From Source to Sea

Aquifer 560 Watershed
Natural Asset Management Project

Natural Assets Initiative
MAKING NATURE COUNT

SUMMARY REPORT

March 2024

Natural Assets Initiative
MAKING NATURE COUNT

Invest in Nature

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

The Town of Gibsons acknowledges that it is situated on the unceded traditional territory of the Skwxwú7mesh Úxwumixw (Squamish Nation). This is the ancestral territory of the Skwx̱wú7mesh speaking peoples and has been stewarded by them since time immemorial.

The Aquifer 560 Watershed is on territory that was never ceded or given up to the Crown by the Skwxwú7mesh peoples. The term unceded acknowledges the dispossession of the land and the inherent rights that the Skwxwú7mesh hold to the territory. The term serves as a reminder that the Skwxwú7mesh have never left their territory and will always retain their jurisdiction and relationships with the territory.

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Foreword

It is my honour to introduce the Source to Sea Report, a testament to our collective commitment to safeguarding our region's natural assets. I am proud that our town is a leader in Natural Asset Management and recognizes and prioritizes the pressing need for innovative solutions to address the challenges posed by aging infrastructure and climate change.

The concept of Natural Asset Management offers an innovative approach to these challenges. By recognizing the value of our natural assets, we can build more resilient services, reduce costs and enhance our quality of life.

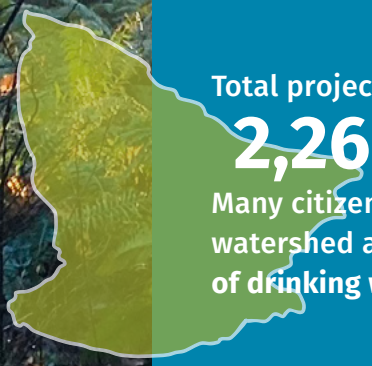
Collaboration is at the heart of Natural Asset Management, emphasizing the importance of collective action across jurisdictions and sectors. This project exemplifies this collaborative spirit, bringing together diverse rightsholders and stakeholders to assess, evaluate and manage our shared watershed.

I am grateful for the dedication of all involved in the Source to Sea Project, and I am confident that its findings will resonate far beyond our borders. I look forward with optimism as we work towards a more resilient future for generations to come.

Sincerely,

Silas White, *Mayor of Gibsons*

Quick Facts: **Aquifer 560 Watershed**



Total project area:

2,269 ha

Many citizens rely on the watershed as their sole source of drinking water

Natural assets provide an estimated value of

$40 million

in stormwater services alone

Drought, development & green waste dumping pose the highest risks to natural asset services

1 Introduction

Canadian local governments, Indigenous and Métis Nations, watershed agencies and other entities face infrastructure and asset management challenges. Many services these organizations provide, including water and wastewater, waste removal, transportation, flood attenuation, erosion control, and environmental services, depend on ageing engineered infrastructure assets that need renewal. Meanwhile, climate change places increasing pressure on the existing infrastructure stock.

The term 'natural assets' refer to the stock of natural resources or ecosystems that a municipality, regional district, or other watershed rightsholders or stakeholders could rely on or manage for the sustainable provision of one or more services.[1] Effective stewardship of natural assets helps these entities to deliver more resilient services in a changing climate, reduce associated costs, and provides an alternative to "building their way out" of infrastructure challenges. Natural assets can provide both critical infrastructure services and numerous co-benefits that add to community quality of life. This practice has become known as a Natural Asset Management (NAM), a subset of the broader field of nature-based solutions (NbS). NAM enables nature to be conceptualized, accounted for, restored, protected, and managed as a vital asset to ensure its long-term viability.

NAM is an important tool for addressing climate change. A 2021 report from the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC) notes "only by considering climate and biodiversity as parts of the same complex problem… can solutions be developed that avoid maladaptation … ignoring the inseparable nature of climate, biodiversity, and human quality of life will result in non-optimal solutions to either crisis."[2] The IPCC Sixth Assessment Report includes a headline statement that stresses the fundamental importance of safeguarding biodiversity and ecosystems in the development of climate resilience.[3] It advises that "maladaptation can be avoided by flexible, multi-sectoral, inclusive and long-term planning and implementation of adaptation actions with benefits to many sectors and systems".[4] NbS — of which NAM is one — may also play a role in reducing liability risks.

A key consideration for NAM is that ecosystems and natural assets rarely align with singular political boundaries and jurisdictions. Many entities rely on natural assets that are under the ownership and/or jurisdiction of others. Therefore, collaboration amongst many entities, and action at the watershed scale, is ultimately required for effective NAM.

1 MNAI (2017).
2 Pörtner et al. (2021).
3 IPCC AR6 WG II. (2022).
4 IPCC AR6 WG II (2022, p. 35).

The goal of the Source to Sea Project is to ensure that the natural assets within the Watershed are *understood, measured, valued*, and ultimately *managed* to protect their integrity, and to safeguard the reliable flow of core infrastructure services and diverse co-benefits.

1.1 The Aquifer 560 Watershed

The Town of Gibsons, which deemed nature its most valuable asset back in 2014, has been an innovator of NAM.[5] The Town continues to be a 'living lab' for NAM and their efforts have inspired many others as well as shape the practice as it is today.

