DISTRICT OF SQUAMISH

NATURAL ASSET MANAGEMENT STRATEGY

URBAN SYSTEMS

PREPARED FOR:

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1.0 INTRODUCTION

1.1 PURPOSE OF THIS STRATEGY

The purpose of the Natural Asset Management (NAM) Strategy is to:

- Bring attention to the quantity and value of natural assets within the District and their role in municipal service delivery, and to the importance of having strong NAM practices
- Provide guidance on how to improve the District's NAM practices, so that informed decisions can be made on when to protect, enhance, and maintain those assets
- Ultimately help the District use NAM to deliver services to the community that are affordable, sustainable, and help achieve the community's vision and goals

1.2 NATURAL ASSETS & NATURAL ASSET MANAGEMENT

Key Terms

Asset management (AM) is the continuous process of bringing together information about assets and finances, with the expertise of people, to make informed decisions about how to provide services to the community. The goal of AM is sustainable service delivery.

Natural asset management (NAM) is the integrated approach of including natural assets in AM processes to deliver sustainable services.

It is important to consider all types of assets in the District's municipal AM and NAM processes and practices. Assets can include:

- Green infrastructure is an engineered asset that aims to mimic natural functions and processes to deliver municipal services and may provide ecological services as co-benefits.
- Grey infrastructure refers to infrastructure that is designed, built, operated, and maintained to provide municipal services – for example, a water treatment plant or a drainage pipe.
- Natural assets are naturally occurring resources that provide services to the community:
    - They provide ecological services, such as habitat for wildlife, and offer co-benefits that are not easily replicated through engineered infrastructure.
    - Some natural assets also provide municipal services, such as drinking water supply and stormwater conveyance.

The distinction between green infrastructure (engineered) and natural assets (naturally occurring) is important because they are treated differently from an AM perspective.

Why consider natural assets?

- **They provide an opportunity to manage the District's infrastructure funding gap.** Without the natural assets that provide core municipal services, local governments typically rely on costly engineered infrastructure to provide the service. Increased reliance on engineered infrastructure (in the place of natural assets) can lead to higher lifecycle costs, as they include upfront construction, ongoing operations and maintenance, and renewal and eventual replacement.

  Like many other communities, the District has an 'infrastructure funding gap': a gap between actual funding levels and the theoretical funding levels it needs to sustain service levels provided by engineered assets. Decisions to protect, maintain, or enhance natural assets and the services they provide can help contain and even reduce the gap:

  - Protect natural assets – contain the infrastructure deficit
  - Maintain natural assets – contain the infrastructure deficit
  - Enhance natural assets – reduce deficit or increase LOS

- **They help increase the community's resilience to climate change**. Reliance on engineered infrastructure may also lead to reduced resilience to climate change. Natural assets can be more resilient to wide ranges of loads (for example, precipitation volume and intensities that vary with climate change) than engineered infrastructure[1].

- **It is best practice.** AM processes have traditionally been applied only to engineered infrastructure. However, there is growing evidence that by considering natural assets within AM processes, local governments can decrease costs; increase levels of service; enhance their ability to adapt to climate change; and reduce the community's unfunded liabilities while protecting and/or enhancing the multitude of other benefits that natural assets bring to communities. For these reasons, there is now an expectation that municipalities integrate natural assets into their broader AM processes and practices[2].

Natural asset management is about understanding the strengths and limitations of engineered assets and natural assets, how they interact, and how the District's decisions can change as a result of viewing natural assets as an integral part of the overall system of service delivery.

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[1] Pilot studies conducted by the Municipal Natural Asset Initiative found that the value of services provided by natural assets often increased in a climate change scenario.

[2] Professional Practice Guidelines on Local Government Asset Management issued by Engineers and Geoscientists of BC establish professional practice expectations that natural assets be included in asset management processes.

The natural asset management process

Natural asset management is part of the broader AM process of assessing, planning, and implementing. This is a continuous and iterative process that is carried out with the goal of delivering services more sustainably. The process of integrating natural assets into the broader AM process is outlined below:[3]

ASSESS	▸ Assess current NAM processes and practices ▸ Develop an inventory of natural assets ▸ Assess the value and condition of natural assets ▸ Identify risks to natural assets and to the sustainability of the services they provide
PLAN	▸ Formalize the organization's commitment to including natural assets in AM via an Asset Management Policy ▸ Identify the approach the organization is taking to integrate natural assets in AM via an Asset Management Strategy ▸ Identify specific risks, impacts to levels of service, actions, and costs for managing risks ▸ Update the long-term financial plan to include natural asset considerations and funding strategies. Identify financial risks of not protecting, maintaining, or enhancing natural assets.
IMPLEMENT	▸ Implement the Policy, Strategy, plans and actions ▸ Measure the health of natural assets and the effectiveness of NAM practices. Report to staff, Council, and the public. ▸ Iteratively repeat the process of assessing, planning and implementing to refine information, planning, and decision-making over time.

