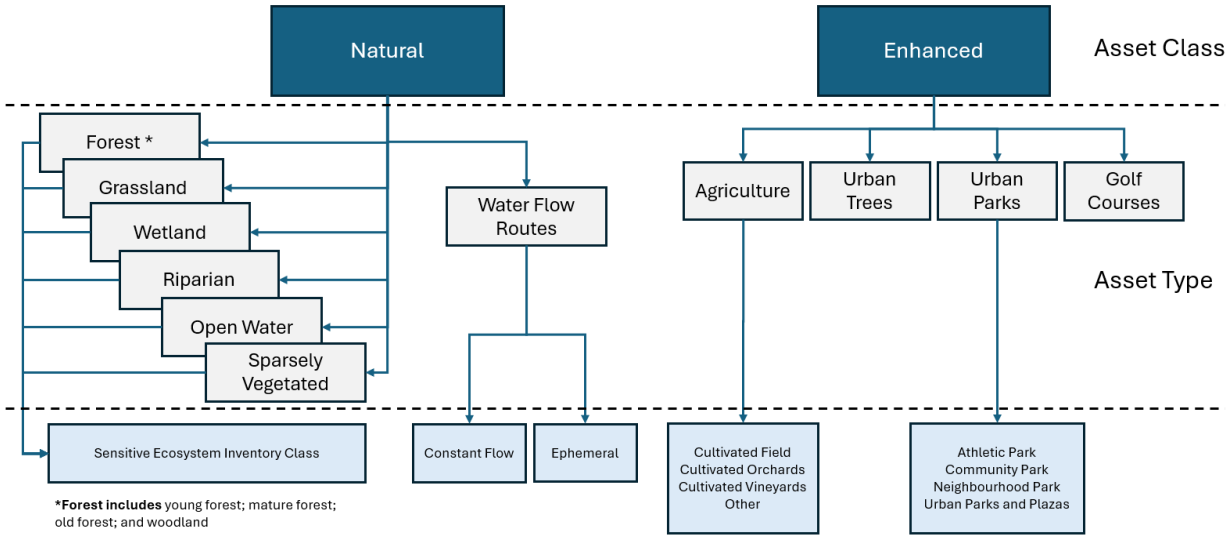


Figure 2-2. Vernon's asset inventory hierarchy.

While the asset database distinguishes between publicly and privately owned assets, this report presents inventory outputs for all natural assets within the City of Vernon's municipal boundary. Publicly owned natural assets do not function independently of nearby lands owned by others, which also provide a range of services. As a result, the inventory and condition assessment include all natural asset types and classes within the municipal boundary. Numerous spatial data layers were reviewed and incorporated into the inventory (see Appendix B for a complete list of the spatial data layers obtained and reviewed to inform the inventory). Several data processing steps were undertaken to categorize assets into natural and enhanced asset classes as well as asset types. The remainder of this section provides additional details on the approach to identifying and categorizing Vernon's natural land cover into natural and enhanced asset types.

2.1.1 Delineating Natural Assets

Table 2-1 defines the asset types into which the natural assets were delineated.

Table 2-1. Definitions and units of measurement for natural assets.

Natural Asset Types	Description	Units
Young Forest	Areas of denser canopies dominated by mature trees aged 40-80 years old	Area (ha)
Mature Forest	Areas of denser canopies dominated by mature trees aged 80-250 years old	Area (ha)
Old Forest	Areas of denser canopies dominated by large, old trees, often exceeding 250 years in age	Area (ha)
Woodland	Characterized by open stands of trees with widely spaced canopies	Area (ha)
Grassland	Ecosystems dominated by bunchgrasses and shrubland	Area (ha)
Wetland	Non-forested ecosystems where the water table is at or near the surface	Area (ha)
Riparian	Streamside ecosystems on floodplains and benches along creeks and rivers, ecosystems in gullies with intermittent or permanent creeks , fringe ecosystems associated with pond and lake shorelines or sites with significant seepage and the river bed of large systems	Area (ha)
Open Water	Standing bodies of freshwater	Area (ha)
Sparsely Vegetated	Occurring on sites where rock or talus limits vegetation establishment. Vegetation cover is discontinuous, interspersed with bedrock or blocks of rock.	Area (ha)
Water Flow Routes	Refers to water flow routes on the landscape. Comprised of ephemeral water flow routes, which are intermittent or temporary flow routes typically occurring when rainfall exceeds the infiltration capacity of the soil or when the soil is saturated and constant water flow routes, which contain flowing water on a permanent basis.	Length (km)

For natural assets, asset type designations were primarily based on the Sensitive Ecosystem Inventory (SEI) (2022). As part of the current project, Ecoscape Environmental Consultants Ltd. (Ecoscape) updated the SEI data based on 2022 imagery. SEI deciles were used to identify the dominant land cover within each SEI polygon. The dominant land cover type was translated into the corresponding asset type designation.

Recognizing that SEI is not appropriate for identifying areas of **open water**, additional datasets (outlined in Appendix B) were utilized to enhance the delineation of open water areas and Okanagan lake.

To improve classification of **wetlands**, two supplementary datasets were utilized. A polygon dataset was produced by Ecoscape, which leveraged local knowledge and analysis. This layer was developed through a review of the Drainage Infrastructure Prioritization Project depressions over 5m², which helped identify depressions and standing water/wetland features on the landscape that were not captured in the SEI. These revised outputs were then utilized to delineate additional areas of wetlands in the inventory. Additionally, the Okanagan Collaborative Conservation Program predictive wetland model was assessed against imagery and SEI data and contributed to wetland delineation in the study area. As this data is rasterized and at a lower resolution than the core inventory, wetland sensitivity ratings are held within the layer attributes for any polygons intersecting It. It is anticipated that a high resolution (3 m) refresh of this data will be available in March 2025. Relevant wetland datasets are identified in Appendix B.

A previous LiDAR (Light Detection and Ranging) based analysis conducted by Urban Systems for the City of Vernon Drainage Infrastructure Investment Plan delineated **water flow routes** within Vernon (ephemeral and constant flow routes). This data was utilized as the core component of the water flow route inventory. LiDAR is a remote sensing technology used in GIS and spatial analyses to collect high-resolution spatial data. It works by emitting laser pulses and measuring the time it takes for them to return after reflecting off surfaces, allowing the creation of detailed three dimensional representations of landscapes. LiDAR provides highly accurate elevation data that enables the delineation of drainage networks and the identification of flow paths, depressions, and low-lying areas where water might accumulate. Thus, the

LiDAR derived dataset was used to outline the length of the water flow routes within the spatial polygons.

Additional processes used to delineate natural asset types include:

- SEI polygons containing a riparian classification in any decile were prioritized and classified as a riparian assets.
- Several SEI polygons were designated as "Non Sensitive" in the SEI data layer. To allocate these areas into asset types, a manual review in collaboration with Ecoscape was used to determine an appropriate asset classification.
- For a small number of cases where SEI classification and deciles could not be used to identify a dominant land cover type, a manual review of satellite imagery to assign asset type was undertaken.

2.1.2 Delineating Enhanced Assets

Table 2-2 defines the asset types into which the enhanced assets were categorized.

Table 2-2. Definitions and units of measurement of enhanced asset types.

Enhanced Asset Types	Description	Unit
Agriculture	Agriculture refers to the cultivation of soil, crops, and livestock by humans to produce food, fiber, and other resources	Area (ha)
Golf Course	Human-managed asset designed for recreational and sporting purposes, characterized by a combination of manicured turfgrass, engineered water features, and naturalized areas.	Area (ha)
Park	A tract of land within the City used for recreation by the public that often includes facilities. In Vernon, parks are further classified as athletic parks, community parks, neighbourhood parks, and urban parks and plazas.	Area (ha)
Urban Trees	Urban trees are trees found within city or town boundaries, often integrated into parks, streetscapes, residential areas, and other urban landscapes to provide environmental, aesthetic, and social benefits. This analysis identified tree points and respective canopy cover outside of natural, agricultural, and golf course areas.	Count (#) Canopy Cover Area (ha)

Datasets used to classify enhanced assets are noted in Appendix B. For enhanced assets, the SEI data was instrumental in classifying most **agricultural areas**, assigning them as cultivated fields, orchards, vineyards or other. A small subset of polygons underwent manual review and classification based on satellite imagery.

For **golf courses**, SEI attributes helped differentiate manicured sections from natural areas. In this inventory, natural areas within golf courses are included as natural assets, as requested by the City of Vernon. Manicured sections of golf courses are included as enhanced assets.

Unmanaged **parks**, including provincial parks, are classified as natural. The "park" designation was retained as an attribute for these natural assets, allowing them to still be identified as part of a park (albeit not a manicured one). Managed parks were kept within the enhanced category, and further broken out into their classifications as athletic parks, community parks, neighbourhood parks, and urban parks and plazas.

For the **tree** assessment, LiDAR data was processed to perform tree segmentation and canopy delineation. Tree segmentation involves identifying individual trees within the LiDAR dataset by analyzing point cloud

data, which consists of millions of points representing the surface of objects, including vegetation. The process uses advanced algorithms to distinguish tree structures from other features, such as buildings or the ground, based on height, shape, and spatial patterns. Canopy delineation further refines the analysis by mapping the outer boundaries of each tree's crown, producing polygons that define the spatial extent of the canopy for each identified tree. This dual output—points for individual tree locations and polygons representing their canopy coverage—provides a highly detailed and spatially accurate understanding of urban vegetation generally and urban trees specifically. For the current inventory, LiDAR data was processed for the urban area within the municipal boundary to estimate the number and associated canopy of urban trees.

As noted above, in a couple of instances areas that were designated as "park" according to the spatial data and would therefore be captured as enhanced assets, were reclassified as natural as these parks are largely unmanaged and thus considered to be more natural than enhanced by definition. Despite their classification as natural assets, within the asset inventory, the park designation was retained as an attribute for those lands. This is one of many attributes contained within the asset inventory. The section below identifies additional attributes.

2.1.3 Inventory Attributes

Each asset within the inventory has a series of attributes associated with it. Attributes describe features or characteristics of the asset that may be relevant to the city to inform management decisions. Attributes contained in the City of Vernon's inventory include:

- Unique asset ID
- Asset area
- Hierarchy classification
- Classification data source
- SEI attribution (e.g. SEI classes, deciles, SEI based assessment outcomes)
- Project area (Commanage, Bella Vista, Coldstream-Vernon)
- Assessment watersheds and fundamental watersheds
- Ownership (City, RDNO, Federal, Provincial, private)
- Forest attributes: age, species, volume, height (where available)
- Park information where applicable (e.g., facility ID, park name, park owner, park classification and category)
- Urban containment (growth area, future growth area, rural protection area)
- Intersecting length of waterflow
- Agriculture (agriculture land reserve and non-agriculture and reserve)
- Condition assessment results

2.2 Summary of Inventory Output

The remainder of this section summarizes outputs derived from the City of Vernon's asset inventory. Figure 2-3 depicts the location and extent of natural and enhanced assets within the municipal boundary. Within the City of Vernon there are a total of 9,188 ha of natural and enhanced assets (78% of total City area). Of that total, 7,411 ha (81%) are natural assets and 1,777 ha (19%) are enhanced assets. Lake Okanagan takes up a large share of the natural asset inventory, comprising 2,113 ha (18%) of the total natural asset area. The red border within the map demonstrates the location of City-owned assets.

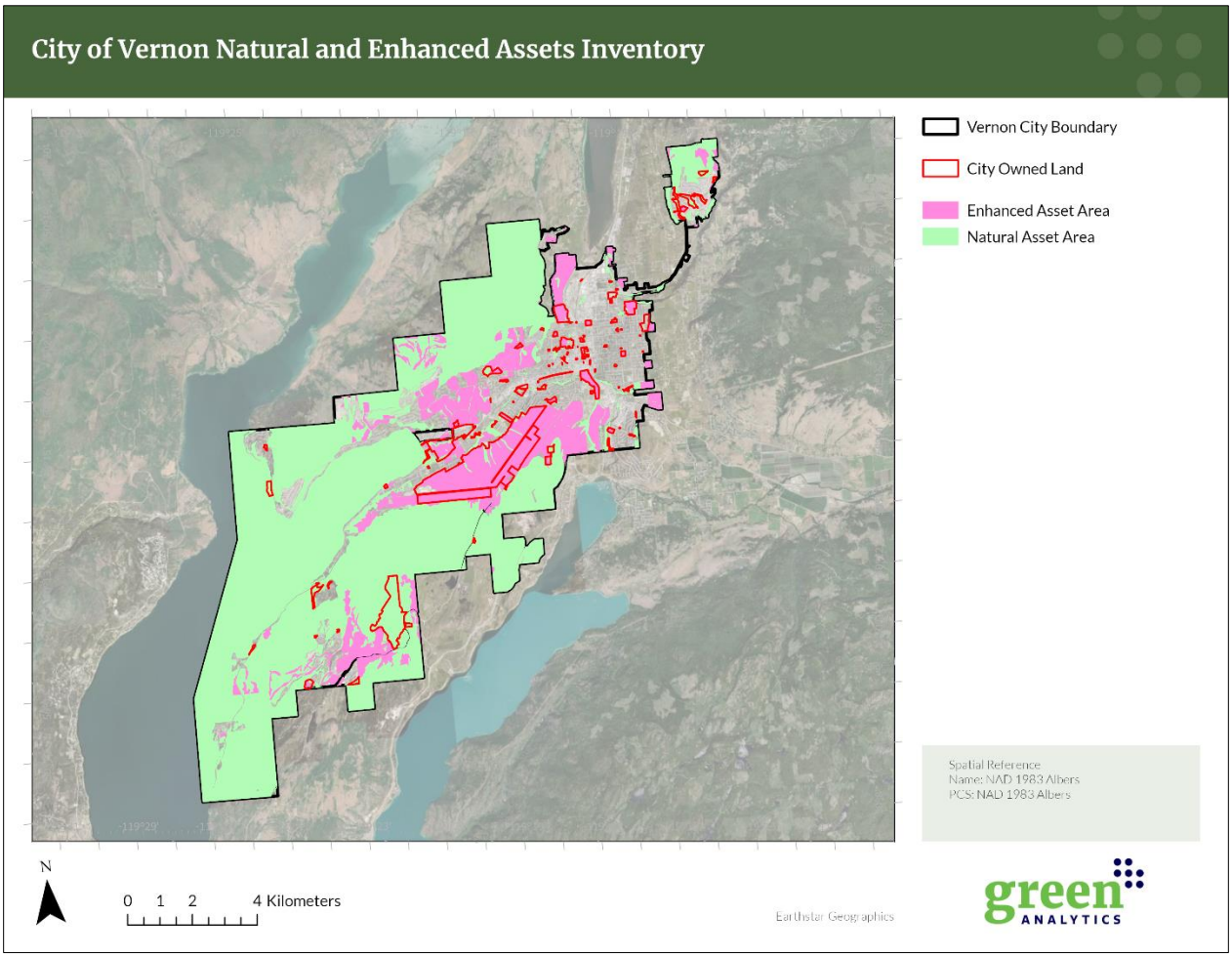


Figure 2-3. Natural and enhanced asset classes.