The health of Aquifer 560 is of critical concern for Gibsons for many reasons, not the least of which being that nearly 100% of Town's high-quality water is drawn from the aquifer.[6]

Within this context, the Town of Gibsons chose to work with the Natural Assets Initiative (NAI), a Canadian non-governmental organization, to expand the spatial scale of their earlier efforts — which focused on either land-based[7] or coastal and marine issues[8] — to consider the entire Aquifer 560 Watershed (hereafter the Watershed).

Gibsons is not the first project to consider NAM at the watershed scale.[9] However, the Source to Sea (S2S) Project also examined surface water – marine interactions in the context of NAM, an area of research which had been unexplored.

The Watershed begins at the top of Mount Elphinstone and extends to the sea. Figure 1 shows the sub-catchments for the 4 major creek systems (Chaster, Charman, Gibson and Soames) in the larger Watershed (see Figure 1).

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5 Town of Gibsons. (2017).

6 The Town of Gibsons was awarded "World's Best Water" at the 2005 Berkely Springs International Water Tasting Contest.

7 Sahl et al. (2016).

8 MNAI. (2023).

9 The Grindstone Creek Watershed project (2022) was the first watershed-scale NAM project of its type; the report is available at *mnai.ca/grindstone-creek-watershed-natural-assets-management-project*

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***Figure 1**: The Aquifer 560 Watershed*

1.2 S2S Project Goal & Objectives

The project goal is to ensure that the natural assets within the Watershed are understood, measured, valued, and ultimately managed to protect their integrity, and to safeguard the reliable flow of core infrastructure services and diverse co-benefits. Four objectives support this goal[10]:

1/ Assessment - Understand the current roles of natural assets in the project area in providing stormwater management and flood mitigation services to the residents of Gibsons and to identify risks to natural assets and their associated services;

2/ Valuation - Quantify the value of natural assets in the project area in terms of service provision, including determining costs and benefits relative to engineered alternatives;

3/ Scenario Modelling - Understand possible future roles of natural assets in the project area in providing stormwater management and flood mitigation services to the Town of Gibsons; and

4/ Recommendations - Develop strategies for effective management of natural assets based on this understanding, including identifying potential synergies with other Town projects.

10 Project objectives were changed from a focus from the provision of safe, reliable drinking water supplies for residents through aquifer recharge to stormwater management and flood mitigation. This change was made to align with modelling capabilities.

1.3 Methodology

The methodology for the S2S Project is based on standard asset management practices that Canadian local governments are increasingly required to adopt, and which are articulated by organizations such as Asset Management BC, based on global norms (see Figure 2). NAI has adapted these methodologies to ensure that natural assets — which are complex in their role in service delivery, are context-specific, and present novel considerations — can be effectively integrated and considered in asset management.