[3] Asset Management BC. (2019). *Integrating Natural Assets into Asset Management: A Sustainable Service Delivery Primer*.

2.0 THE DISTRICT'S NATURAL ASSETS

2.1 ASSESSMENT SCOPE

To inform decisions about how best to manage natural assets as part of municipal service delivery, it is important that the District has an understanding of:

- The natural assets that provide municipal services, and which services they provide
- The level of service (quality and quantity of service) provided by those natural assets
- The value of those services
- The condition of the assets
- Risks to the sustainable delivery of services by those natural assets

Natural asset management is a continuous improvement process. Therefore, for the purpose of this NAM Strategy, a preliminary desktop assessment was conducted to provide information on the above, except for a condition assessment. This work will be expanded upon and refined over time.

Natural assets were inventoried that provide the following core municipal services:

- Drainage services (stormwater conveyance, detention, retention, and treatment)
- Drinking water services (supply and treatment)
- Wastewater services
- Flood protection

An assessment of the level of service, value of services, and risks to services was then conducted for assets that provide these services, except for flood protection services. Due to limitations of readily available data and the complex nature of the local study area, further study is required to reasonably quantify the flood protection services and any other municipal services provided by the estuary and foreshore.

In addition to the core services listed above, it is recognized that municipalities also provide recreational services and, increasingly, climate change mitigation through carbon sequestration and other measures. Therefore, natural assets that provide these services are included in the inventory, but the level and value of the services they provide were not quantified as part of this exercise.

2.2 ASSESSMENT METHODOLOGY

Assumptions and data sources for each asset and service are detailed in Appendix A. The following is a summary of the methodology and data sources.

Overview

Natural asset management is a continuous improvement process. The current assessment was conducted using best available information, and methods and assumptions suitable for the purpose of this NAM Strategy. The District is at the forefront of municipal NAM by undertaking this exercise and is laying the foundation for broader and more refined study over time.

Valuation of Services

There are numerous methods that can be used to valuate the services provided by natural assets. Given that the focus is on *municipal* services provided by natural assets (and not broader ecosystem services), the replacement cost method was used where possible. The fundamental assumption in this methodology is that the value of the service provided by the natural asset is considered equal to the cost the municipality would incur to replace the natural asset with engineered infrastructure that provides the same level of service. This is a particularly useful method for informing decisions regarding when and how to protect, maintain, and enhance natural assets, because it provides an indication of the cost the municipality may incur if the natural asset no longer exists (e.g., it is impacted through development) but the same level of service is desired. The primary disadvantage is that it may lead to under-valuating the service, as it does not reflect the broader ecosystem services provided by natural assets. The replacement cost method is also only focused on the capital cost of replacement infrastructure rather than full lifecycle cost.

To use the replacement cost method, an estimation of the level of service being provided by the natural asset is required, as described further below.

Unit costs used to derive total estimated replacement costs. Assumptions on which they are based are provided for each asset and service in Appendix A.

Quantification of Level of Service

Natural assets are complex systems that deliver services through a variety of mechanisms, each with numerous dependencies and often interdependencies. This makes the exercise of quantifying the level of municipal service that natural assets provide complicated and highly contextual. It is particularly difficult to do this to a high degree of accuracy without significant detailed and localized study. For example: on-site stormwater retention (volume control) is a service that municipalities provide as part of broader drainage service delivery to protect the environment from the impacts of development. Retention occurs in nature through a combination of evapotranspiration and infiltration, whereby the level of retention service is dependent on inter-related factors such as land cover (i.e., whether it is forest, shrubland, or grassland), the underlying soil (i.e., whether it has high or low infiltration capacity), slope, and groundwater elevation. Furthermore, how mature the vegetation is (for example, old growth versus young forest) is a factor, as is time of year, as service levels will vary between wet and dry conditions. Such site-specific detail and variability could not be accounted for in the scope of

this exercise. Therefore, simplified methods were used to quantify and valuate the retention services provided by natural assets, with a focus on vegetation as the natural service provider versus the underlying soil. Similar complexities exist for other assets and services, and simplified methods were also applied to their valuation.

Methods and assumptions to estimate the level of service being provided by each natural asset for each service it provides are outlined in Appendix A.

Data Sources

Where available and feasible, assumptions about level of service and replacement cost were based on local data from master plans such as the Phase 1 and Phase 2 Integrated Stormwater Management Plans and Water Master Plan. In the absence of local information, published values from other studies and professional judgement were used. Details on each asset and service are outlined in Appendix A.