Figure 2-4 provides a breakdown of natural versus enhanced assets along with their associated ownership. The outer ring represents the total area of natural and enhanced assets, which together amount to 9,189 ha. Natural assets comprise the vast majority (7,412 ha, or 81%) of the total area, while enhanced assets account for 1,777 ha (19% of the total).

The inner ring of the figure categorizes the asset classes by ownership. Of the natural assets, 180 ha (2% of the total area of natural assets) are city-owned, while the remaining 7,232 ha (98% of the total area of natural assets) are owned by other entities. Enhanced assets, on the other hand, consist of 540 ha (30% of the total area of enhanced assets) that are owned by the City and 1,237 ha (70% of the total area of enhanced assets) that are owned by other entities.

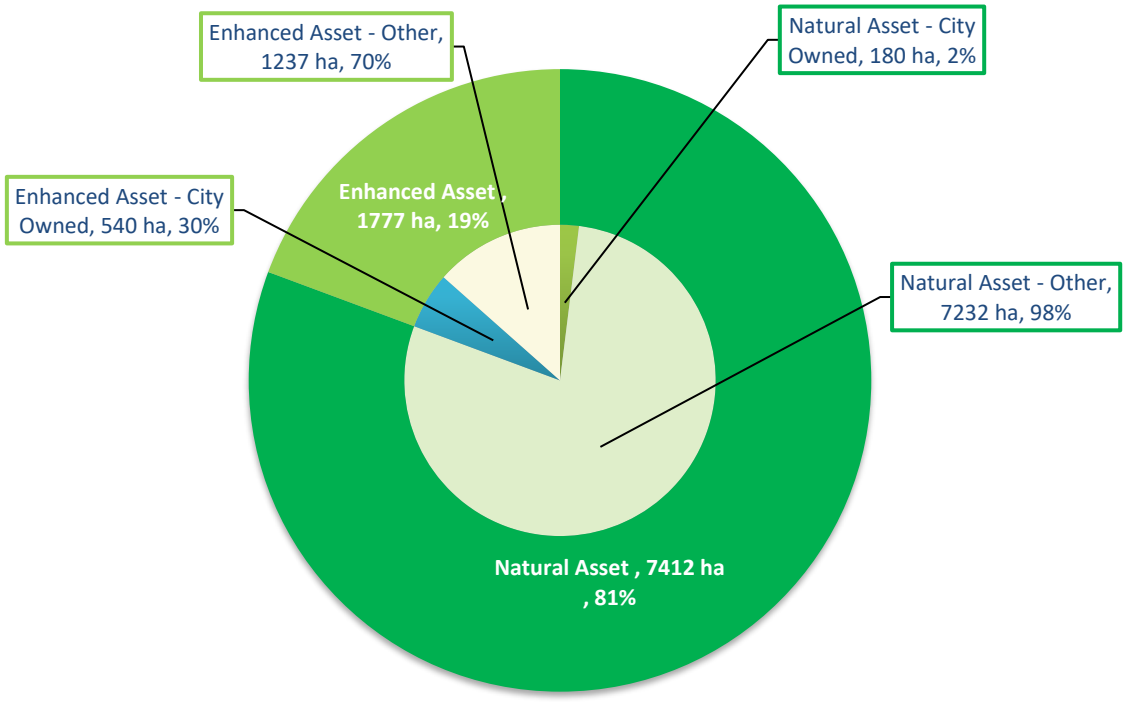


Figure 2-4. The composition of assets in Vernon region by natural or enhanced assets and by ownership types. The outer ring represents the total area in ha and percentages of natural and enhanced assets in Vernon, and the inner ring further subdivides natural asset and enhanced assets into city-owned and other ownership types.

Figure 2-5 shows the City of Vernon's natural asset inventory by asset type. This figure demonstrates the wide range of natural and enhanced assets present within Vernon's municipal boundary. Dominant asset types include forests (young, mature, old and woodland) and grasslands. These assets provide important services to Vernon residents including water filtration, stormwater management, carbon sequestration and storage and habitat provision. Natural asset management provides details on the type, location and extent of such assets so that they can be managed and enhanced for continued and increased service provision.

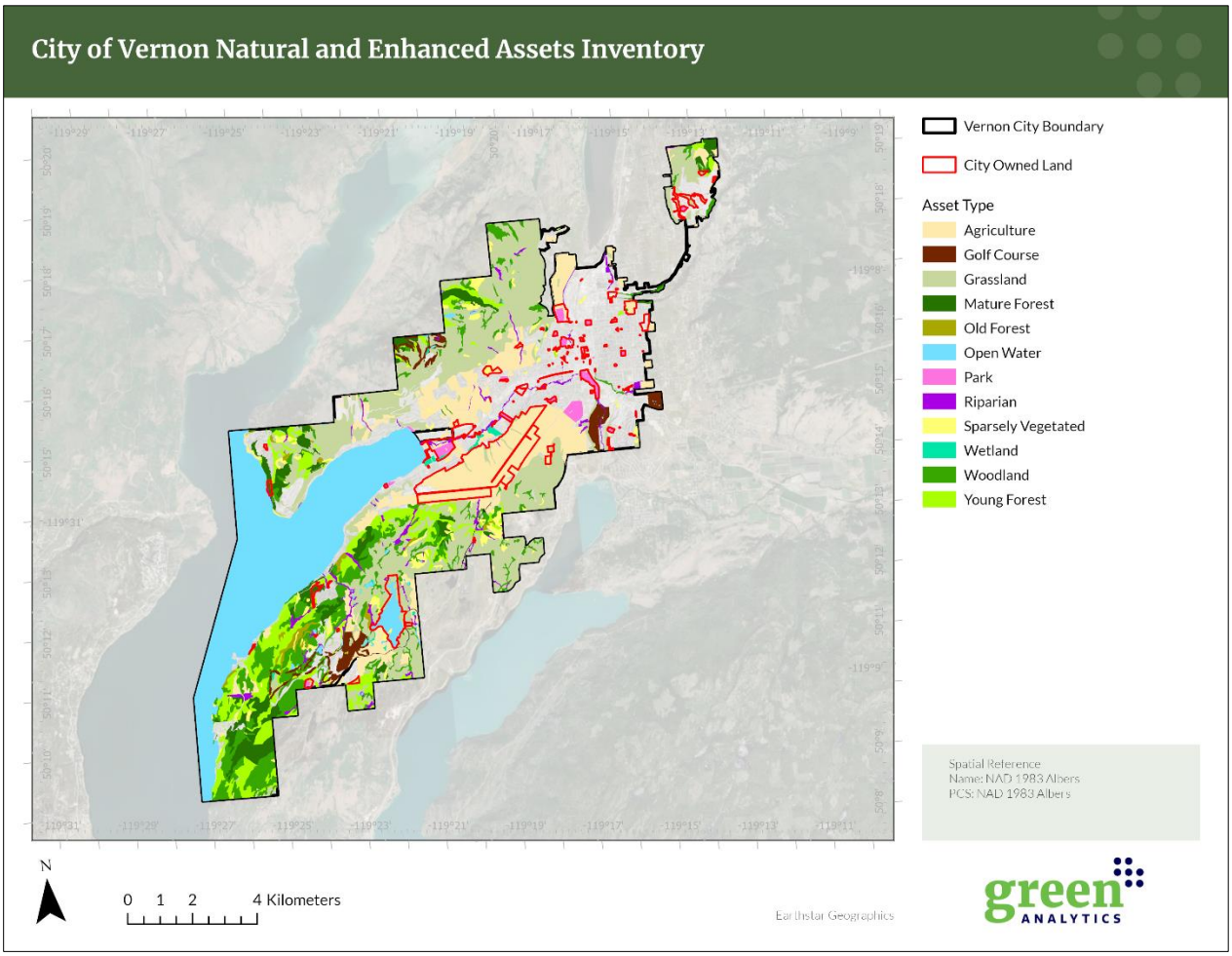


Figure 2-5. Natural and enhanced asset types.

Figure 2-6 demonstrates the extent of canopy cover within Vernon's urban boundary. Urban canopy areas encompass 266 ha, of which 19 ha is associated with city-owned lands. Urban trees provide numerous benefits to local residents including urban heat reduction, air quality improvements, water storage and filtration and carbon storage and sequestration. They also provide amenity benefits by improving street views. A portion of the trees within Vernon's urban boundary are city-owned. Proper management of city-owned urban trees will support service provision over time. To start, the City could undertake a more detailed inventory of such trees that includes information on species, age and condition. For urban trees that are privately owned, municipalities can pursue incentive programs and tree by-laws that limit tree removals and encourage owners to maintain trees in a healthy condition.

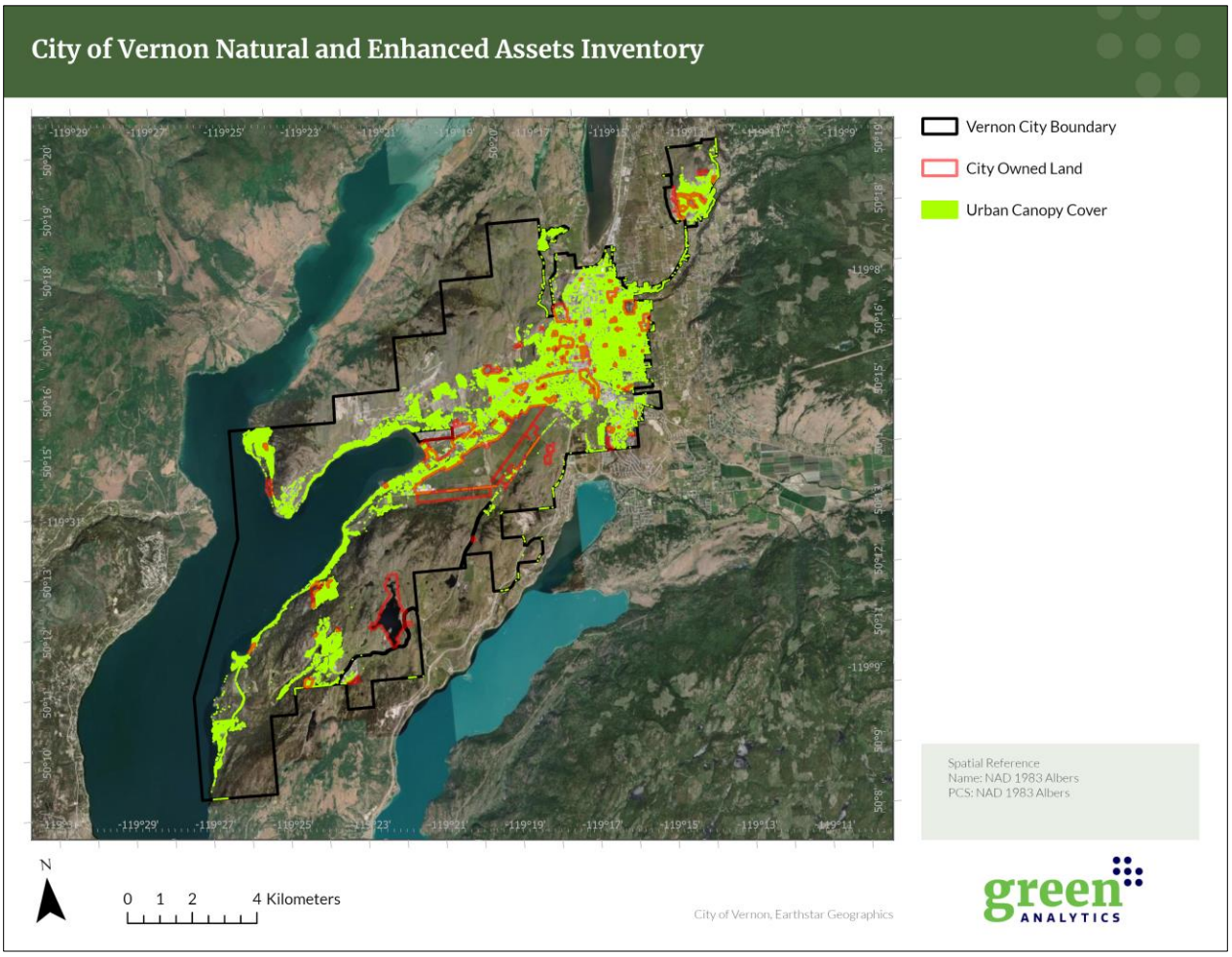


Figure 2-6. Urban canopy cover within Vernon city boundary and city-owned land.

Figure 2-7 demonstrates the water flow route assets. There is a total of 154 km of water flow route assets within the Vernon municipal boundary. Of these, 137 km (89%) are ephemeral (seasonal or intermittent) and 17 km (11%) are constant flow. These routes are significant for many reasons. The vast majority of the water flow route assets are ephemeral in nature. Ephemeral routes differ from constant routes in that they only intermittently contain water. It is important to know where such routes are located and the volume of water that they are capable of managing. Ensuring adequate vegetative cover within the routes helps reduce flow rates and increase water filtration when flows exist. Such flow routes may have a different risk profile than permanent flow routes and should thus be managed accordingly. The water flow routes in the natural areas have the potential to retain and absorb water to reduce or limit the volume of water reaching the impervious surfaces within the urban boundary. Such routes in close proximity to high population areas have high impact potential from a flow management perspective. Protecting and restoring priority routes, both ephemeral and constant, will reduce challenges and pressures associated with water flow into urban areas. Further, streams that collect and route water to Okanagan Lake provide an important water management service to the City of Vernon. These streams have been shown to have poor water quality (Urban Systems, 2019). Protecting and enhancing these streams so they continue to collect and channel water as well as filter water on route to Okanagan Lake is an important asset management opportunity. Finally, flow routes through steep slopes have the potential to cause erosion, which can lead to loss of natural areas, safety concerns and sedimentation. Such flow routes are high priority for protection or improvement.