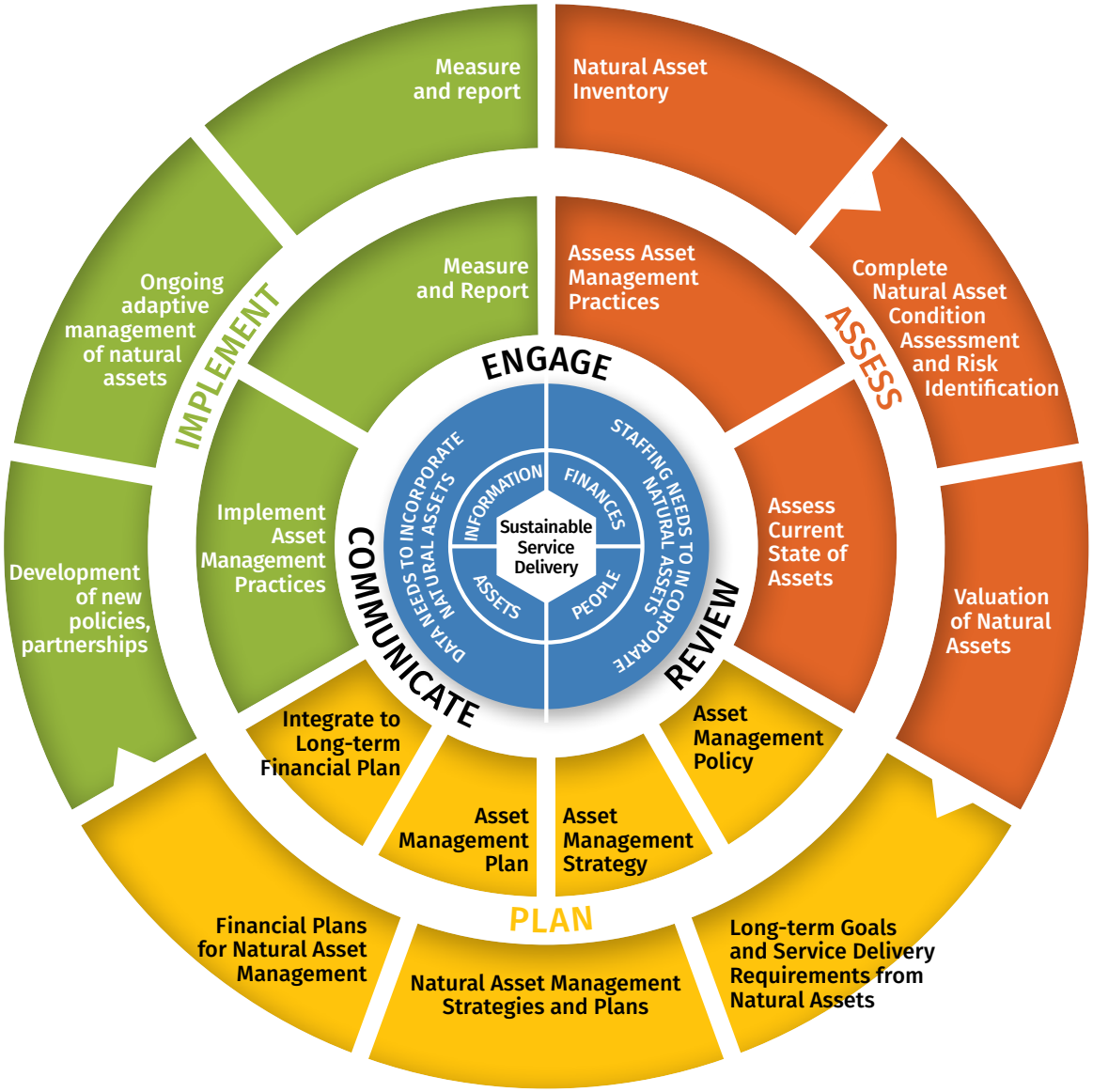

Figure 2: *Natural Asset Management wheel*
Source: *NAI, 2017; Adapted from Asset BC, 2014*

1.4 Limitations & Assumptions

The S2S Project contains several limitations and assumptions, which are each addressed in depth in the Technical Report. Briefly, these included:

Valuation

NAI's valuation can be considered as a minimum service value[11] to inform decision-making and is an estimated value of only a portion of the services provided by natural assets in the Watershed and is only part of a broader understanding of the inherent and immeasurable values of nature.

Modelling

NAI undertakes detailed hydrologic modelling to assess the Levels of Service (LOS) that natural assets provide to allow for service-based comparisons with engineered assets. However, all environmental modelling simplifies systems and is limited by the assumptions required for generalization. PCSWMM[12] was used for the project but limited in its ability to simulate non-urban systems, and integrated coastal-terrestrial modelling was not possible between it and the Coastal Toolbox developed for the Managing Natural Assets to increase Coastal Resilience project[13].

Indigenous Nations

NAM initiatives will achieve better outcomes when they include Indigenous worldviews and knowledge, through meaningful collaboration with Indigenous Nations. The Squamish Nation was engaged at the project outset and provided input, but capacity restrictions limited engagement in project components. Efforts can be expanded and broadened through collaborative watershed initiatives going forward.

11 It is important to recognize these findings in terms of minimum service value as, unlike engineered assets that depreciate, natural assets are often adaptable, providing services that become more valuable over time within a changing climate.

12 Acronym for Personalized Computer Storm Water Management Model

13 See full report at *mnai.ca/town-of-gibsons-2*

2 Local Context

2.1 Geography & Land Use

Gibsons is situated along the perimeter of the Salish Sea at the entrance to Átl'ka7tsem/ Howe Sound (Figure 1). As of the 2021 Census of Population (Statistics Canada), Gibsons was home to 4,758 residents. The project area selected is the same as for the Town of Gibsons 2013 aquifer study[14]; the northern project boundary is the top of Mt. Elphinstone.

The project area spans 2,269 ha (22.7 km2) and encompasses the Town of Gibsons, portions of the Sunshine Coast Regional District (SCRD), and the four sub-catchments that contribute flows to Chaster Creek, Gibson Creek, Charman Creek, and Soames Creek.

As depicted in Figure 2, the project area services and is stewarded by multiple jurisdictions and right holders. This means that collaboration among stakeholders, multiple levels of government, and First Nations is essential to long-term success.

2.2 Indigenous Peoples

The Watershed is located on the unceded territory of the Skwxwú7mesh Úxwumixw (Squamish Nation); the S2S Project and related work respects their Rights and Title. The Town of Gibsons is committed to ensuring alignment between Town priorities and the Squamish Nation's values.

2.3 Governance, Policy, and Structure

Ecosystem realities are often misaligned with local, regional, and provincial governance structures, meaning that, historically, the Town of Gibsons' NAM approach has been restricted to its jurisdictional boundary. Examples of how this has hindered the Town's NAM efforts include:

- Governance structures that exist at the scale of the watershed are fragmented and overlapping; different entities in the region are at different stages in terms of planning, monitoring, and implementation that affect natural assets; and few institutional or governance mechanisms require or even facilitate dialogue across jurisdictional boundaries.
- There is no overarching strategy, imperative, or plan to ensure stewardship and protection of the ecological area in which Gibsons is located, notwithstanding the increased urgency created by climate change.
- There are no mechanisms that enable the Town of Gibsons to access relevant watershed scale data for areas beyond its jurisdiction.

14 Town of Gibsons. (2013).

This reality has practical implications when one considers the fact that the recharge area of Aquifer 560 — the Town's source of drinking water supply — extends beyond Gibsons' jurisdiction, limiting their ability to monitor or manage critical infrastructure on which its citizens rely.

On the positive side, there are multiple entities that can contribute important resources, data and expertise to support NAM to the extent that these entities can be mobilized around a common, coherent vision (see *Recommendations #3*, *#7* and *#11*).