2.3 NATURAL ASSET INVENTORY

Inventory and Value of Services

The following is a summary of the natural asset inventory based on the scope outlined in Section 2.1 and using the methodology described in Section 2.2 and detailed in Appendix A.

Natural Asset	Municipal Services	Quantity of the Service	Value of Services
Creeks	Stormwater Conveyance	168,816 m	$355 M
	Total (Creeks)		**$355 M**
Estuary	Carbon sequestration	161 ha	Further study required
Foreshore of estuary	Flood Protection (storm surge and wave dissipation)	55 ha	Further study required
Forest	Stormwater Detention (runoff rate control)	7,586 ha	$32 M
	Erosion control (in riparian areas)	832 ha	$349 M
	Stormwater Retention (runoff volume control)	7,586 ha	$303 M
	Stormwater Treatment	7,586 ha	$44 M
	Carbon sequestration and storage	7,586 ha	Further study required
	Total (Forest)		**$728 M**
Grassland	Stormwater Detention	82 ha	$0.1 M
	Erosion control	11 ha	$5 M
	Stormwater Retention	82 ha	$1 M
	Stormwater Treatment	82 ha	$0.2 M
	Carbon sequestration and storage	82 ha	Further study required
	Total (Grassland)		**$6 M**
Ponds/Lakes	Stormwater Detention	81 ha	$32 M

Natural Asset	Municipal Services	Quantity of the Service	Value of Services
	Stormwater Retention	81 ha	$16 M
	Total (Ponds/Lakes)		**$49 M**
Ring Creek Aquifer	Water supply		$64 M
	Water treatment		$31 M
	Total (Ring Creek Aquifer)		**$95 M**
Mashiter Creek and Stawamus River	Backup water supply		Further study required
Shrubland	Stormwater Detention	877 ha	$2 M
	Erosion control	68 ha	$28 M
	Stormwater Retention	877 ha	$20 M
	Stormwater Treatment	877 ha	$3 M
	Carbon sequestration and storage	877 ha	Further study required
	Total (Shrubland)		**$53 M**
Squamish River	Wastewater (receiving body for effluent)		$19 M
	Total (Squamish River)		**$19 M**
Wetland	Stormwater Detention	911 ha	$292 M
	Stormwater Treatment	911 ha	$1.4 M
	Carbon storage	911 ha	Further study required
	Total (Wetland)		**$293 M**
Grand Total			**$ 1.6 B**

*Mashiter Creek and Stawamus River are backup sources to the Ring Creek aquifer and in this sense are the traditional engineered replacement to a preferred groundwater source. Further study would be required to identify alternative water sources and required treatment given the quality of the supply.

Risks to Service Delivery

There are numerous risks to the sustainable delivery of the services provided by natural assets as inventoried above. Qualitatively, these include:

- Land development
- Recreation
- Climate change
- Forest fires (a risk that is likely to increase over time due to climate change)
- Pests (primarily risks to forests and shrubland)

2.4 KEY TAKEAWAYS FROM THE INVENTORY

Key Takeaway #1: Natural assets provide valuable municipal services that would otherwise be costly to deliver with built infrastructure

- The inventory highlights the fact that natural assets are currently providing costly core municipal services to the District. As the District loses these natural assets, it will incur costs through the construction of new infrastructure, if the service levels currently provided by the existing natural assets are to be sustained. The District might not always provide the same level of service with built infrastructure that natural assets currently provide – it might not always be necessary and in some cases the District may decide that the trade-offs between loss of natural asset service and cost to build and maintain infrastructure are acceptable.
- New infrastructure required to meet the municipal levels of service provided by nature will also have ongoing O&M and replacement costs, ultimately adding to the District's required annual funding levels for asset maintenance and recapitalization.
- Since natural assets don't have the same lifecycle costs as built infrastructure, they can deliver municipal services at a fraction of the cost to the District and taxpayers/ratepayers. Maintaining, protecting and enhancing natural assets presents a cost-effective means for delivering services.

Key Takeaway #2: There are numerous risks to the sustainable delivery of services provided by the District's existing natural assets.

- The inventory demonstrates that forests (municipal services valuated at $728 M) play a very significant role in delivering a wide range of valuable municipal services over a large area. Shrublands ($53 M) play a similar role at a smaller scale. Both are at risk of development, recreation, climate change, forest fires, and pests.
- Creeks ($355 M) and wetlands ($293 M) play a significant role in stormwater conveyance, detention, and treatment. Risks to these services primarily include development and climate change, though recreation also poses some risk to sustainable service delivery.

Key Takeaway #3: This is valuable information to support planning and decision-making that should be improved upon over time.