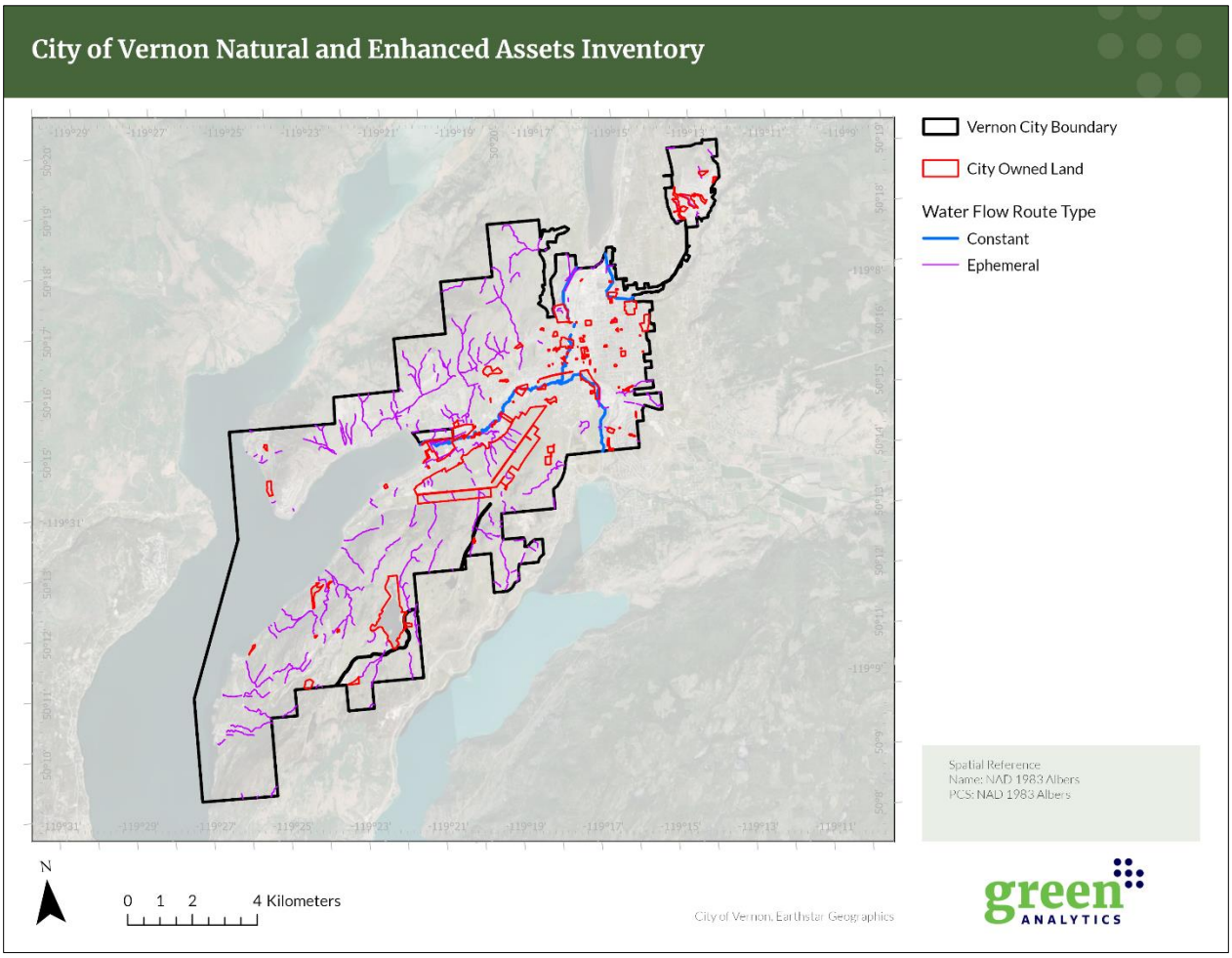


Figure 2-7. Water flow route asset inventory.

Table 2-3 summarize the area (or length) of natural assets within the City of Vernon's natural asset inventory. Collectively, the forest related assets (including woodlands and young, mature and old forests) comprise over 2,000 ha of area. Forests are important natural assets in Vernon and should be managed carefully to both maximize their environmental and social benefits as well as the risk they present during wildfire season.

Other asset types presented in significant quantities include grasslands (2,553 ha) and open water (2,223 ha). Grassland assets in Vernon and the broader Okanagan region of British Columbia provide unique ecological, economic, and cultural benefits. They support a diversity of plant and animal species, including rare or endangered species. Grasslands sequester and store carbon, support soil stabilization, and filter water.

The open water assets within Vernon are dominated by Lake Okanagan, which accounts for 2,113 ha of open water assets (approximately 95%). Okanagan Lake is an important natural asset for the residents of Vernon, offering ecological, economic, and recreational benefits. The lake provides drinking water and supports agriculture in the region. It provides opportunities for swimming, boating, and fishing, attracting tourism and boosting the local economy. Okanagan Lake supports aquatic habitats and species, contributing to regional biodiversity. The lake also enhances the area's scenic beauty and fosters community connection and identity. While the City of Vernon does not have management authority for Okanagan Lake, the importance of this asset to the residents of Vernon speak to the need to collaborate

with those that have the authority to manage, maintain and enhance the health of the lake.

Wetland assets within Vernon's municipal boundary are relatively small in area (36 ha), making up 0.5% of the total natural asset area in the City. Wetlands are critical natural assets because they provide a variety of ecological services including water storage and filtration. They should be maintained and enhanced for continued service provision over time. The City owns a higher percentage of wetlands than most other assets (10%). This presents a opportunity for the City to ensure the long-term viability of Vernon wetlands.

Of the total area of natural assets (7,412 ha), 2.6% (or 193 ha) are City-owned with the majority of these being grassland and water assets with city-owned riparian assets also being fairly significant. This speaks to both the need to ensure the protection, maintenance and enhancement of these limited assets as well as the importance of collaboration with other landowners and jurisdictions to ensure continued service provision from the array of assets within the municipal boundary into the future.

Table 2-3. Asset type summary for all and city-owned natural assets.

Asset Type	Units	Total per Type	Percent of Total City Area	Percent of Total Natural Asset Area	City-owned Area	City-owned Percent by Type
Young Forest	Area (ha)	781	6.6%	10.5%	6	0.8%
Mature Forest	Area (ha)	449	3.8%	6.1%	11	2.5%
Old Forest	Area (ha)	76	0.6%	1.0%	0	0.0%
Woodland	Area (ha)	889	7.6%	12.0%	6	0.7%
Grassland	Area (ha)	2,553	21.7%	34.3%	66	2.6%
Wetland	Area (ha)	36	0.3%	0.5%	4	10.3%
Riparian	Area (ha)	186	1.6%	2.5%	15	7.9%
Open Water – Lake Okanagan	Area (ha)	2,113	18.0%	28.5%	0	0.0%
Other Open Water	Area (ha)	110	0.9%	1.48%	77	68.9%
Total Open Water	Area (ha)	2,223	18.9%	30.0%	77	3.5%
Sparsely Vegetated	Area (ha)	218	1.9%	2.9%	8	3.5%
Total natural asset area		**7,412**	**NA**	**100%**	**193**	**2.6%**
Water Flow Routes	Length (km)	154	NA	NA	18	12.0%

Note: Numbers were rounded, which may lead to slight differences in summed numbers.

Figure 2-8 depicts the natural asset profile of the City of Vernon by asset type and ownership. The outer ring of the figure reflects the total area (ha and percentage) of natural assets. Grassland covers 2,553 ha, and open water accounts for 2,223 ha, making them the largest asset types. These are followed by woodlands at 889 ha, young forests at 781 ha, mature forests at 449 ha, sparsely vegetated areas at 218 ha and riparian areas at 186 ha. Among all other natural asset types, old forests and wetlands represent the smallest area, which only account for 76 ha and 36 ha, respectively.

The portion of the natural assets that are city-owned is presented in the inner ring of the circle. For grassland assets, 66 ha are city-owned. There are 6 ha of city-owned woodland assets. None of the 76 ha of old forest assets are city-owned. For mature forest assets, 11 ha are city-owned. The City also owns 6 ha of young forest assets, 8 ha of sparsely vegetated areas, 77 ha of open water, 15 ha of riparian areas, and 4 ha of wetlands.

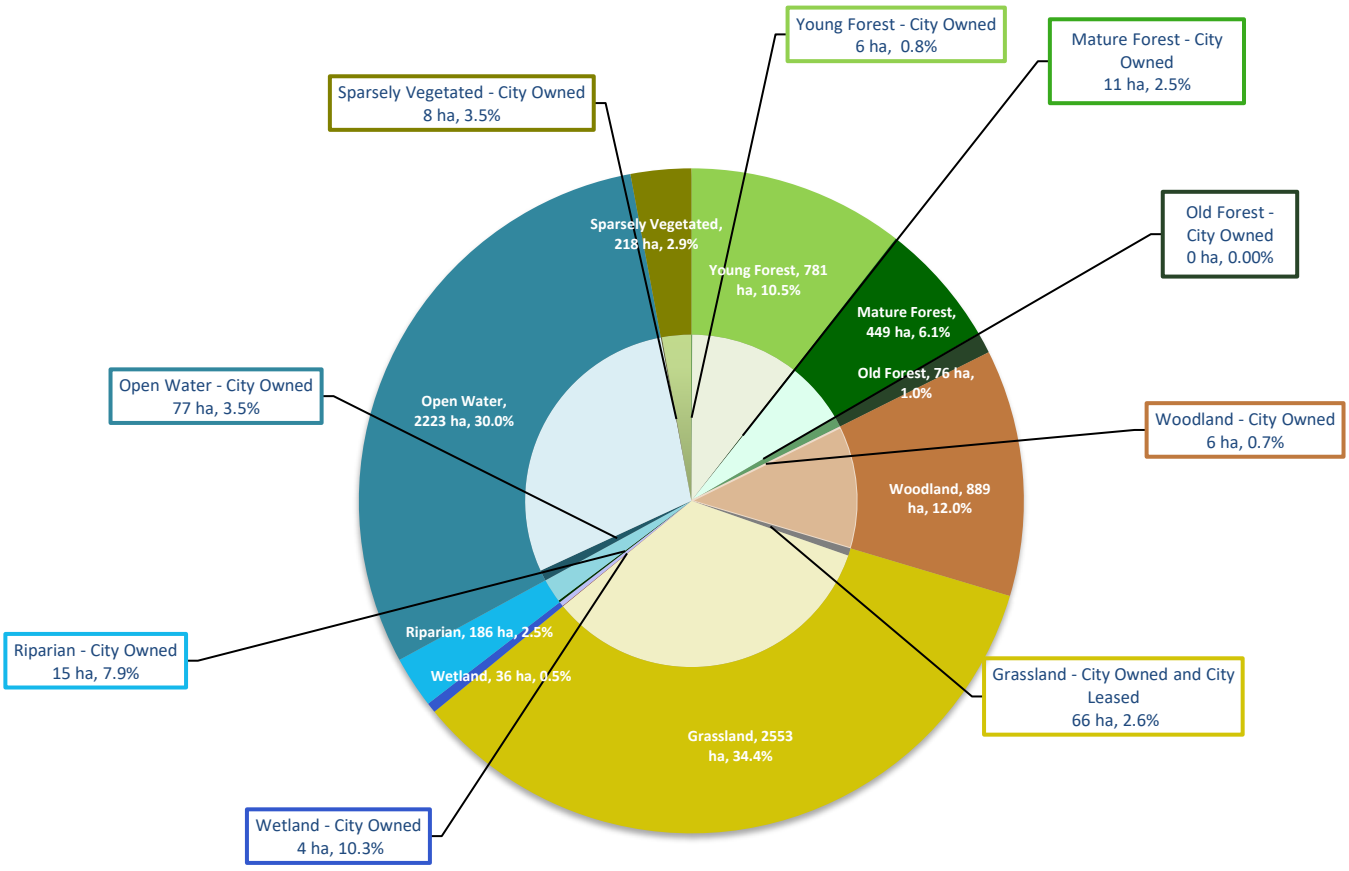


Figure 2-8. The composition of natural asset types and ownership types. The outer ring represents the total area in ha and percentages of each natural asset type, and the inner ring further subdivides each natural asset into city-owned and other ownership types.

Table 2-4 and Figure 2-9 summarize the area (or number) of enhanced assets within the City of Vernon's enhanced asset inventory demonstrating the areas that are owned by the City of Vernon. City ownership exists for 461 ha of agriculture assets and 79 ha of park assets. These assets have the potential to provide numerous services to the residents of Vernon. The park assets provide opportunities to reap recreation, social connection and mental and physical well-being benefits. In addition, along with agriculture assets, park assets store and filter water, sequester and store carbon and provide aesthetic benefits to Vernon citizens. Identifying and understanding the full range of services and benefits these assets provide allows land managers to manage them effectively for continued and improved service delivery.

Table 2-4. Asset type summary for all and city-owned enhanced assets.

Asset Type	Units	Total per Type	Percent of Total City Area	Percent of Total Enhanced Asset Area	City-owned Area	City-owned Percentage by Type
Agriculture	Area (ha)	1,448	12.3%	81.5%	461	31.8%
Golf Course	Area (ha)	215	1.8%	12.1%	0	0.0%
Parks	Area (ha)	114	1.0%	6.4%	79	69.7%
Total enhanced asset area		**1,777**	**NA**	**100%**	**540**	**30.4%**
Urban Trees	Count (#)	70,026	NA	NA	5,862	8.4%
	Canopy Area (ha)	266	NA	NA	19	7.0%

Note: Numbers were rounded, which may lead to slight differences in summed numbers.

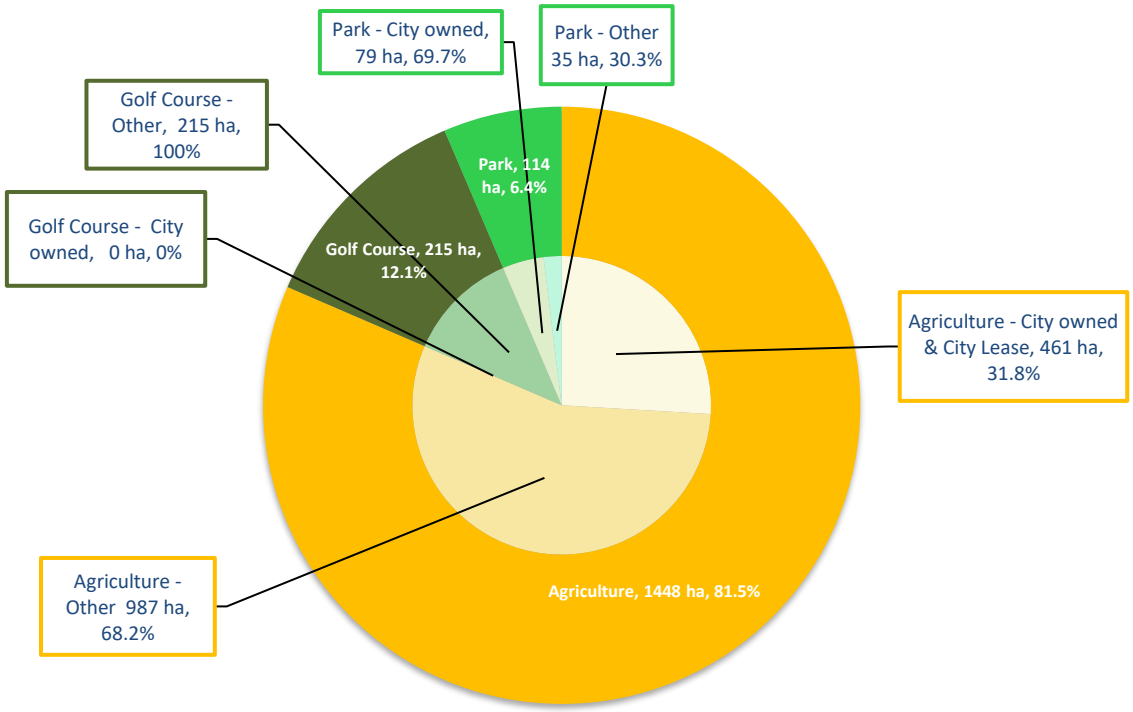


Figure 2-9. The composition of enhanced assets by type and ownership type. The outer ring represents the total area in ha and percentages of each natural asset category, and the inner ring further subdivides each natural asset category into city-owned and other ownership types.