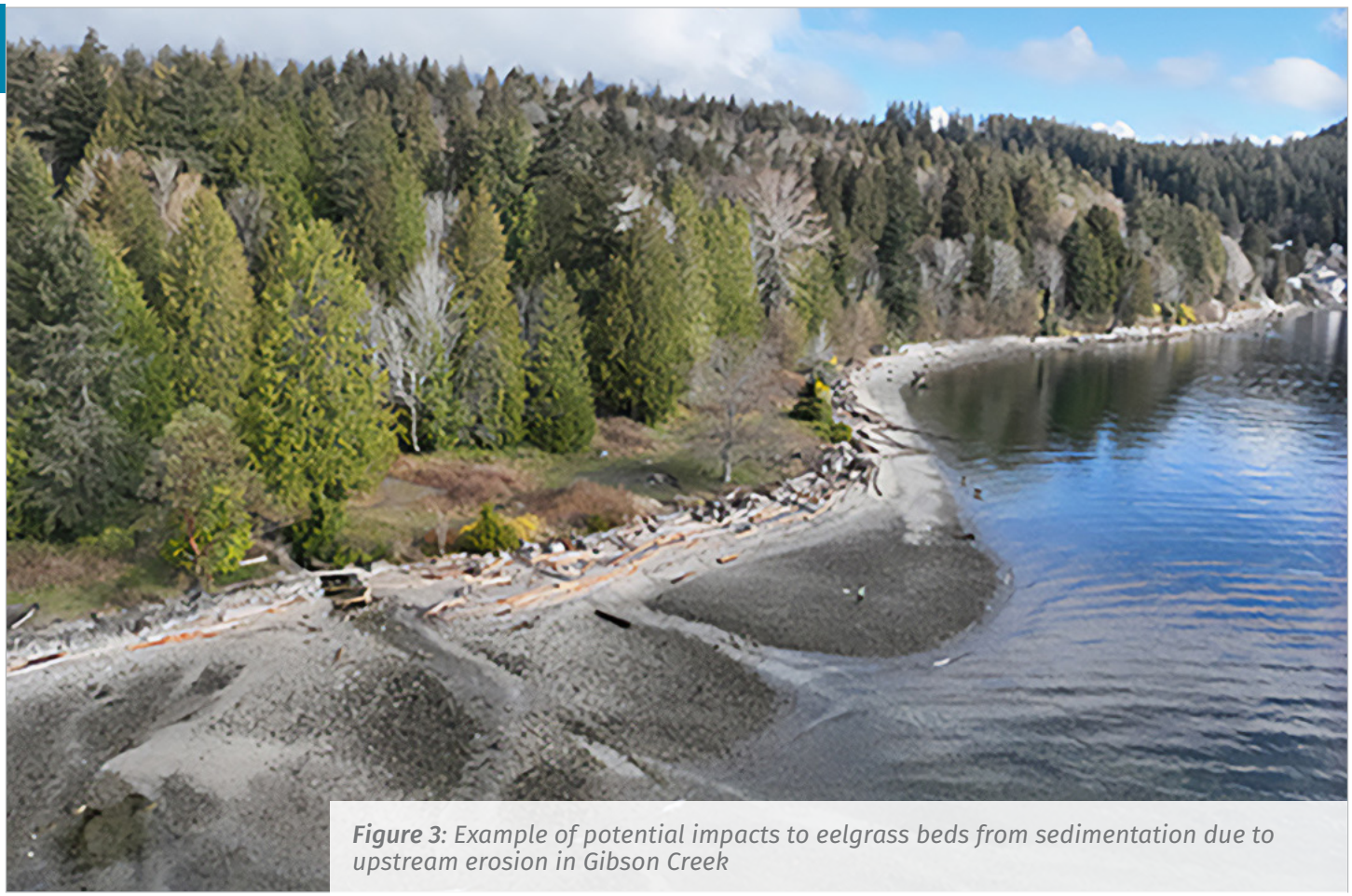

***Figure 3**: Example of potential impacts to eelgrass beds from sedimentation due to upstream erosion in Gibson Creek*

2.4 Risk & Climate Change

Climate change is shifting the overall risk context in the Watershed; predictions indicate an increase in the frequency and intensity of storms, altered precipitation patterns, a shift in the timing and volume of snowmelt during the spring freshet, and a decrease in summer stream flows.[15]

Based on this, the S2S Project prioritized and focused on three interconnected risks that relate to stormwater management: flooding and erosion, sea level rise and storm surge, and aging infrastructure.

15 Urban Systems. (2019).

2.5 Integration Between Coastal and Terrestrial Systems

While both land-based (terrestrial) and coastal systems can contribute to flooding and erosion, sometimes simultaneously, modelling — and often resulting management approaches — for each system are typically evaluated separately, which may overlook feedbacks between each system, making it difficult to identify a comprehensive package of NAM actions that address the full range of a coastal community's flood and erosion mitigation needs. To address this, the S2S Project considers how NAM for flood and erosion mitigation can be evaluated quantitatively by integrating terrestrial freshwater with coastal systems.

The Town of Gibsons has already completed some coastal NAM activities through the Managing Natural Assets to Increase Coastal Resilience project in 2021.[16] The project developed and tested a Coastal Toolbox (CT) model to determine how enhancing coastal natural assets could reduce flood and erosion impacts to the foreshore, especially if used alongside conventional grey infrastructure.

Building on these findings, the S2S Project considered the role of watersheds in flood management and explored the extent to which terrestrial NAM contributes to both river and coastal flood mitigation, which would emphasize the need for a systems approach from source to sea in defining the role of natural assets in flood mitigation. The S2S Project found integration between coastal and terrestrial systems was not possible using PCSWMM and CT model. Recognizing this, guidance on future integration between coastal and terrestrial systems has been developed and a summary of it provided in the S2S Technical Report.