- Developing the District's natural asset inventory is one step in the continuous improvement process and will help to inform decisions on where to focus efforts moving forward.
- The inventory highlights the need to integrate natural asset assessments into land use and development planning processes to support decision-making on when and how to protect, enhance, and maintain natural assets, and when new infrastructure is the acceptable approach to service delivery. Updates to the OCP and land use plan, neighbourhood planning, master planning, and even at subdivision are all opportunities to gather more detailed information about natural assets to inform decisions.

- As discussed, there is significant variability in the level of service provided by natural assets and the work to date has not included an assessment of the condition of natural assets. This should be done on a more localized basis when integrating natural asset assessments into planning processes.
- As the District seeks to improve NAM practices over time, there is an opportunity to refine and expand data and information, and monitor the effectiveness of NAM practices over time to improve processes

3.0 THE DISTRICT'S CURRENT NATURAL ASSET MANAGEMENT PRACTICES

The Federation of Canadian Municipalities' (FCM) Asset Management Readiness Scale (AMRS) is an industry standard assessment tool and has been adapted to include NAM practices.[4] The adapted AMRS was used as a lens to assess the District's current NAM practices.

The 'current practices' summarized below are the key takeaways from the assessment of the District's current NAM practices, which was conducted based on a high-level desktop review of the District's various policies, plans, and regulations, and discussion with District staff.

'Opportunities' are the strategies the District could consider implementing to advance its NAM practices from where they are today. The purpose of doing so would be to reduce or contain the District's infrastructure funding gap, meet the community's service needs and expectations, and also support broader community goals such as environmental protection.

Strategies that are considered priorities for implementation are identified in Section 4.0.

3.1 PEOPLE AND LEADERSHIP

People and leadership in AM and NAM are at the center of service delivery. They are as critical to sustainable service delivery as good data and information, guiding policy, and strong planning and decision-making processes.

District Current Practices	Opportunities to Advance District Practices
- Strong leadership from Council and staff with mandate - Subject matter knowledge within the District, though not consistent throughout the organization	- Enhance communication and capacity-building across the organization so that natural assets can be considered widely in planning and decision-making - Increase Council's awareness of the importance of natural assets for service delivery and for meeting sustainability-related directions, and of the need for funding for NAM - Increase staffing levels to support integration of NAM into planning and decision making

[4] Municipal Natural Assets Initiative (MNAI). (2019). *Advancing and Integrating Municipal Natural Asset Management through Asset Management Planning in Ontario*. https://mnai.ca/media/2020/01/MNAI_MNAPOntario.pdf

3.2 POLICY AND GOVERNANCE

Policy and governance tools and practices set the foundation for making tough decisions that involve trade-offs and balancing community objectives.

District Current Practices	Opportunities to Advance District Practices

- Official Community Plan (OCP) acknowledges eco-assets
- Environmental Development Permit Areas exist to provide guidelines for development without sterilizing lands
- Protection of natural assets included in Loggers East Neighbourhood Plan policy
- Recommendations for NAM included in the District's Integrated Stormwater Management Plans (ISMPs)
- Natural assets are referenced in the District's current AM Policy
- The District has an Environmental Reserve Fund
	- Consider natural assets when updating bylaws and use them as a tool for NAM
	  - OCP
	  - Zoning Bylaw
	  - Subdivision and Development Control Bylaw
	  - Tree Bylaw
	  - DCC Bylaw
	  - Environmental Reserve Fund
	- Integrate NAM into next update of Community Amenity Contribution Policy and consider using it as a tool for NAM
	- Continue to include direction for NAM in the District's AM Policy, and consider enhancing guidance on NAM in the AM Policy at the next update

3.3 DATA AND INFORMATION

Data should help the District understand the condition, risk, level of service, and value of natural assets; their integration with grey infrastructure systems; and help the District develop the business case for decisions on what actions to take.

District Current Practices	Opportunities to Advance District Practices
- Inventory, preliminary risk assessment and valuation completed as part of the process to develop this Strategy - Also completed as part of ISMP process	- Improve understanding of condition, risk, and level of service by collecting data on priority assets using the natural asset inventory as a guide - Leverage monitoring data gathered by other organizations to understand condition, risk, and level of service - Use the Squamish Community Forest initiative as a way of gathering data on

District Current Practices	Opportunities to Advance District Practices
	the forest (condition, service, risks, cost to maintain or enhance) - Monitor the effectiveness of NAM practices over time to improve practices and communicate success

3.4 PLANNING AND DECISION-MAKING

Planning and decision-making processes need to align with policy directives and provide pathways for meaningful integration between departments to navigate trade-offs, such as the services that natural assets provide, the costs of managing them, and risks.