3 Condition Assessment

A condition assessment was conducted for Vernon's natural assets. This section provides an overview of the condition assessment approach (with additional details contained in Appendix C) and results.

3.1 Approach Overview

A natural asset condition assessment aims to evaluate each natural asset's ability to provide services at a high level. This approach uses the cascade model outlined in CSA (2023), which links biophysical processes, function, ecosystem services, and human benefits (Figure 3-1). For instance, a wetland's biophysical processes enable water storage, which reduces flood risks and provides human benefits by minimizing flood damages. Condition indicators capture ecological condition and connect it to ecosystem services and community value. The assessment assumes that a natural asset in "good" ecological condition is more likely to deliver a "good" level of ecological services, which, in turn, benefit the community.

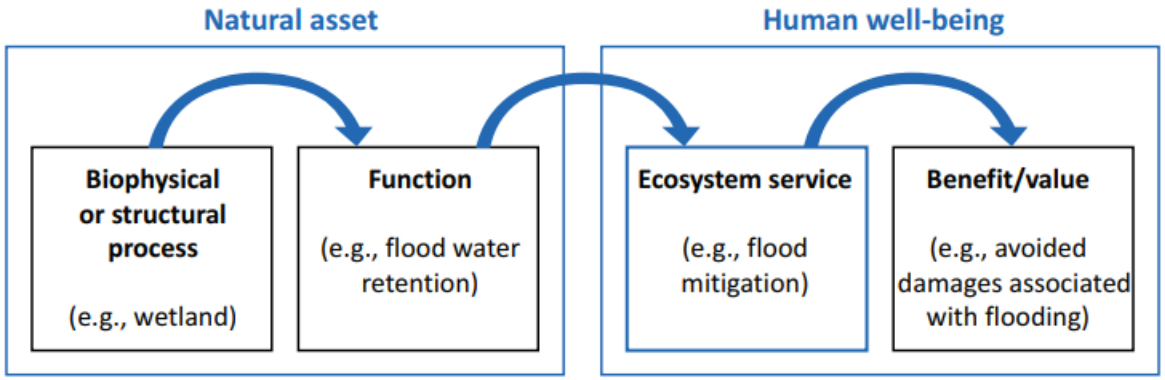


Figure 3-1. Cascade model upon which the condition assessment is based (CSA 2022).

The process used for the condition assessment aligns with that outlined in the Canada-wide standards and specifications for natural asset inventories (Figure 3-2) (CSA 2022). The standard provides guidance on condition assessment criteria, indicators and scoring in the context of natural assets. The standard identifies three criteria - landscape context, physical context and ecological condition – to guide the selection of indicators. For each of the indicators, a scoring system is established to allow the results of the assessment to be positioned within a standardized 5 point ranking system ranging from very good to very poor.

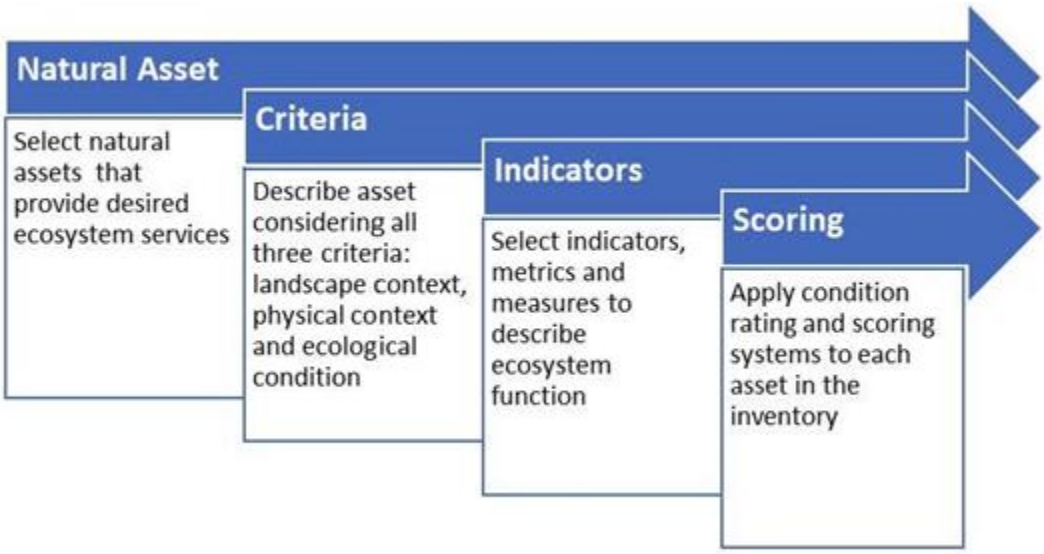


Figure 3-2. The natural asset condition assessment process (CSA 2022).

While a specific scoring system is needed for each individual indicator (see Appendix C for details on the scoring system applied to each indicator employed in Vernon's condition assessment), the scores generally align with the condition descriptions presented in Table 3-1.

Table 3-1. Sample condition rating scale definitions (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.

The first step in the condition assessment was to identify a set of relevant condition indicators. Based on past project experience, Green Analytics identified a preliminary set of potential indicators. These were vetted with local environmental consultants – Ecoscape – and revised considering feedback received. The list of indicators was then presented and refined in keeping with discussions with the City of Vernon. Draft results were generated and presented to the City and the list of indicators was further adjusted to ensure the selection and application of indicators aligned with the Vernon context. The final set of condition indicators are noted below and categorized into two criteria (i.e., landscape context and physical context) to align with the CSA standard for natural asset inventories. Note that suitable indicator/s for evaluating ecological condition (the third criteria identified in the CSA standard) were not found for the City of Vernon. Indicators within this criteria are frequently collected through field-based work focused on the ecology of the assets. Future data collection targeting species diversity, invasive species or habitat quality would help respond to this gap.

CRITERIA FOR PHYSICAL CONTEXT

1. Interior habitat
2. Road density

CRITERIA FOR LANDSCAPE CONTEXT

3. Extent of adjacent permeable land uses
4. Natural asset proximity to other natural assets
5. Percent of intact watershed area
6. Connectivity

CRITERIA FOR ECOLOGICAL CONDITION

7. Suitable indicators not currently available

The condition indicators identified above were applied to the **natural assets** defined in Table 2-1 with the exception of Okanagan Lake. The condition assessment indicators (identified below and described in detail in Appendix C) are not conducive to assessing the condition of a large lake such as Okanagan Lake; an entirely different set of indicators focused on water quality and aquatic health would be needed to incorporate the condition of the lake into the current assessment. Likewise, while enhanced assets are included in the inventory to provide a complete picture of the land-based assets within the City of Vernon and to recognize their important contribution to community services such as stormwater management and recreation, they are excluded from the condition assessment. The condition of agricultural lands from an asset management perspective has limited relevance since those lands are largely managed by private landowners. For built-up pervious assets, condition ratings can be useful from a management perspective. However, such ratings require input from field staff on each individual property, which is beyond the scope of this project.

The select condition indicators were applied to the natural assets within Vernon's municipal boundary through a desktop exercise relying on GIS. Details on the approach employed for each indicator is provided in Appendix C. The desktop condition assessment completed for the natural assets within the City of Vernon is grounded in landscape ecology metrics; it is nonetheless recommended that field-based verification of the condition of the natural assets be completed over time to support and improve natural asset condition monitoring. Field-based condition assessments provide details and information on the condition of assets as well as the factors contributing to the condition results. Observations of habitat structure and complexities, risks (e.g. invasive species) and factors contributing to service delivery (e.g. encroachments) can be obtained through field-based assessments. A standard for field-based condition assessments for natural assets does not currently exist. However, the Natural Assets Initiative's guidance document on natural asset management references a rapid condition assessment developed by the Credit Valley Conservation Authority in Ontario (NAI 2024). The assessment is intended to guide the efficient collection of field data to inform natural asset management. Condition assessment approaches for urban trees, which collect data on tree species, age, size, and health, are more established. Field-based condition assessments of natural assets and urban trees can be completed on a pre-determined schedule over a number of year starting with high priority areas (e.g. those at high risk, those with high service delivery, those suspected to be in poor condition). Condition assessments can also be pursued as part of land use planning as areas flagged as environmentally sensitive require a professional to assess and verify the presence of sensitive areas on-site before development can proceed.

3.2 Summary of Condition Assessment Results

This section of the report summarizes the results of the GIS-modeling desktop condition assessment. Appendix C describes the approaches employed and results derived for each of the indicators noted above. The indicator results were combined to derive an overall condition score for each of the natural assets within the inventory. This was done by averaging the scores across the indicators assuming equal weight for each indicator. The spatial distribution of the amalgamated condition result is depicted in Figure 3-3. As is demonstrated in the figure, the asset conditions are rated as very good, good, fair, or poor. The assets in the poorest condition were found to be those within or in close proximity to urban areas within the City boundary.

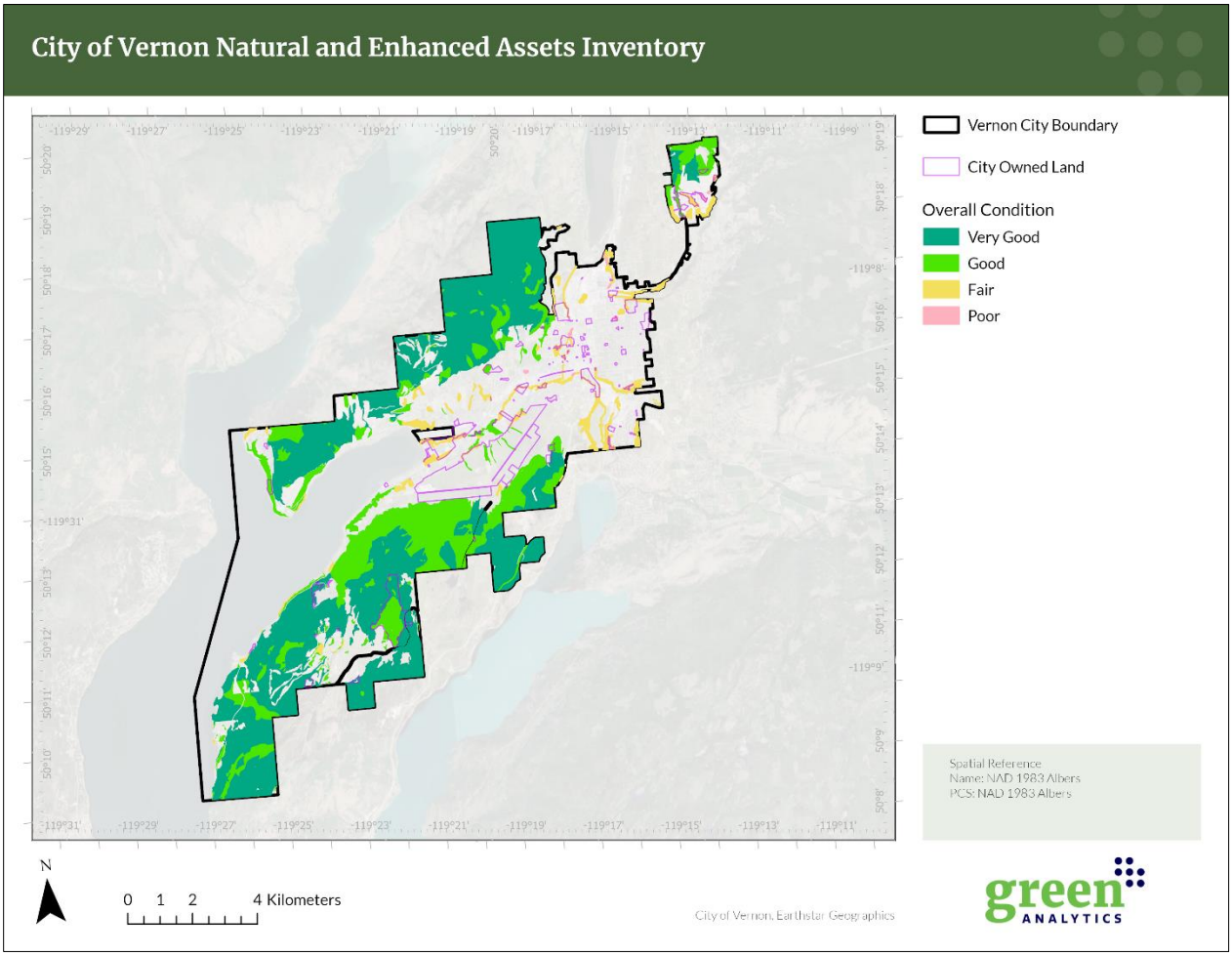


Figure 3-3. Overall condition rankings for Vernon's natural assets.

According to the indicators employed in this assessment, the majority of the City of Vernon's natural assets are in very good condition (77%). A high portion of assets are in good condition (19%) and a small portion of assets are in fair condition (4%). Very few assets are in poor condition (0.1%) and none are in very poor condition. These results are useful for informing high level management actions but are not, on their own, sufficient to prescribe specific management actions for particular assets. Good and very good condition results indicate assets that may be appropriate for conservation or protection. Fair, poor and very poor condition results signal assets that may be appropriate for restoration or enhancement. To confirm specific actions for particular assets, as per natural asset management, the condition results should be a) verified through field based assessments, b) considered in light of applicable risks, c) evaluated for the services

they deliver, and d) examined in light of community priorities and strategic objectives.