16 The Coastal Resilience reports are available at mnai.ca/resources-and-reports-coastal-resilience-project

3 Assessment of Natural Assets

3.1 Inventory & Condition of Natural Assets

As depicted in Figure 4, a natural asset inventory is a first component of the NAM assessment phase and was an early deliverable of the S2S Project. Natural asset inventories provide details on the types of natural assets upon which a local government relies, their condition, and the risks they face.

The S2S Project inventory is available for viewing in a *web-based dashboard* which maps natural assets by asset type, area and condition. Figure 4 (taken from the dashboard) shows the percentage area of natural assets within the Watershed by condition rating. The majority (approximately 60%) of assets are rated in high condition.

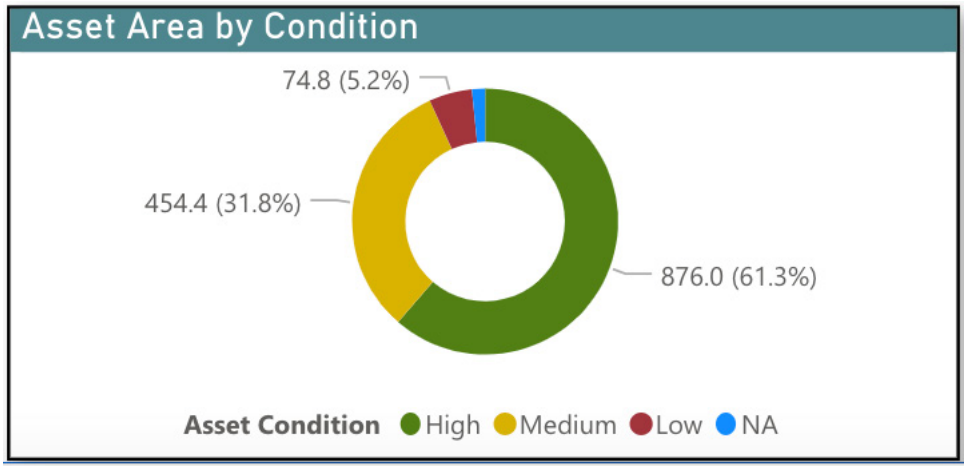

***Figure 4**: Percentage of asset area by condition*

3.2 Valuation of Natural Asset Services

In NAI's methodology, a primary objective of NAM economic valuations is to measure the contribution of natural assets to critical infrastructure services such as drinking water filtration, storm water management, or flood risk reduction. Results are easily operational and support decision-making related to infrastructure building, replacement, and renewal. NAI valuations typically use detailed hydrologic or other modelling to ensure comparability with engineered asset performance.

A secondary objective of valuations is measuring non-infrastructure service values, or **co-benefits**, from the same natural assets, such as recreation. These additional service values provide a more realistic and somewhat more holistic understanding of nature's importance in terms of benefits. Together, these two valuations — critical infrastructure services plus non-infrastructure values — provide a composite valuation. While far from exhaustive, it provides a basis for improved decision making.

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

3.2.1. Stormwater Regulation Services

The S2S Project explored natural asset service values in the Watershed related to Stormwater Management (SWM). The PCSWMM model was selected as it permitted the NAI team to leverage prior modelling efforts and is familiar to Town of Gibsons' staff.

Two primary scenarios were modelled for the project:

Scenario 1 reflects baseline conditions (i.e., the location and extent of existing natural assets) of the Watershed to manage a 12hr 100yr storm, which has a 1% chance of occurring in any given year)

Scenario 2 assumes natural assets are removed and replaced with a "single-family residential" land-use type in Charman Creek and a "forestry practices" land-use type in Chaster, Gibson, and Soames Creek sub-catchments. The same rainfall event as Scenario 1 is modelled to demonstrate the peak flow and infiltration changes without the natural assets.

Based on modelling and valuation, the conceptual cost of replicating the natural assets' hydrological functions using conventional SWM and low-impact development (LID) solutions[17] was estimated at a rate of $65.11/m² for forest (riparian and non-riparian) and $268.84/m² for wetlands.

Based on the above, the total value of Aquifer 560 Watershed's forest and wetland natural assets for a single service — stormwater management — is estimated at $40 million ($40,924,000).

17 E.g., bio-retention areas, infiltration trenches, permeable pavement

3.2.2. Co-benefits Values

Part of assessing a community's natural assets is understanding the value of co-benefits. The project team identified priority co-benefits to be captured in this assessment, which included the following, shown in Table 1:

- Recreation & tourism
- Water supply
- Climate mitigation
- Habitat provision
- Science and education opportunities
- Maintenance of culture

SERVICE	DESCRIPTION	OUTCOME MEASURED
Recreation (incl. tourism)	Non-market value derived from engaging in recreation activities within the Gibsons' watershed (e.g., biking, boating, motoring, fishing, etc.)	Value people place on recreation opportunities
Water quality regulation	Estimates the value of water quality regulation by forests & wetlands using a replacement cost approach based on the cost of treatment for drinking water	Value people place on clean drinking water
Climate mitigation (e.g., carbon storage & sequestration)	Addresses the non-market values associated with the regulation of climate, including regulating albedo (ability of a surface to reflect light), some aspects of greenhouse gas emissions & carbon sequestration.	Value of carbon sequestered by natural areas
Habitat provision	Addresses the non-market values associated with the refuge & reproductive habitat that ecosystems provide to wild plants and animals.	Value people place on preservation of biodiversity & habitat
Science and education opportunities	Assesses the social value of publications in social & natural science academic journals arising from research activities.	Value people place on research publications
Maintenance of culture	Addresses the role of natural resources in Indigenous well-being. This can include maintenance of culture, food, ceremony, sites of importance, etc.	Addressed qualitatively

***Table 1**: Summary of Services Explored and Outcomes Measured*

Tables 2-4 summarize the co-benefit valuation results (in 2022 CAD) for forest and wetland natural assets in the Watershed for the services identified by the project team.