District Current Practices	Opportunities to Advance District Practices
- Initial steps have been taken to integrate natural assets into stormwater management via the ISMPs - Natural assets are being integrated into the District's broader AM practices via this Strategy and the ISMPs - Natural assets were considered as part of land use decisions in the Loggers East Neighbourhood Plan	- Integrate into all master planning processes through the assess, plan, implement process documented herein - Integrate into financial planning processes by considering funding for natural asset protection, enhancement, and maintenance - Integrate into maintenance planning processes - Integrate into the development permit review process (degree to which this is formalized depends on extent to which natural assets are integrated into regulations) - Bring Planning, Engineering, Finance, Public Works together in planning processes

4.0 PRIORITIES FOR ADVANCING NATURAL ASSET MANAGEMENT PRACTICES

4.1 OVERVIEW OF PRIORITIES

Why they matter

- Progressively improving NAM practices will help the District make more informed decisions about when and how to protect, maintain, and enhance its existing natural asset inventory and deliver services in a way that balance cost, risk, and service
- Implementing the priorities will help the District manage its grey infrastructure deficit
- The priorities that are identified will help the District leverage natural assets as a way of achieving the community's vision and goals

How they were selected

Strategies the District could potentially implement to advance its NAM practices are listed as 'opportunities' in Section 3.0.

The strategies in this section are those that are considered priorities for implementation. They were identified by asking:

- What will be most impactful in terms of moving towards more sustainable service delivery?
- How might the District leverage processes and investments already committed to, to make progress?

The strategies identified are designed to be high-value and to integrate with ongoing activities at the District to ensure their feasibility. Implementation of the strategies is more about how things are done, not about adding additional work.

4.2 PEOPLE AND LEADERSHIP

Priority: Enhance Communication and Capacity-Building

1. Use the NAM Strategy as a tool for convening conversations across the District about the importance of natural assets and of integrating NAM into practices across Engineering, Planning, Public Works, and Finance
2. Share the NAM Strategy with Council and provide updates on its implementation
3. Highlight how natural assets were considered in planning and decision-making processes when bringing master plans, bylaw updates, etc. to Council
4. Encourage staff to take training in natural asset management

4.3 POLICY AND GOVERNANCE

Priority: Consider natural assets when updating bylaws and use them as a tool for NAM

1. Use information gathered on assets (see 'Data and Information' below) to inform specific decisions on the extent to which regulations are used to protect, maintain, or enhance natural assets
2. When updating the Zoning Bylaw, consider setbacks, land uses, and densities and how level of development can be used to protect natural assets. Explore how density bonusing can be used as a tool for NAM.
3. When updating Subdivision and Development Control Bylaw, consider impacts to services provided by natural assets alongside engineered assets (e.g., drainage and easements).
4. When updating the DCC Bylaw, include natural asset-related projects in the program. These may be projects to protect natural assets (e.g., land acquisition) or enhance them (capital works to improve the level of service they provide), to benefit growth.
5. When updating the OCP, consider how land use, growth boundary, Environmentally Sensitive Areas (ESAs) and Development Permit Areas (DPAs) can be used to protect natural assets. Consider dedicating areas as Protected Natural Assets (PNAs) to be excluded from development – precedence for this has been set by the District of Mission. Where there is a reduction of natural assets on proposed development sites consider compensation by either:
    (a) dedication of a portion of land on the development site to the District at a ratio that's acceptable to the District (e.g. 2:1); or
    (b) a contribution in accordance with the District's Community Amenity Contribution Policy.
6. When updating the AM Policy, consider enhancing guidance on NAM
7. Consider increasing contributions to the Environmental Reserve Fund through mechanisms such as, but not necessarily limited to, updates to the Tree Management Bylaw (such as increasing the payment required for not planting Replacement Trees). Also consider enhancing the protection and/or replanting requirements stated in the Tree Management Bylaw.

4.4 DATA AND INFORMATION

Priority: Use master planning processes to collect data on priority assets and improve the District's understanding of condition, risk, and level of service

1. Additional data should be gathered on natural assets at a more localized level. Use master planning processes as the primary mechanism for gathering data:

(a) Include a natural asset condition and capacity assessment in the scope of the Phase 3 ISMP

(i) assess watercourses, riparian areas, forests, and wetlands through the lens of their condition/capacity to provide stormwater services

(ii) model overland drainage flow pathways to understand the service provided by natural and low-lying areas

(b) Include an update to the detailed assessment of the aquifer in the Water Master Plan update

(c) Include a more detailed inventory of services provided by the estuary and foreshore in future updates to the Integrated Flood Hazard Management Plan

(d) Update the District's natural asset inventory accordingly

2. Once more data is gathered, identify the cost to protect, maintain, or enhance those priority assets and what actions to take (see 'Planning and Decision Making' below), and can make informed decisions about how to update bylaws (as outlined above)

4.5 PLANNING AND DECISION-MAKING

Priority: Integrate natural assets into land use planning, master planning, financial planning, and maintenance planning processes