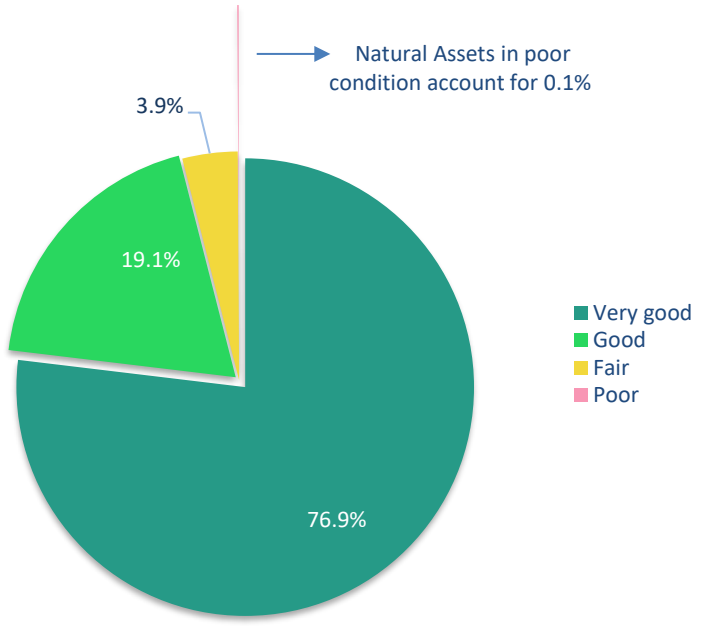


Figure 3-4. Summary of natural assets by condition ranking.

It is informative to consider the condition results by asset type to better understand the implications for asset management. Figure 3-5 shows the breakdown of condition ranks across the range of natural asset types within the inventory. Overall, the vast majority of assets rank good and very good. Relatively speaking, the asset types that rank the highest or very good include woodland and grassland assets. From a management perspective, the focus for these assets is on maintaining their condition, particularly in the face of potential risks. Wetlands and riparian areas had the highest percentage of fair condition rating, which suggests prioritization of these asset types for further assessment as well as potential enhancement and restoration activities. The poor condition ratings are associated with minor amounts of riparian and sparsely vegetated lands. As is shown in Figure 3-3, these assets are concentrated close to or in Vernon's urban area. Thus, the factors contributing to the relatively lower condition rating would be the permeability of adjacent lands and the density of roads. Given the nature of the assets, particularly the riparian assets, further consideration of these condition ratings is warranted. Riparian assets, especially when they are in close proximity to populated areas, may be important from a water storage, management and filtration perspective. Field-based inspection of these assets may be prudent and actions to restore and enhance these assets is likely in order.

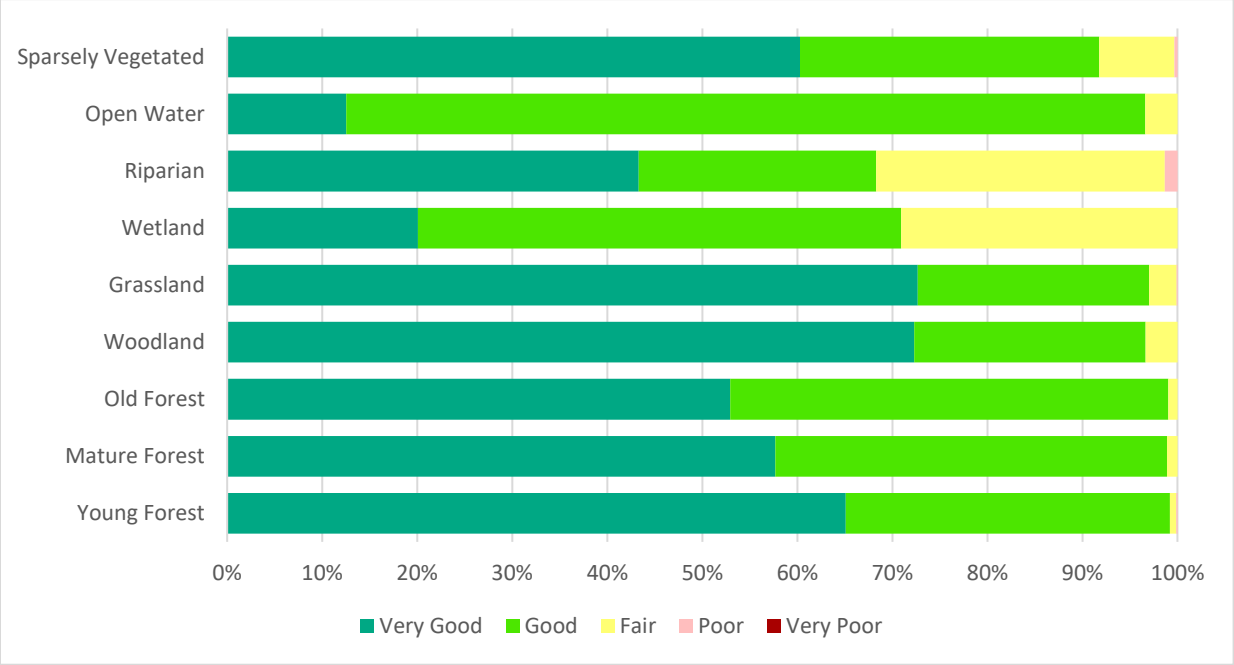


Figure 3-5. Condition rankings by natural asset type.

4 Conclusion

Natural and enhanced assets provide a cost-effective, resilient, alternative to some built infrastructure in terms of the services that they can provide for local governments. Indeed, when managed properly, such assets provide several valuable services such as stormwater management, urban heat reduction, air quality improvements, and recreation. Asset management, including the creation of an asset inventory that quantifies the natural and enhanced assets within municipal boundaries along with the services those assets deliver, provides a framework for measuring and monitoring the ways people depend on and benefit from nature. In so doing, asset management ensures the services provided by natural and enhanced assets are maintained or improved over time.

The City of Vernon has significant natural and enhanced assets, such as forests, grasslands, wetlands, urban trees and open water, that provide multiple benefits to Vernon residents and the natural environment. Natural asset management, like asset management for built infrastructure, provides an avenue for the City of Vernon to understand the location, extent and type of natural and enhanced assets within the municipal boundary. It provides a foundation for identifying and implementing management actions to help ensure continued or improved service delivery in the future while also informing land use planning decisions. The purpose of this project was to inventory Vernon's natural and enhanced assets and conduct a natural asset condition assessment. The inventory and condition assessment are foundational aspects of natural asset management and as such they position Vernon to continue to advance natural asset management over time.

The City of Vernon's natural asset assessment resulted in the following findings:

- **Asset Inventory**: Within the City of Vernon:
    - Enhanced and natural assets cover 9,188 ha within the municipal boundary (77% of the total area within the municipal boundary), including Canoe Bay (Vernon Arm of Okanagan Lake). Without Canoe Bay included, the enhanced and natural assets cover 7,075 ha of the City (60% of the total area within the municipal boundary).
    - Natural assets cover 7,411 ha or 81% of the asset area.
    - Enhanced assets cover 1,777 ha or 19% of the total area of assets.
    - There are 154 km of water flow routes. Of these, 137 km (89%) are ephemeral (seasonal or intermittent) and 17 km (11%) are constant flow.
    - Dominant natural asset types include forest assets, grassland assets and open water assets (when Canoe Bay is included in the open water area calculations).
    - Less dominant natural asset types include wetlands, riparian areas, and sparsely vegetated land.
    - The city owns 8% of the natural and enhanced assets within Vernon's municipal boundary.
- **Condition Assessment**: Most of Vernon's natural assets are in good or very good condition**:**
    - The majority of the City's assets were rated as good or very good, with approximately 19% and 77% of the assets, respectively falling into these categories.
    - Grassland and woodland assets have the highest percent of assets in very good condition with over 70% of these assets rated as such.
    - Riparian and wetland assets have the highest portion of assets rated as fair condition. Of the 186 ha of riparian assets, 57 ha (30%) rated as fair condition. Of the 36 ha of wetland assets, 11 ha (29%) rated as fair condition.
    - Riparian and sparsely vegetated lands were the only assets that included assets rated in poor condition. Of the 186 ha of riparian assets, 3 ha (1%) rated as poor condition. Of the 218 ha of sparsely vegetated assets, 0.7 ha (0.3%) rated as poor condition.

The inventory and condition assessment results are useful for indicating potential high-level management actions. Assets in good and very good condition may be suitable, for example, for conservation or protection and assets in fair, poor or very poor condition may be appropriate for enhancement and restoration. However, to identify specific actions for particular assets, as per natural asset management, the condition results should be a) verified through field based assessments, b) considered in light of applicable risks, c) evaluated for the services they deliver, and d) examined in light of community priorities and strategic objectives.

Natural asset management is a progressive approach to City planning that is increasingly being adopted by local governments in Canada. The asset inventory and condition assessment undertaken by the City of Vernon is a significant opportunity for the City to be a leader in this budding movement. They provide the foundation from which the City of Vernon can continue to advance natural asset management. Natural asset management can inform multiple City planning processes in Vernon, such as the Official Community Plan, Transportation Plan, Climate Action Plan, and asset and infrastructure planning. Subsequent phases of work are needed to complete the overall natural asset management process for the City of Vernon.

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6 Appendix A: Developing a Natural Asset Management Plan

This appendix briefly describes the steps associated with developing a natural asset management plan. Readers seeking further guidance and best practices on natural asset management are encouraged to refer to the ***Nature is Infrastructure: How to Include Natural Assets in Asset Management Plans*** guidance document by the Natural Assets Initiative. Figure 6-1 identifies the steps typically involved with natural asset management plans. Brief descriptions of each step are articulated in Table 6-1 following the figure.

Figure 6-1. Steps for developing a natural asset management plan.

Table 6-1. Short descriptions of steps involved in developing a natural asset management plan.

Step	Description
1. Obtain and Review Data	A natural asset management plan begins with gathering relevant geo-spatial datasets. This includes spatial depictions of landcover, land use, roads, administrative boundaries, watercourses, and ecological data. Asset types and classes are defined relying on designations within the spatial data layers. Assets are frequently categorized as either enhanced or natural with further breakdowns within these categories to define forests, wetlands, grasslands, urban trees, parks and more.
2. Structure the Asset Registry	The spatial data layers are amalgamated in GIS and an asset registry is structured. The registry is a tabular depiction of the inventory where each asset is a row in the registry and attributes are housed in a series of columns. Each asset is assigned a unique identifier and is associated with relevant attributes such as asset type, ownership, condition and service potential.
3. Delineate and Quantify Assets	The spatial data is used to delineate the type, location and extent of each asset. This step ensures that all assets within the project boundary are accounted for and quantified appropriately.
4. Assess Asset Condition	A desktop (GIS-based) condition assessment is performed to evaluate the ecological condition of the assets. Indicators such as permeability of adjacent lands, road density, connectivity, and intactness are applied to the assets and a ranking system for each indicator is used to assign condition scores on a standardized scale (e.g., from very good to very poor). The condition scores are summed for each asset to get an overall condition score that reflects the combined results for each condition indicator. The condition results are incorporated into the asset registry.
5. Assign Replacement Costs	Replacement costs that reflect the cost of replacing (restoring) the assets are assigned to each asset and incorporated into the asset registry. The costs encompass costs associated with restoration planning, materials, labour, and initial maintenance.
6. State of Infrastructure Report	The State of the Infrastructure Report summarizes the inventory, condition assessment and replacement costs providing guidance on the approaches employed and the outputs derived. Similar reports are produced for built assets as part of asset management for built

Step	Description
	infrastructure.
7. Identify Priority Services	During this step priority ecosystem services for the area under consideration are identified. This is done in consultation with project leads and through review of local context. Ecosystem services that are frequently identified as high priority include stormwater management and drinking water provision; services that are typically associated with natural assets and can have significant implications for the well-being of local populations.
8. Quantify and Value Services	At this point, consideration is given to quantifying the priority services. This may entail an economic valuation of the services (to the extent feasible given data availability and limitations on valuation approaches) and/or the articulation of levels of service indicators. Levels of service describe the current or target service provision levels that the municipality seeks to provide to local citizens.
9. Risk Assessment	Hazards that could negatively impact natural assets and their ability to deliver services are then identified and evaluated. Hazards may be evaluated based on their relative likelihood and impact and/or their probability and consequence of failure. Critical assets are commonly identified through this process along with risk mitigation actions. The results of the risk assessment are incorporated into the asset registry.
10. Lifecycle Activities	Management activities that consider the condition of the assets, their risk profile and the services they provide are identified at this stage of the process. Activities reflect the lifecycle of the assets and thus include maintenance, enhancement and restoration activities.
11. Financial Assessment	The financial assessment considers the cost of the lifecycle activities. The purpose is to quantify the financial resources needed over the lifecycle of the assets to ensure continued or improved service delivery in the face of risks. The cost of the lifecycle activities are compared with budget allocations to identify budget shortfalls should they exist.
12. Asset Management Plan	The final step is to integrate the results of the preceding steps into a comprehensive Natural Asset Management Plan. This plan serves as a strategic framework for managing natural assets, ensuring their long-term sustainability and alignment with broader community goals.

7 Appendix B: Data Sources

Dataset	Use / Description	Source	Year
City Boundary	Used as the study area boundary	City of Vernon	2023
Land Ownership	Used to determine various entities land ownership within natural and enhanced assets	City of Vernon	
Building Footprints	Used to eliminate buildings from asset delineation	City of Vernon	2023
Parks	Used to provide attributes to unmanaged natural park space as well as delineate enhanced park areas	City of Vernon	2023
Roads	Used to eliminate roads from asset delineation as well as acting as the core layer in the road density condition assessment	City of Vernon	2023
Raw LiDAR	Processed to produce individual tree segmentation points and canopy cover polygon delineation	City of Vernon	2018-2019
SEI Commonage	Used as the core dataset for asset classification and delineation	Ecoscape Environmental Consultants	2024
SEI Bella Vista	Used as the core dataset for asset classification and delineation	Ecoscape Environmental Consultants	2024
SEI Coldstream	Used as the core dataset for asset classification and delineation	Ecoscape Environmental Consultants	2024
Wetlands (DIPP Review)	Used to improve wetland delineation within the study area	Ecoscape Environmental Consultants	2024
Wetland Predictive Modeling	Used to improve wetland delineation within the study area	Okanagan Collaborative Conservation Program	2024
Water Flow Routes	Used to delineate areas of water flow within the study area	City of Vernon (Drainage Infrastructure Prioritization Project) (2019) Urban Systems (2019)	2019

Dataset	Use / Description	Source	Year
North and Central Okanagan Region Habitat Connectivity Rankings	This model integrated a series of parameters to identify connected and potentially fragmented habitats. The model was not specific to a particular species. The goal was to identify portions of the landscape offering a higher opportunity for wildlife movement at a regional scale. Used to aid in conducting the connectivity condition assessment	Okanagan Collaborative Conservation Program	2011
Cumulative Effects Framework – Human Disturbance	Used to aid in conducting the watershed intactness condition assessment	Province of BC	2023
Assessment Watersheds	Used to assign attributes to assets	Province of BC	2024
Fundamental Watersheds	Used to assign attributes to assets as well as in the intactness condition assessment	Province of BC	2024
Open Water and Lakes	Used to aid in waterbody delineation	Province of BC	2024
Manmade Waterbodies	Used to spot check waterbody delineation to ensure natural waterbodies were correctly attributed	Province of BC	2024
Vegetation Resources Inventory (VRI)	Used to apply forest attributes to forested and woodland polygons	Province of BC	2023
Sentinel-2 10-Meter Land Use/Land Cover	Used to provide landcover within a 1km buffer outside of the study area. This area was used within condition assessments to eliminate artificial cutoffs of continuous natural space.	ESRI	2023

8 Appendix C: Condition Assessment Approach and Detailed Results

This appendix provides a description of each individual condition assessment indicator used in the GIS-based spatial analysis to estimate the overall natural asset condition scores presented in Section 3. The following sub-sections detail each condition indicator, explaining how the indicators were defined and applied within a GIS framework, and summarizing the rationale, analytical approach, scoring methodology, and results.