SERVICE	NON-RIPARIAN FOREST	RIPARIAN FOREST	WETLAND	ASSET AREA (HA)
Recreation (incl. tourism)	$195,000	$27,000		$222,000
Water quality regulation*	$3,323,000	$458,000	$10,000	$3,791,000
Carbon sequestration	$336,000	$46,000	$8,000	$390,000
Science and educational opportunities	$96	$13	$1	$110
Total	**$3,854,096**	**$531,013**	**$18,001**	**$4,403,110**

Table 2: *Summary of Annual Co-Benefit Values from Forests and Wetlands in the Watershed*

** Results are based on value transfer from surface water studies, not groundwater studies. The Town of Gibsons relies primarily on groundwater.*

SERVICE	NON-RIPARIAN FOREST	RIPARIAN FOREST	WETLAND	ASSET AREA (HA)
Recreation			$9,000*	$9,000
Carbon storage†	$175–000 - 224,000	$27–000 - 34,000		$202–000 - 258,000
Habitat provision	$11,000 – 208,000	$2,000 – 29,000	$7,000	$20,000 – 244,000
Total	**$186,000 – 428,000**	**$29,000 – 63,000**	**$16,000**	**$231,000 – 511,000**

Table 3: *Summary of 'One-Time' Co-Benefit Values from Forests and Wetlands in the Watershed*

** Not possible to annualize due to hedonic pricing method used by value transfer source.*

† Storage is the current base value and is not an annualized amount like sequestration, which occurs over time. ***Note:*** *Low-end values are used here to err conservatively.*

3.2.3. Non-Quantified Values

Cultural Ecosystem Services (CES) are often the co-benefits most valued by community members,[18] but they are frequently overlooked because their intangible nature makes them challenging to evaluate. Maintenance of Culture is a subset of the broader category of CES and was identified by the project team as a critical service to assess. Few studies have attempted to quantitatively evaluate other aspects of CES such as cultural identity, and sense of place.

18 Rodrigues et al. (2018).

Maintenance of Culture includes the importance of the Watershed in cultural traditions and generational knowledge transfer, and the appreciation a community has for local ecosystems.[19] It is meant to represent the cultural heritage and identity of all peoples in a project area but can be used to refer only to that of Indigenous peoples, which is how it is applied here.

The S2S Project area is integral to the culture, history and heritage of the Squamish Nation.

The following information was provided by *Ta na wa Ns7éyx̱nitm ta Sneẃíyelh of the Sḵwxwú7mesh Úxwumixw* (Squamish Nation):

The area called Ch'ḵw'elhp and Scheṅḵ (Gibsons) is the site of an early Sḵwx̱wú7mesh village. It was both a permanent village and a seasonal camp, used by Sḵwx̱wú7mesh people who travelled from the Squamish area to Gibsons and back. It was a shared place, as with all villages, between permanent villagers and seasonal visitors. There are two place names associated with the general area extending from Gibson Creek to Gibsons Harbour: Scheṅḵ (leaning or steadying rear against something) and Ch'ḵw'elhp (spruce). Part of the land in this area is still recognized as reserve lands belonging to ta Sḵwx̱wú7mesh Úxwumixw (the Squamish Nation). Many Sḵwx̱wú7mesh people are descendants of the inhabitants of this place and still have ties to Ch'ḵw'elhp and Scheṅḵ.

This area is known as one of the origin places of the Sḵwx̱wú7mesh people and is included in the Nation's plans for future land use. The Sḵwx̱wú7mesh people have occupied the present-day Sunshine Coast since the beginning of time. Our place names, lineage, and legends establish a long and continuous history.

According to the 1876 census, there was a large longhouse, a burial ground, a potato patch, and a hunting and fishing station in the Gibsons area. It was also a plant gathering area, where medicinal plants were grown. Ancestral remains still exist in this region.

Ch'ḵw'elhp and Scheṅḵ are important ḵwex̱nís (sea lion) hunting grounds as well as cháchu7 (saltwater hunting) grounds for the Sḵwx̱wú7mesh people and were rich/abundant with other marine life, including sts'úḵwi7 (salmon), x̱íxwa (sea urchin), asxw (seal), sheykw (clam), skeṁts (littleneck clam), yéẃyews (orca), and ḵwenís (whale).

19 The Gibsons area also includes archeological sites and middens.

3.3 Risk Identification

In October 2021, Town of Gibsons staff participated in an NAI-led risk management workshop to identify risks to natural assets and their associated services. This exercise led staff to identify a total of 13 stressors, including:

1/ Development Pressure
2/ Erosion
3/ Green waste dumping
4/ Invasive plant species
5/ Drought (current and future)
6/ Deforestation
7/ Flooding (current and future)
8/ Forest Fire
9/ Pollutant loading from urban, agricultural or industrial sources (e.g., road salts)
10/ Storm events (rainfall)
11/ Storm surge
12/ Sea level rise
13/ Ocean temperature rise

'Stressors' become 'risks' when they have been identified as high probability and high consequence. As summarized in Table 5 and spatially represented in Figure 5, the natural asset types that faced the highest number of risks were creeks (7 high risks) and riparian areas (6 high risks), followed by the foreshore and the urban forest (both 4 high risks).