- Integrate NAM into land use planning: Consider impacts to the level of service provided by natural assets when evaluating land use scenarios or changes, such as for OCP amendments and neighbourhood planning
- Integrate NAM into master planning: In each of the following planning processes, identify options to protect, maintain, and enhance natural assets that provide municipal services; identify ongoing monitoring that should be conducted to understand risks and the levels of service provided; and evaluate the costs and benefits of each option to inform decisions like the extent to which natural assets or grey infrastructure will be relied upon for service delivery:

(a) Phase 3 ISMP / future updates to ISMPs

(b) Water Master Plan

(c) Transportation Master Plan

(d) Liquid Waste Management Plan

(e) Integrated Flood Hazard Management Plan

3. Integrate maintenance-focused actions from Master Plans into maintenance plans for Public Works

4. Integrate the costs of managing natural assets as outlined in Master Plans into long-term financial planning and budgeting, and identify funding sources

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Appendix A:
District of Squamish
Natural Asset Inventory and Valuation

NATURAL ASSET DELINEATION

The methods and data sources summarized in Table A were used to delineate natural assets within the District of Squamish.

Table A Natural asset delineation methods and data sources

Natural Asset / Area	Methodology	Source
Forest	Land cover data clipped to DoS boundary. Converted raster to polygon. Erased land use where waterbody/rivers and estuary (from DoS datasets) overlapped.	Land Cover of Canada, CCMEO, 2015
Grassland	Land cover data clipped to DoS boundary. Converted raster to polygon. Erased land use where waterbody/rivers and estuary (from DoS datasets) overlapped.	Land Cover of Canada, CCMEO, 2015
Shrubland	Land cover data clipped to DoS boundary. Converted raster to polygon. Erased land use where waterbody/rivers and estuary (from DoS datasets) overlapped.	Land Cover of Canada, CCMEO, 2015
Wetlands	Excluded selection from wetlands dataset where “Comments” field contained “estuary”	Wetland, District of Squamish Open Data
Squamish, Stawamus, Mashister Rivers	Total area	Major Rivers, District of Squamish Open Data
Creeks	Total length	Watercourses, District of Squamish Open Data
Waterbody	Total area	Lakes and Ponds, District of Squamish Open Data
Estuary	Selection from wetlands dataset where “Comments” field contained “estuary”	Wetland, District of Squamish Open Data
Foreshore of estuary	30m inside buffer around estuary	Estuary provided by District of Squamish
Riparian buffer	30m buffer around creeks, rivers, and lakes	USL, aligns with Riparian Areas Regulation assessment methods
Erosion control areas (forest, grassland, shrubland)	>25% slope based on slope raster creater from LiDAR BC DEM	USL

The methods used to develop the NAMS reflect the purpose and scope of the project. Developing the District's natural asset inventory is one step in the continuous improvement process of NAM and recommendations are provided in the NAMS to improve the natural asset inventory over time.

SERVICE QUANTIFICATION AND VALUATION METHODS

How the quantity and value of services were estimated was unique to each type of asset and service. A description is provided for each in Table B.