The condition indicators were combined to generate an overall condition score for each natural asset within the inventory. This was done by averaging the scores across the indicators assuming equal weight for each indicator.

8.1 Interior Habitat

INDICATOR: The relative size of contiguous natural asset areas with larger patches that have more interior area considered higher quality than smaller patches.

RATIONALE: The objective of this indicator is to create a proxy for condition, based on the relative size of contiguous patches of natural assets. In general, larger blocks of habitat (whether they be meadow, forest, and/or wetland) tend to support a greater diversity of plants and wildlife, including habitat specialists that require, or benefit from, conditions only found somewhat removed from a non-natural land cover type (e.g., roads, residential, institutional, or commercial development). In an urbanized context, as the distance from the edge of a natural area to the interior of that area decreases, the penetration of noise and other human-related disturbances and encroachments that can negatively impact certain species associated with those habitats increases.

APPROACH: "Interior" habitat – particularly in forest and woodlands - is typically measured by buffering inwards from the feature or "patch" edge. The first step was thus to establish the "patch" edge. The area within the inner boundary was then quantified. The quantification of interior habitat was applied to asset classes.

SCORING: Recognizing the landscape ecology principle that large "blocks" of habitat generally provide a greater range of better-quality habitats, a scoring system was developed based on whether interior habitat exists with varying distances from the habitat edge. Continuous patches of asset classes were used as the basis for this scoring.

Table 8-1. Condition ranking criteria for interior habitat.

Condition Rating	Criteria
Very Good	An asset within a habitat patch with an interior area measured >200 m from the feature edge
Good	An asset within a habitat patch with an interior area measured 150-200 m from the feature edge and not already captured as "very good"
Fair	An asset within a habitat patch with an interior area measured 100-149 m from the feature edge and not already captured as "very good" or "good"
Poor	An asset within a habitat patch with an interior area measured 50-99 m from the feature edge and not already captured as "very good", "good", or "fair"
Very Poor	Any asset with no interior area measured at <50 m from the feature edge

RESULTS:

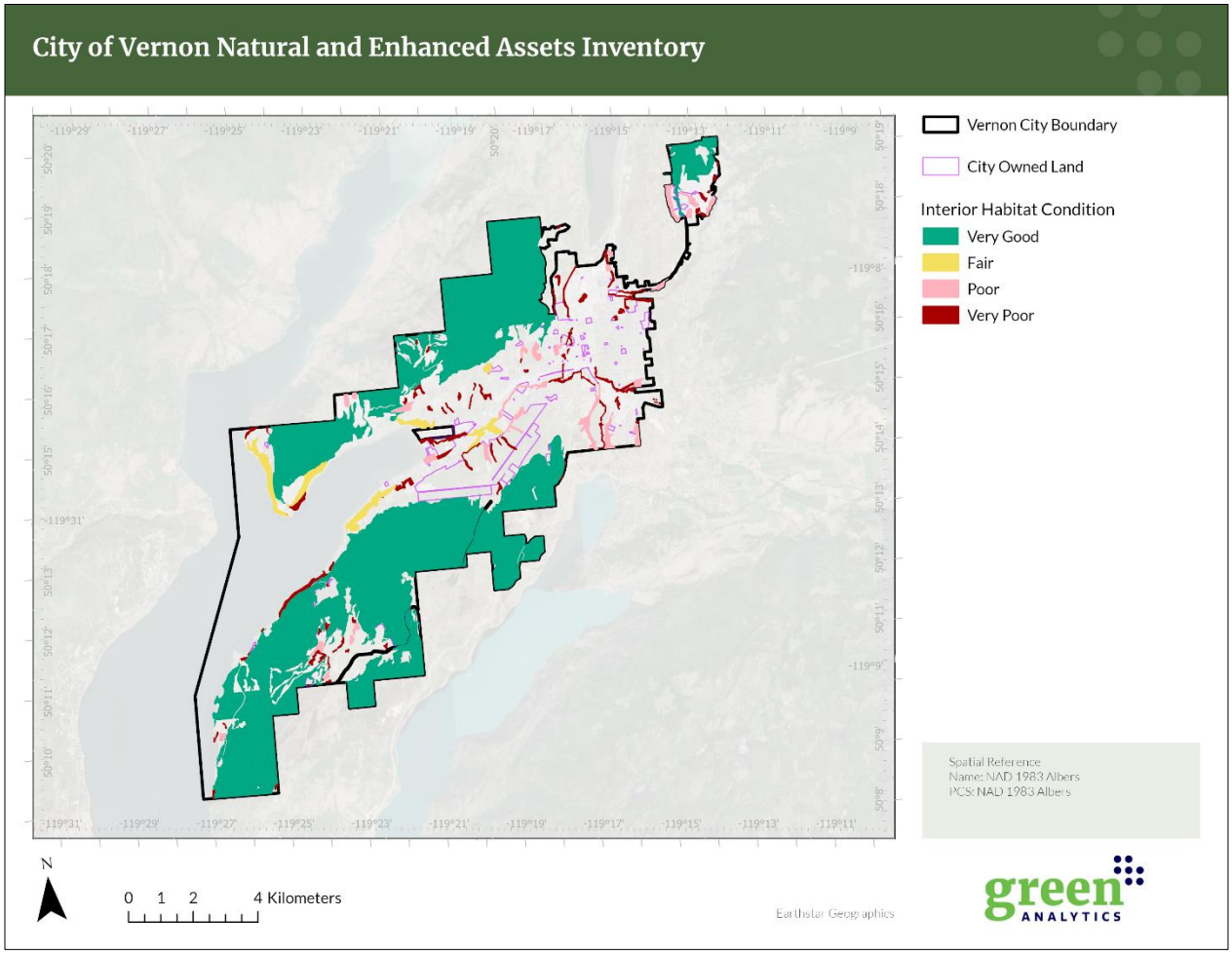
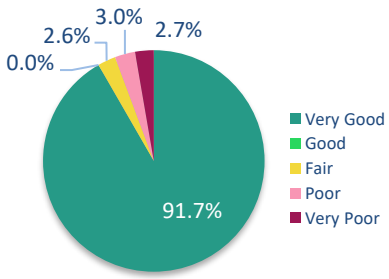


Figure 8-1. Condition assessment results for interior habitat.

Table 8-2. Condition assessment results for interior habitat.

Condition Rating	Area (ha)	Percent of Total
Very Good	4,856	91.7%
Good	0	0%
Fair	140	2.6%
Poor	157	2.9%
Very Poor	144	2.7%



8.2 Road Density

INDICATOR: Density of roads within 120 m of the terrestrial natural assets, with higher road density ranking less favorably.

RATIONALE: Roads both adjacent to and within natural areas are known to cause negative impacts to natural features and their functions because they contribute directly to fragmentation, introduce noise and pollutants associated with vehicles, and provide vectors that facilitate human access to these features, which can result in additional encroachments and impacts (e.g., Environment Canada 2013; DeCatanzaro and Chow-Fraser 2010). The objective of this indicator is to capture the relative level of human use/activity occurring within natural assets and in the lands adjacent to terrestrial natural features (including wetlands) as reflected in road density.

APPROACH: To develop locally appropriate road density ranges aligned with the five condition score ratings (i.e., very good, good, fair, poor, and very poor) the range of road density metrics used as part of the BC Cumulative Effects Framework was reviewed. This framework draws on BC relevant research to establish different road density thresholds (see Section 8.7 for additional details). However, the thresholds in the BC Cumulative Effects Framework are most appropriate when applied to a broader landscape scale such as a watershed. They are less applicable to a municipal context. The current study is focused on estimating road density in the immediate vicinity of natural assets located in and around an urban centre. For this reason, an alternative study was selected to inform the approach and scoring for the City of Vernon's condition assessment. Specifically, DeCatanzaro and Chow-Fraser (2010) was used to inform the relevant road density thresholds since it was based on buffering the sites of interest and correlating measures of condition with road densities. DeCatanzaro and Chow-Fraser (2010) demonstrate that for 77 marsh sites along the coast of lakes Erie, Ontario, and Huron that the water quality index (WQI) and wetland macrophyte index (WMI) scores were highly negatively correlated with surrounding road densities. Their results show the highest road density was 102 m/ha (or 10.2 km/km^2). Given the correlation to condition indices noted above, 10 km/km^2 was established as the threshold for very poor. Similarly, their lowest road density estimates for Lake Ontario 7.16 m/ha (or 0.72 km/km^2) was established as the threshold between good and very good. Other category thresholds are outlined below.

SCORING: Road density was assessed for areas within 120 m of the natural asset classes. Rankings were assigned as per the following table.

Table 8-3. Condition ranking criteria for road density.

Condition Rating	Criteria	Rationale
Very Good	0 to 0.7 km/km^2	Low road densities are indicative of landscapes that are minimally fragmented, supporting high ecological integrity and habitat connectivity.
Good	0.8 to 2.9 km/km^2	Moderate road densities allow for some development while maintaining a reasonable level of ecological functionality.
Fair	3 to 6.9 km/km^2	Higher road densities in this range suggest significant human use of the landscape.
Poor	7 to 10 km/km^2	Densities within this range indicate heavily fragmented landscapes with limited ecological functionality.
Very Poor	> 10 km/km^2	Extremely high road densities represent landscapes that are heavily urbanized or industrialized, leaving minimal room for natural processes.

RESULTS:

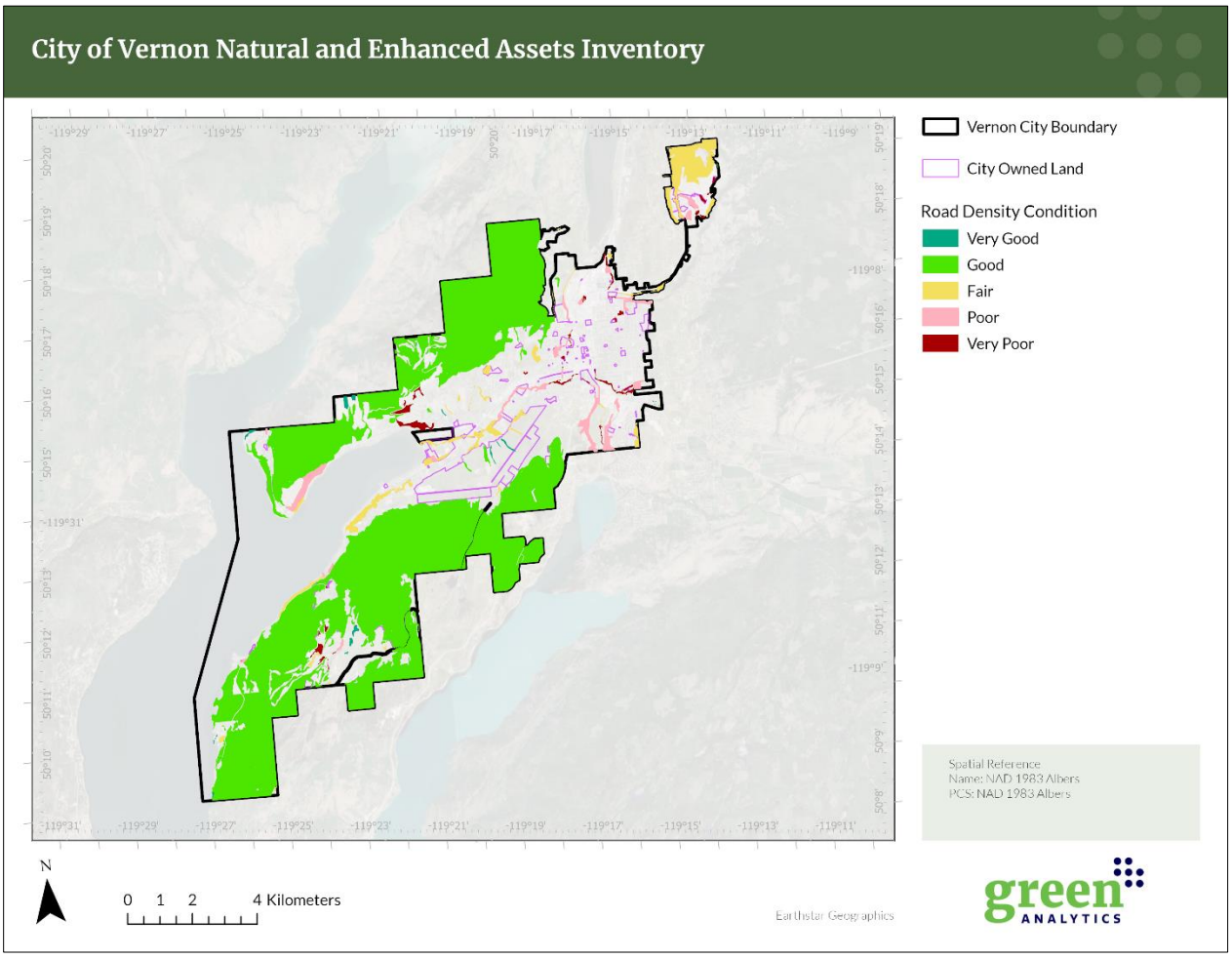
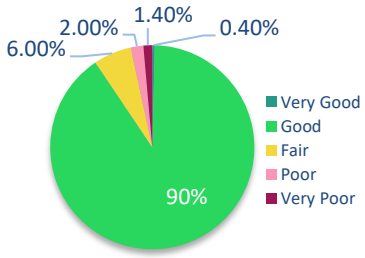


Figure 8-2. Condition assessment results for road density.