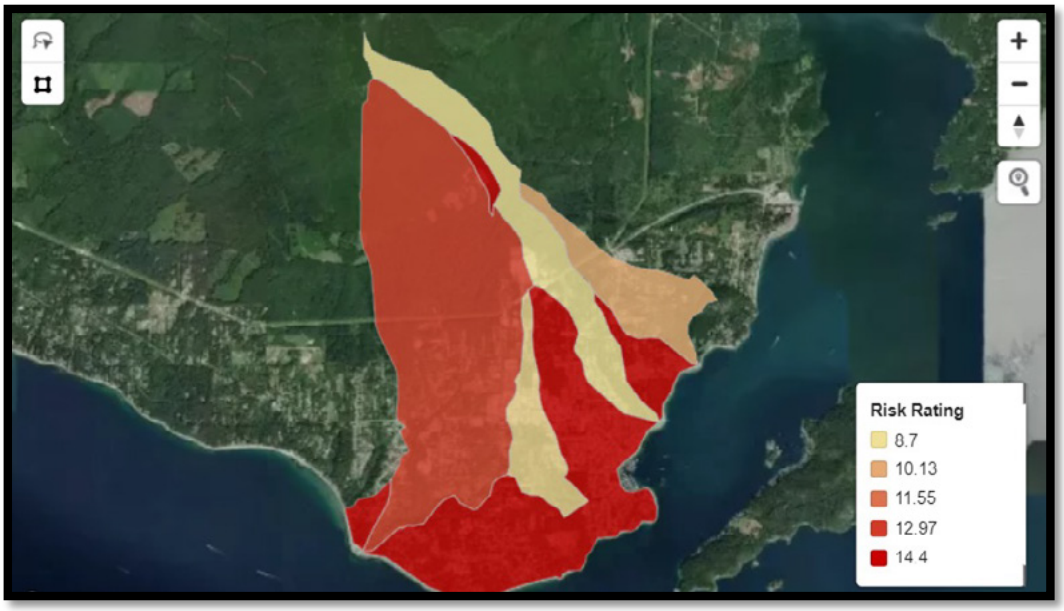

***Figure 5**: Risk Rating by Sub-catchment*

RISKS	FORESHORE	CREEKS	FOREST	URBAN FOREST	WETLANDS & PONDS	RIPARIAN AREAS	EELGRASS	AQUIFER	H COUNT
Green waste dumping	H	H	M	H	M	H	L	L	**4**
Flooding (current & future)	M	H	L	L	L	M	L	L	**1**
Forest fire	L	L	M	L	L	M	L	L	**0**
Invasive species	L	H	H	H	M	H	M	L	**4**
Development pressure	M	H	H	H	H	H	M	H	**6**
Pollutant loading	L	M	L	M	H	L	M	L	**1**
Storm events (rainfall)	M	H	L	L	M	H	M	L	**2**
Drought (current & future)	L	L	H	H	L	M	L	H	**3**
Erosion	H	H	L	L	L	H	L	L	**3**
Storm surge	H	L	L	L	L	L	H	L	**2**
Sea level rise	H	L	L	L	L	L	H	M	**2**
Ocean temperature rise	L	L	L	L	L	L	H	L	**1**
Deforestation	L	H	H	M	M	H	M	H	**4**

Table 4: *Cumulative Risk Ratings for each Sub-catchment in the Project Area.*
H=high, M=medium, L=low risk *Top risk categories are highlighted in grey.

4 Exploring Future Scenarios

4.1 Scenario Modelling

The S2S Project assessed five candidate management alternatives that either increase or decrease the extent or quality of natural assets in the project area. This is summary of the additional benefits or costs relative to current conditions (i.e., with natural assets) from implementing these alternatives.

Outputs from the model quantify SWM services provided by the watershed's natural assets (forests, riparian areas and wetlands) these were assigned a dollar value based on their cost of replacement with a built alternative (in this case, stormwater retention ponds). The scenario analysis extends this baseline valuation to determine if changes in the management of natural assets would result in significant improvement or diminishment in the value of service provision.

4.1.1. Enhance/Restore Forests

This management option envisions implementing forest restoration (e.g., tree planting) to enhance 0.9 ha of existing forest in the Goosebird Creek watershed, thereby increasing canopy cover and interception.

Since Goosebird Creek's forest canopy interception service is degraded to an unknown per cent, results for different levels of degradation are provided. If the service is 50% degraded, restoring the forest to a fully functional state would generate $4.7 thousand in SWM benefit (50% of $10,532/ha x 0.9 ha) in addition to baseline values for the catchment; the equivalent values for assumed degradation of 20%, 10% and 5% are $1.90 thousand, $0.95 thousand, and $0.47 thousand respectively.

4.1.2. Decrease Forest

This management option envisions forest removal due to urban development in four areas: The Shaw Rd South/Gospel Rock area; potential developments in Park Rd West and Park Rd East; and Whitetower/Shaw Rd area.

The total SWM value that would be lost if forests were removed in all four potential development areas is $1.54 million ($0.754 + $0.027 + $0.666 + $0.093).