Table B Service Quantification and Valuation Methods

NATURAL ASSET			MUNICIPAL SERVICES		VALUATION						ADDITIONAL INFORMATION	REFERENCE
Natural Asset	Area (ha)	Length (m) providing	Municipal Service	Municipal Service (Sub)	Valuation Method	Engineered Replacement	Unit Rate ($)	Unit	Total ($)	Risks to continued delivery of these services by these assets	Notes/Assumptions	Full reference
Forest	832		Drainage	Erosion control	Replacement	Landscaping	$42.00	$/m2	$349,242,000	- Development - Climate change - Forest fires - Pests and Disease - Recreation	Area is woodlands riparian buffer and slope > 25% Costs are supply and install cost for synthetic Turf Reinforcement Mat (Nilex P550) and seeding	
Forest	7,586		Drainage	Detention (runoff rate control)	Replacement	Constructed storage	$4,163.20	$/ha	$31,581,000	- Development - Climate change - Forest fires - Pests and Disease - Recreation	Reflects constructed storage cost of $150/m3 inflated to 2021 dollars. For 2-year, 24-hour rainfall. Consistent with methodology from Phase 1 ISMP.	Squamish Integrated Stormwater Management Plan - Phase 1, Urban Systems, 2019
Forest	7,586		Drainage	Retention (runoff volume control)	Replacement	Amended topsoil	$3.99	$/m2	$302,672,000	- Development - Climate change - Forest fires - Pests and Disease - Recreation	Assumes 57mm topsoil depth at unit rate of $70/m3. Topsoil depth is the replacement topsoil needed (assuming porosity of 0.2) to provide volume equivalent to the difference in evapotranspiration volume between forested (assuming 40% surface water evapotranspiration) and developed conditions (assuming 20% surface water evapotranspiration) under the 57mm 50% MAR event.	
Forest	7,586		Drainage	Treatment	Replacement	Proprietary enhanced treatment system (e.g., biofilter)	$5,800.00	$/ha	$43,997,000	- Development - Climate change - Forest fires - Pests and Disease - Recreation	Costs based on 2022 budget pricing from Langley Concrete excluding Taxes and FOB. Budget Pricing is for Jellyfish JF4 and JF6 models with various cartridge / treatment flow rate configurations. Assumed a treatment area of 5 ha and a 6-month 24-hour event, with flows rates generally within the capacity of a JF4 model.	file://usl.urban-systems.com/projects/Projects_VAN/1928/0039/01/D-Design/D1-Calculations/2022-01-21%20Squamish%20Natural%20Assets%20Pipe%20Equivalents.xlsx
Forest	7,586		Gas and climate regulation	Carbon sequestration	n/a	n/a	n/a	n/a	n/a	- Development - Climate change - Forest fires - Pests and Disease	n/a	
Forest	7,586		Gas and climate regulation	Carbon storage	n/a	n/a	n/a	n/a	n/a	- Development - Climate change - Forest fires - Pests and Disease	n/a	
Grassland	11		Drainage	Erosion control	Replacement	Landscaping	$42.00	$/m2	$4,748,000	- Development - Climate change - Forest fires - Recreation	Budget Pricing is for Jellyfish JF4 and JF6 models with various cartridge / treatment flow rate configurations.	
Grassland	82		Drainage	Detention (runoff rate control)	Replacement	Constructed storage	$1,665.20	$/ha	$136,000	- Development - Climate change - Forest fires - Recreation	Assumed a treatment area of 5 L/s/ha and a 6-month 24-hour event, with flows rates generally within the capacity of a JF4 model.	
Grassland	82		Drainage	Retention (runoff volume control)	Replacement	Amended topsoil	$1.61	$/m2	$1,320,000	- Development - Climate change - Forest fires - Recreation	Based on forest methodology but adjusted based on runoff coefficient difference (0.10 for forest, 0.25 for grassland) for 23mm topsoil depth.	
Grassland	82		Drainage	Treatment	Replacement	Proprietary enhanced treatment system (e.g., biofilter)	$2,300.00	$/ha	$188,000	- Development - Climate change - Forest fires - Recreation	Costs based on 2022 budget pricing from Langley Concrete excluding Taxes and FOB. Budget Pricing is for Jellyfish JF4 and JF6 models with various cartridge / treatment flow rate configurations. Assumed a treatment area of 5 ha and a 6-month 24-hour event, with flows rates generally within the capacity of a JF4 model.	
Grassland	82		Gas and climate regulation	Carbon sequestration	n/a	n/a	n/a	n/a	n/a	- Development - Climate change - Forest fires - Recreation	n/a	
Grassland	82		Gas and climate regulation	Carbon storage	n/a	n/a	n/a	n/a	n/a	- Development - Climate change - Forest fires - Recreation	n/a	
Shrubland	68		Drainage	Erosion control	Replacement	Landscaping	$42.00	$/m2	$28,455,000	- Development - Climate change - Forest fires - Recreation	Area is woodlands riparian buffer and slope > 25% Costs are supply and install cost for synthetic Turf Reinforcement Mat (Nilex P550)	
Shrubland	877		Drainage	Detention (runoff rate control)	Replacement	Constructed storage	$2,312.78	$/ha	$2,028,000	- Development - Climate change - Forest fires - Recreation	Based on forest methodology but adjusted based on runoff coefficient difference(0.10 for forest, 0.18 for shrubland)	
Shrubland	877		Drainage	Retention (runoff volume control)	Replacement	Amended topsoil	$2.24	$/m2	$19,645,000	- Development - Climate change - Forest fires - Recreation	Based on forest methodology but adjusted based on runoff coefficient difference(0.10 for forest, 0.18 for shrubland) for 32mm topsoil depth.	
Shrubland	877		Drainage	Treatment	Replacement	Proprietary enhanced treatment system (e.g., biofilter)	$3,200.00	$/ha	$2,805,000	- Development - Climate change - Forest fires - Recreation	Costs based on 2022 budget pricing from Langley Concrete excluding Taxes and FOB. Budget Pricing is for Jellyfish JF4 and JF6 models with various cartridge / treatment flow rate configurations. Assumed a treatment area of 5 ha and a 6-month 24-hour event, with flows rates generally within the capacity of a JF4 model.	
Shrubland	877		Gas and climate regulation	Carbon sequestration	n/a	n/a	n/a	n/a	n/a	- Development - Climate change - Forest fires - Recreation	n/a	
Shrubland	877		Gas and climate regulation	Carbon storage	n/a	n/a	n/a	n/a	n/a	- Development - Climate change - Forest fires - Recreation	n/a	
Creeks		168,816	Drainage	Conveyance	Replacement	Pipe	$2.00	m*mm	$354,514,000	- Development	Assumes 1050 mm pipe. Assumption is valid based on analysis conducted as part of Phase 2 ISMP (average conveyance capacity of creeks). Length is all creeks, including Squamish, Mashiter, and Mamquam and Stawamus. For these larger systems, their rainwater conveyance value is still assumed to be equivalent to that provided by a 1050mm pipe.	Replacement value estimated Urban Systems, consistent with Phase 1 and Phase 2 ISMP methodology.