Table 8-4. Condition assessment results for road density.

Condition Rating	Area (ha)	Percent of Total
Very Good	24	0.4%
Good	4,771	90%
Fair	319	6.0%
Poor	107	2.0%
Very Poor	76	1.4%



8.3 Natural Asset Proximity to Other Natural Assets

INDICATOR: A measure of the proximity of natural asset classes to other natural asset classes with assets in closer proximity rating higher than those further away.

RATIONALE: Measuring proximity is a common metric used for understanding and improving habitat connectivity, particularly in fragmented landscapes. It helps identify critical areas for wildlife movement and gene flow, supporting biodiversity and ecosystem resilience by facilitating species dispersal and recolonization. In urban contexts, proximity measures guide the creation of interconnected green spaces that enhance ecological functions, such as air quality and urban cooling. These metrics also inform conservation strategies, policy-making, and urban planning decisions, ensuring that both ecological and human needs are met.

APPROACH: Each natural asset class patch was buffered by the condition rating thresholds noted below and the appropriate rating was applied based on the closest buffer where another natural asset class patch is found.

SCORING: The following table summarizes the proximity distances assumed for each condition rating and the rationale for each condition rating.

Table 8-5. Condition ranking criteria for proximity to other natural assets.

Condition Rating	Criteria	Rationale
Very Good	< 100 m	Patches nearly adjacent or minorly separated.
Good	100–500 m	Nearby patches separated by minor roads or open spaces.
Fair	500 m–1 km	Somewhat isolated patches, significant barriers present.
Poor	1–5 km	Limited movement likely; only highly mobile species benefit.
Very Poor	> 5 km	Patches are functionally disconnected for most species.

RESULTS:

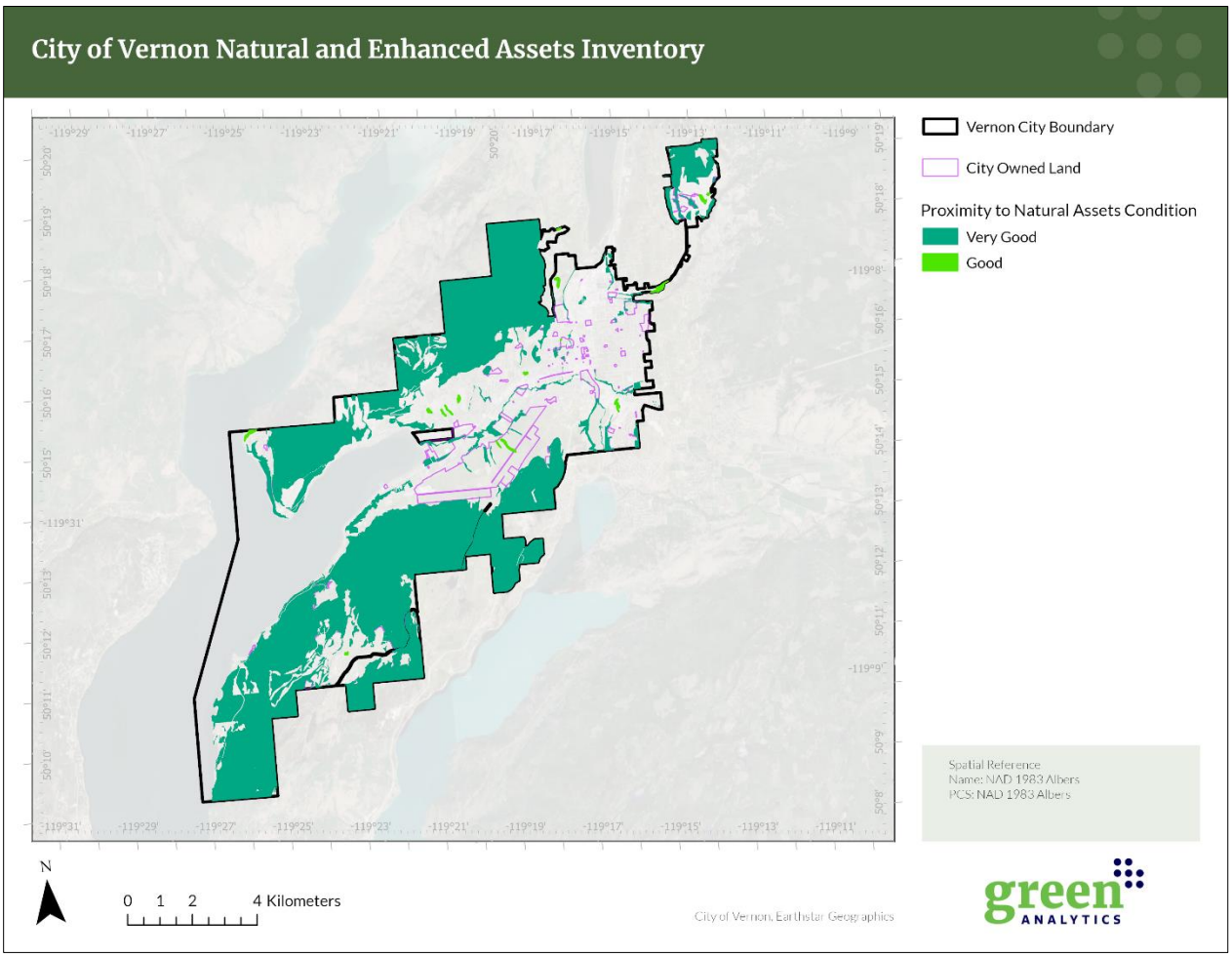
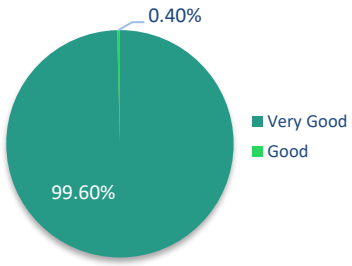


Figure 8-3. Condition assessment results for proximity to other natural assets.

Table 8-6. Condition assessment results for proximity to other natural assets.

Condition Rating	Area (ha)	Percent of Total
Very Good	5,275	99.6%
Good	22	0.4%
Fair	0	
Poor	0	
Very Poor	0	



8.4 Extent of Adjacent Permeable Land Uses

INDICATOR: The extent of permeable land cover within 120 m of an asset with more permeable adjacent lands resulting in a more favorable rating.

RATIONALE: How and the extent to which a given natural area is influenced by drainage in the adjacent landscape varies depending on factors such as local topography and soils, where the feature “sits” in the landscape and the size and nature of the feature itself. However, it is well-established that the condition

of a terrestrial natural feature (including wetlands) in an urban context tends to be negatively impacted when more of the surrounding land uses are impervious (i.e., paved, concrete or buildings) as this tends to alter pre-existing drainage and infiltration pathways, which can cause a natural area to receive more or less drainage than prior to being in the urban context. Urban runoff also typically carries a host of sediments and contaminants, and when such runoff is directed to natural areas and not properly treated, it can negatively impact the feature and its functions.

Increases in the extent of impervious surfaces within a given watershed or catchment area are generally known to have negative impacts to natural features in that watershed or catchment area, particularly for features downstream of the impervious areas, resulting in a push towards planning that limits impervious surfaces and incorporates low impact development measures that facilitate local infiltration.

However, land cover types with extensive pervious surfaces that are not "natural" *per se* but occur in the lands adjacent to natural areas, such as manicured parks/open spaces and agricultural lands, are recognized as potentially supporting the functions of nearby natural areas in some regards by providing one or more of the following:

- Permeable surfaces (thereby supporting hydrologic regimes),
- Temporary or permanent vegetation (e.g., isolated or small groupings of trees/landscaped areas, agricultural crops), and/or
- Intervening lands between natural areas and built areas that are used less frequently and/or less intensively by people.

For example, a school ground between a wooded area and a high-density residential area is generally considered preferable to having a high-density residential area directly abutting the natural area.

APPROACH: A 120 m buffer (exclusive of asset area) was drawn around each natural asset class boundary. The extent of landcover associated with permeable land uses and natural assets was estimated in ha within each buffer. Areas of permeable uses include agriculture, built-up pervious, and golf course land covers. These areas have vegetated cover but are not natural in the true sense of the definition. The area of the 120 m buffer was estimated in ha, and the percentage of each buffer that consists of these natural areas/permeable land uses was estimated. A ranking was then applied to each buffer and linked to the relevant natural assets.

SCORING: A ranking was assigned to each asset based on the percentage of permeable land uses with the 120 m buffer as per the following table.

Table 8-7. Condition ranking criteria for extent of adjacent permeable land.

Condition Rating	Criteria	Rationale
Very Good	51 to 100% permeable land uses	High permeability indicates that areas surrounding the assets are dominated by natural or semi-natural land uses that allow for water infiltration, biodiversity, and ecological processes.
Good	31% to 50% permeable land uses	Moderate permeability supports a balance between natural processes and human activities. While development impacts are present, sufficient permeable land remains to sustain ecosystem services and mitigate environmental stress.
Fair	16% to 30% permeable land uses	Low permeability reflects a transition to more intensive land use. Ecological functionality is increasingly compromised, with reduced water infiltration, higher runoff, and fragmented habitats.
Poor	1% to 15% permeable land uses	Very low permeability indicates significant landscape modification, often associated with urbanization or industrial land use. Environmental impacts are severe, with minimal capacity for natural processes.
Very Poor	0% permeable land uses	Complete impermeability surrounding natural assets results in the loss of natural function, leading to challenges for water management, biodiversity, and ecosystem resilience.

RESULTS:

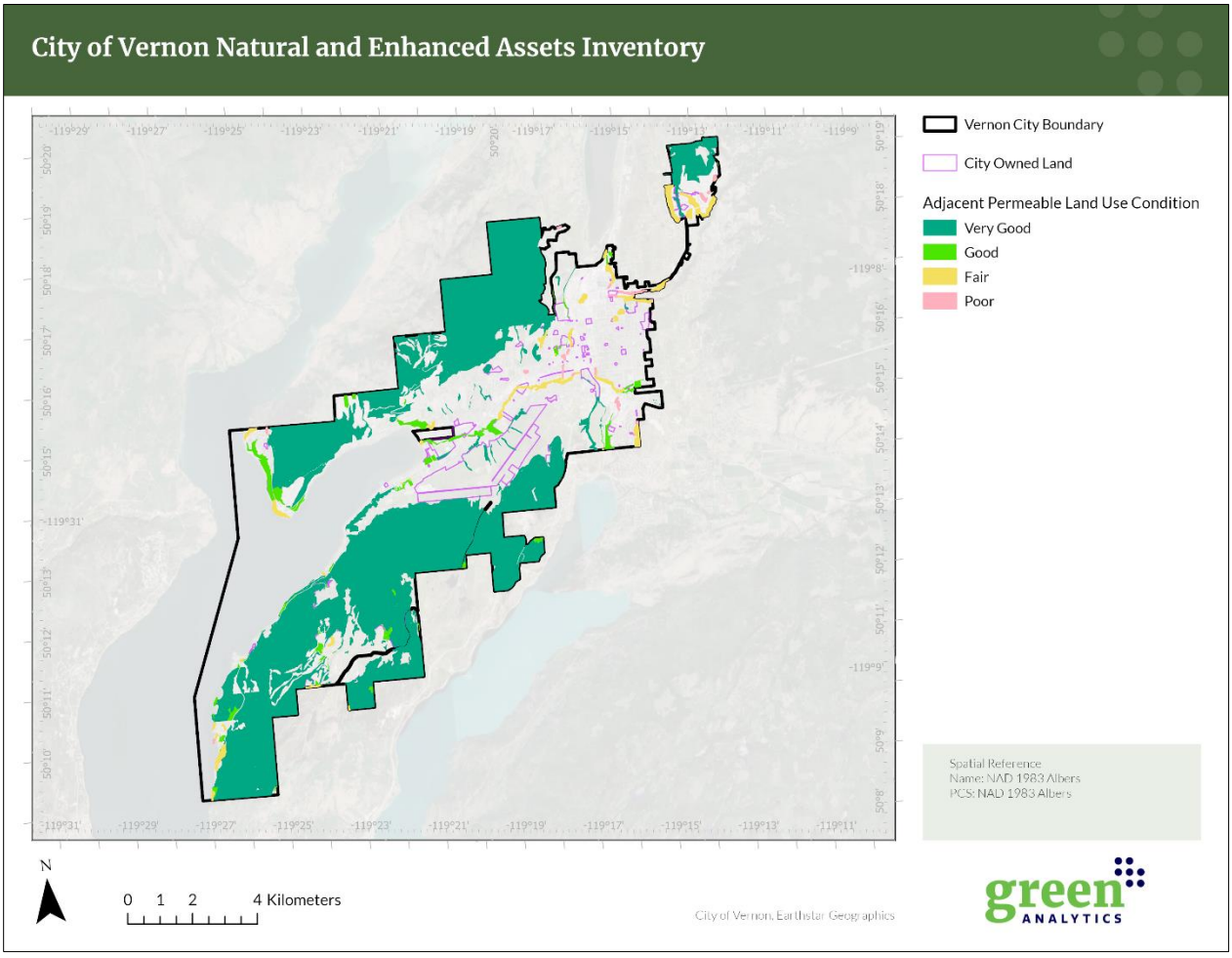
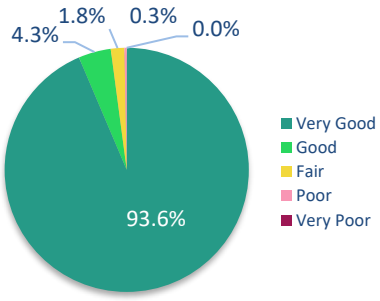


Figure 8-4. Condition assessment results for extent of adjacent permeable land uses.

Table 8-8. Condition assessment results for extent of adjacent permeable land uses.

Condition Rating	Area (ha)	Percent of Total
Very Good	4,953	93.6%
Good	230	4.3%
Fair	95	1.8%
Poor	15	0.3%
Very Poor	0	0%



8.5 Percent Intact Watershed Area

INDICATOR: Percent of a fundamental watershed area that is intact, as measured by natural asset area outside a 250-meter buffer around disturbed and developed areas.

RATIONALE: The indicator serves as a practical and science-based indication of watershed health by highlighting the extent of ecological intactness. Human disturbances such as urban development, agriculture, and roads introduce stressors like nutrient runoff, sedimentation, and habitat fragmentation, which disproportionately impact areas within close proximity. The 250-meter buffer captures these influence zones, allowing the remaining "core" areas outside the buffer to reflect zones with greater ecological integrity, supporting natural hydrological, biological, and chemical processes. This makes it a robust tool for assessing the degree of disturbance and prioritizing conservation or restoration efforts.