Table B - Service Quantification and Valuation Methods

Wetland	911		Drainage	Detention (runoff rate control)	Replacement	Storage/control structure	$160.00	$/m3	$291,633,000	- Development - Climate change	Assumes wetlands provide 0.2m depth of storage. Method consistent with that applied in Phase 1 ISMP. Unit costs used in that study inflated to 2021 dollars.	Squamish Integrated Stormwater Management Plan - Phase 1, Urban Systems, 2019
Wetland	911		Drainage	Treatment	Value Transfer	n/a	$1,595.00	$/ha	$1,454,000	- Development - Climate change	Unit rate based on methodology described in Phase 1 ISMP, inflated to 2021 dollars. Focuses on nitrogen and phosphorus removal functions of wetlands and cost of nitrogen and phosphorus removal in a treatment plant.	
Wetland	911		Gas and climate regulation	Carbon storage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Ponds/Lakes	81		Drainage	Detention (runoff rate control)	Replacement	Constructed storage	$200.00	$/m3	$32,372,000	- Climate change - Development - Recreation	Assumes 25% more storage function than that provided by wetlands.	Squamish Integrated Stormwater Management Plan - Phase 1, Urban Systems, 2019
Ponds/Lakes	81		Drainage	Retention (runoff volume control)	Replacement	Amended topsoil	$20.00	$/m2	$16,186,000	- Climate change - Development - Recreation	Assumed to be same as forest. Conservative.	
Estuary	161		Gas and climate regulation	Carbon sequestration	n/a	n/a	n/a	n/a	n/a	- Climate change/sea level rise	n/a	
Foreshore of estuary	55		Flood Protection	Storm surge and wave dissipation	n/a	Hard armoring, such as robust riprap, 1-2m size.	NA	$/ha		- Climate change/sea level rise - Development - Recreation	Quantification not feasible within the scope of this study. Local damage costs unavailable for use in avoided damage cost method. Replacement costs highly dependent on service level currently provided for which data is not readily available. Also dependent on design event. Other studies have cited estimates of $0.7 to $1.4M CAD per ha of capital cost savings provided by salt marshes in terms of flood defense but estimates are from UK and should be updated to local conditions for valuation purposes.	
Ring Creek Aquifer			Water	Water supply	Replacement	Storage reservoir	$ 28.00	2,281,250	$63,875,000	- Development (pollutant loading and reduced recharge) - Recreation (pollutant loading) - Climate change (affecting recharge)	- Assume 6 months of average day demand storage (12.5 MLD) - Cost based on flat land with liner, excavation, backfill	Replacement value estimated by Urban Systems (2022)
Ring Creek Aquifer			Water	Water treatment	Replacement	Water treatment plant and storage reservoir	$ 30,800,000	1.00	$ 30,800,000	- Development (pollutant loading and reduced recharge) - Recreation (pollutant loading) - Climate change (affecting recharge)	- Based on DAF + Filtration plant + UV Disinfection + 2,500 m3 reservoir	Replacement value estimated by Urban Systems (2022)
Squamish River			Wastewater	Receiving body for wastewater effluent	Replacement	Forcemain, Outfall, Diffuser	See notes	n/a	$18,520,000	- Climate change	- Assumes replacement with $2.00 m*mm for pipe on land, assumed to be 6,000 m in length along existing roadways. Existing infrastructure is a 400mm pipe with additional twinning of 910 mm (section). Used existing pipe diameter to calculate rerouting of outfall to Howe Sound. - Assumes outfall/difuser cost is $2.0million x 1.4 (E&C) - Costs are high-level and meant to provide an indication of value of the service. Actual replacement costs may be different based on local bathymetry and outcomes of a feasibilty study.	Replacement value estimated by Urban Systems (2022)

Notes:
- All values in 2021 Canadian Dollars.
- 2% inflation applied to previous estimates where applicable.
- Replacement costs consider capital cost only; total lifecycle costs not considered.