This metric is straightforward to calculate, scalable, and enables comparisons across regions or over time, making it valuable for watershed management. It aligns with landscape ecology principles by emphasizing connectivity, minimizing edge effects, and protecting core habitats, which are critical for biodiversity and ecosystem resilience. While it does not directly measure factors like water quality or disturbance intensity, it complements other metrics and provides insights to guide sustainable land use planning and conservation initiatives. By focusing on areas less impacted by human activity, this metric underscores the importance of preserving intact natural spaces for maintaining watershed health.

APPROACH: This indicator draws on the Provincial disturbance dataset which captures all known human disturbances on the land base.[1] The data captures a range of disturbances such as cut blocks within the last 20 years, geophysical seismic lines, anything the province indicates is human or built up areas, transmission lines, pipelines, oil and gas wells, well sites, road and rail infrastructure. All human disturbance areas were buffered by 250 m to define the core intact area of each watershed. Discrimination between types of disturbances was not undertaken for this exercise because the primary focus of this exercise was to identify intact lands. To determine the area of intact land the area disturbed was subtracted from the total area of the fundamental watershed, which was then converted into a percentage value to determine the condition rating threshold of each fundamental watershed.

SCORING: A ranking was assigned to each fundamental watershed based on the percentage of intact land as per the following table.

[1] https://catalogue.data.gov.bc.ca/dataset/7d61ff12-b85f-4aeb-ac8b-7b10e84b046c

Table 8-9. Condition ranking criteria for percent of watershed intact.

Condition Ranking	Threshold Criteria	Rationale
Very Good	>75% intact	Most of the watershed remains green or undeveloped, with natural areas integrated into the urban matrix. Careful urban planning supports ecological connectivity and water management.
Good	>45-75% intact	A significant portion of the watershed is intact, with green spaces, parks, and riparian buffers helping maintain ecosystem services. Some fragmentation exists, but the watershed retains good functionality.
Moderate	>35-45% intact	Substantial urban development has reduced intact areas, and ecological functions are moderately impaired. Connectivity is limited, but some natural features remain to support partial ecosystem services.
Poor	>10-35% intact	Urban infrastructure dominates, with few remaining natural areas. Ecological functions are significantly disrupted, and water quality and habitat are degraded.
Very Poor	≤10% intact	The watershed is almost entirely developed, with minimal green spaces or natural buffers. Ecosystem services are negligible, and significant restoration and built infrastructure alternatives are needed to mitigate environmental impacts and reduced ecosystem services.

RESULTS:

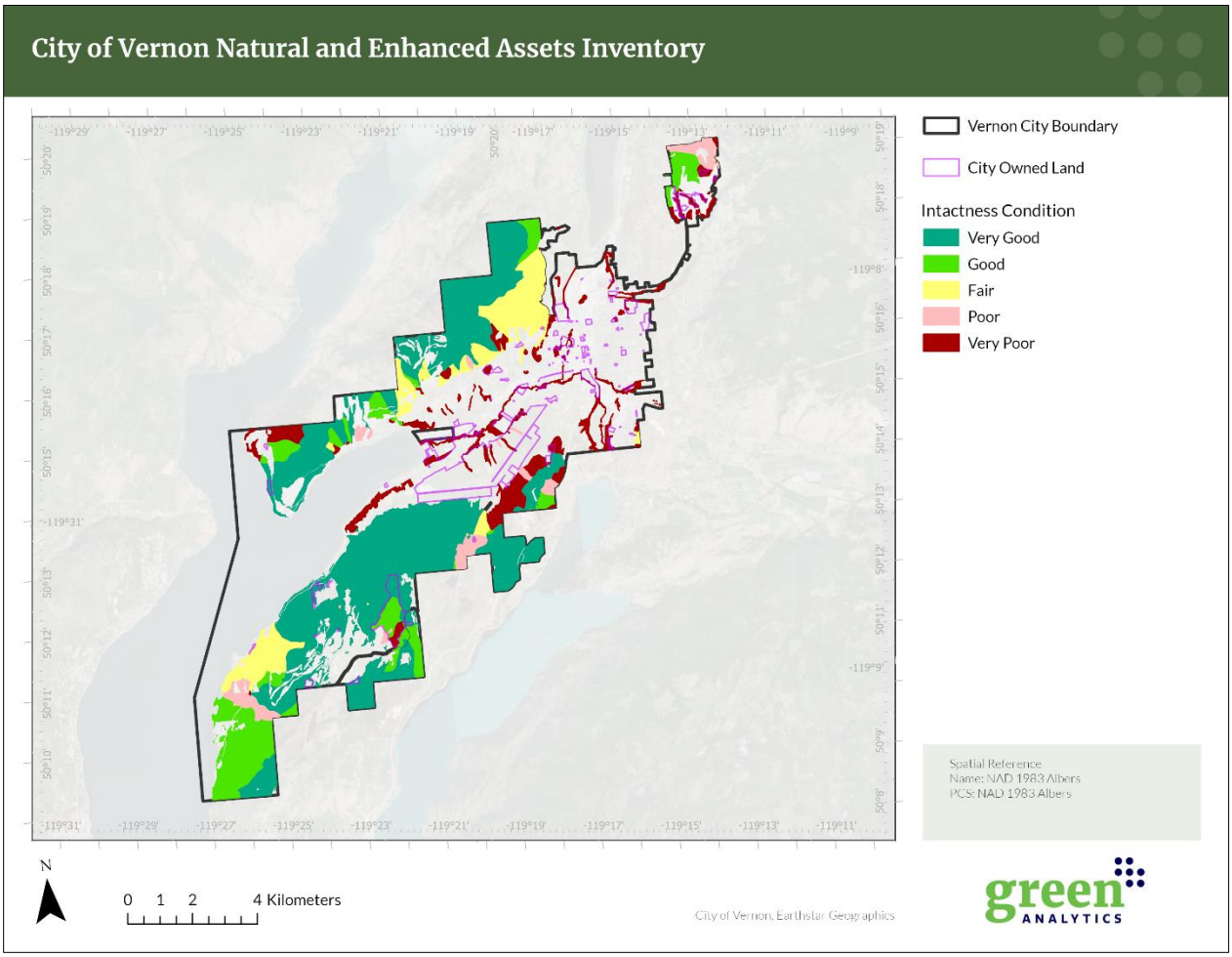
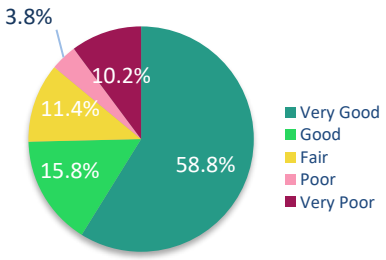


Figure 8-5. Condition assessment results for percent of watershed intact.

Table 8-10. Condition assessment results for percent of watershed intact.

Condition Rating	Area (ha)	Percent of Total
Very Good	3,118	58.9%
Good	835	15.8%
Fair	601	11.4%
Poor	204	3.8%
Very Poor	539	10.2%



8.6 Connectivity

INDICATOR: Habitat connectivity rankings for the north and central Okanagan Region.

RATIONALE: Previously existing data was available (Caslys Consulting Ltd. 2014) from a GIS-based analysis used to model habitat connectivity in the three Okanagan Regional Districts. The GIS model identified connected and potentially fragmented habitats with the goal of identifying portions of the landscape offering a higher opportunity for wildlife movement at a regional scale. Key parameters used to rank connectivity corridors included:

- Elevation – Lower elevations (i.e., the valley) receive higher scores;
- Slope – Steep slopes receive lower scores;
- Terrain Ruggedness – Terrain with less variability receive higher scores;
- Accessibility to water – Areas that are more readily accessible to water receive higher scores; and
- Urban areas – Urban areas and roads were not considered to provide connectivity.

Based on the scores generated by the model, habitat connectivity was ranked as either low, moderate, high or as a connectivity barrier. Given this pre-existing data was designed to quantify and map biodiversity and wildlife habitat connectivity in the region, the mapping results were leveraged to help inform the condition of the natural assets across the City of Vernon.

APPROACH: The available habitat connectivity ranking data was overlaid with the natural asset inventory. Natural assets were allocated the corresponding habitat connectivity ranking. The north and central Okanagan connectivity analysis ranked habitat connectivity as follows: 0 – connectivity barrier, 1 – Low, 2 – Moderate, 3 – High.

RANKING: The existing connectivity rankings were converted to comparable condition rankings as per the following Table.

Table 8-11. Condition ranking criteria for connectivity.

Condition Ranking	Criteria
Very Good	High connectivity
Good	Moderate connectivity
Moderate	Low connectivity
Poor	Connectivity barrier
Very Poor	NA

RESULTS:

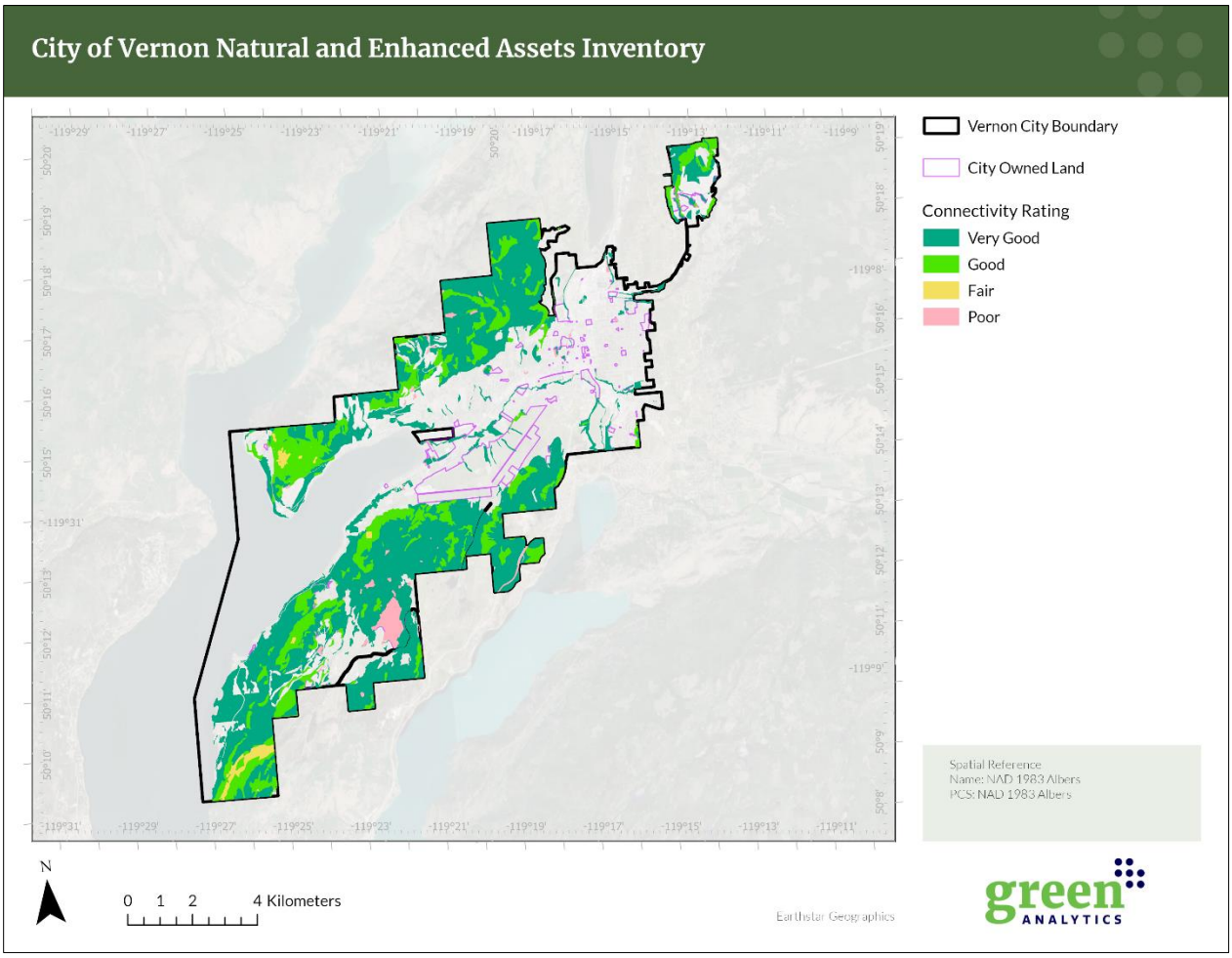
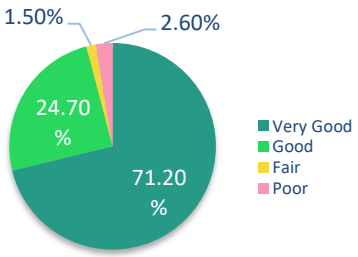


Figure 8-6. Condition assessment results for connectivity.

Table 8-12. Condition assessment results for connectivity.

Condition Rating	Area (ha)	Percent of Total
Very Good	3,771	71.2%
Good	1,3012	24.7%
Fair	78	1.5%
Poor	135	2.6%
Very Poor	0	0%



8.7 Cumulative Effects Framework – Road Density Thresholds

The BC cumulative effects framework (CEF) was reviewed to potentially identify BC-specific road densities for use in the road density condition indicator assessment. The CEF provides several scoring options, which vary depending on the context in which they are applied. Separate criteria are articulated for application as a water quality metric versus application as a metric for grizzly bears. The scoring thresholds from the CEF are provided below. As is noted in Section 8.2, these thresholds were not employed in the Vernon condition assessment as they were deemed more applicable to a watershed scale condition assessment and thus less applicable to a municipal level assessment such as that employed in the current study.

Example 1: Thresholds based on water quality metric applied to sensitive watershed as defined by BC CEF (British Columbia 2020a).

Impact Ranking	**Threshold Criteria**
Low	Road density < 0.6 km/km^2
Moderate	Road density between 0.6 and 1.2 km/km^2
High	Road density > 1.2 km/km^2

Example 2: An alternative (or secondary) water quality metric used by the BC CEF that is aligned with Watershed Assessment Procedure (WAP) benchmarks and was applied to all non-sensitive watersheds (British Columbia 2020a).

Impact Ranking	**Threshold Criteria**
Low	Road density < 1.5 km/km^2
Moderate	Road density between 1.5 and 2.1 km/km^2
High	Road density > 2.1 km/km^2

Example 3: Based on biodiversity metric used for Grizzly Bears by BC CEF (British Columbia 2020b).

Impact Ranking	**Threshold Criteria**
Low	Road density >0 – 0.3 km/km^2
Moderate	Road density between 0.31 and 0.6 km/km^2
High	Road density between 0.61 – 0.75 km/km^2
Very High	Road density > 0.75 km/km^2