4.1.3. Increase Wetland Area

This management option envisions an increase in wetland area at four locations: Henry Rd East and West; Davis Rd wetland; and Reed Rd. In total, if the increase in all four wetlands were completed, the added SWM value would be nearly $3 million (the SWM value of the existing Whitetower Park ponds is $0.87 million.)

4.1.4. New Wetland

This management option involves creating 1,290 m2 of new wetland near Payne Road. If this wetland were added, it would provide an estimated SWM value of $177,960 (0.129 ha x $1,379,533/ha).

4.1.5. Increase Riparian Area

Similar to the “enhance/restore forest” management option (see above), this management option envisions implementing forest restoration (e.g., tree planting) to enhance the canopy interception service provided by riparian forest in two locations: 1) along Charman Creek and, 2) along Goosebird Creek. The equivalent values for 20%, 10% and 5% degradation are $1,072, $536, and $268, respectively. The proposed new riparian area at the mouth of Goosebird Creek (locally known as Labonte Park) has an estimated value $1,072 (0.1 ha x $10,716/ha).

4.2 Summary of Results

Results for baseline valuation, climate change, and the five management options are summarized in Table 7. These results are for a 12hr 100yr storm (i.e., 1% chance of occurring in any given year).

CATCHMENT	Baseline Natural Asset Value (2021 CAD $ '000s)	DIFFERENCE FROM BASELINE (2021 CAD $ '000S)					
		Climate Change	Enhance / restore Forest	Decrease Forest	Increase Riparian Area	Increase Wetland Area	New Wetland
Charman Creek (156.5 ha)							
Forests (72.8 ha)	$767	$99		($415)			
Riparian Areas (13.7 ha)	$147	$63			$3		
Wetlands (0.7 ha)	$966	$315				$152	
Total	**$1,880**	**$477**					
Chaster Creek (590.9 ha)							
Forests (590.9 ha)	$20,597	$240		($405)			
Riparian Areas (104.5 ha)	$3,871						
Wetlands (0 ha)						$165	$178
Total	**$24,468**	**$240**					
Gibson Creek (387.3 ha)							
Forests (257.0 ha)	$5,592	$249					
Riparian Areas (33.8 ha)	$1,264	$108					
Wetlands (0 ha)						$2,662	
Total	**$6,856**	**$356**					
Soames Creek (176.4 ha)							
Forests (116.3 ha)	$4,624	$633					
Riparian Areas (8.0 ha)	$161	$27					
Wetlands (0 ha)							
Total	**$4,785**	**$660**					
Residual Areas							
Forests			$5				
Riparian Areas					$1		
Wetlands							
All Areas							
Forests (1,036.1 ha)	$31,580	$1,221	$5	($820)			
Riparian Areas (160.0 ha)	$5,443	$197			$4		
Wetlands (0.7 ha)	$966	$315				$2,979	$178
Grand Total	**$37,988**	**$1,733**	**$5**	**($820)**	**$4**	**$2,979**	**$178**

Table 5: Valuation results for stormwater management under each NAM scenario

5 Developing Nature-Related Levels of Service

Levels of Service (LOS), including strategic, corporate, to customer (also referred to as community), and technical LOS represent the service delivery commitment of a local government. LOS inform asset management and financial plans and help local governments to prioritize capital and operational spending decisions.[20]

The Town of Gibsons, like most local governments of its size and maturity in asset management, is at an early stage of developing LOS. The Town has already drafted some LOS for some assets, but they have not yet been finalized or approved by Council. As part of the S2S Project, staff participated in an LOS workshop to build capacity in developing LOS for natural assets and to explore potential natural asset-related LOS for stormwater services.

The S2S Technical Report describes these outcomes in full; notably, there are four key corporate stormwater service objectives that flow naturally from the Town's strategic objectives, shown in Table 6, that can be used as a proposed starting point for defining customer and technical LOS.

POTENTIAL CORPORATE LOS FOR STORMWATER	SOURCE DOCUMENT
Provide integrated stormwater management services at the lowest possible lifecycle management cost.	**Asset Management Policy** seeks to provide services at lowest possible lifecycle cost. **Drainage Asset Management Plan (Draft):** includes customer LOS statement: understand natural asset value and capacity.
Leverage green infrastructure to manage stormwater services.	**Eco assets strategy:** Leverage natural assets to prevent flooding, provide drinking water and manage rainwater (compare costs with engineered assets, save money). **Drainage Asset Management Plan (Draft):** includes related customer LOS: Prioritize open channel conveyance of rainwater where possible; natural environment is enhanced. **OCP policy 6.3.6:** Consider daylighting the culverted sections of Charman and Goosebird Creeks in the Gibsons Landing area & other enclosed watercourses, wherever possible.
Minimize risks to life and property from natural hazards and disasters such as floods, erosion and slides.	**OCP:** Minimize risks to life and property from natural hazards and disasters such as floods, erosion and slides. **Source to Sea co-benefits assessment (this project):** Manage risk of landslides and stream sedimentation from erosion; forest root networks help hold the soil around trees.

20 See *mnai.ca/media/2022/01/MNAI-Levels-of-Service-Neptis.pdf*

POTENTIAL CORPORATE LOS FOR STORMWATER	SOURCE DOCUMENT
Support safe, high-quality multi-functional use of natural stormwater infrastructure to provide residents with access to nature for cultural, recreational, and economic activities.	**Source to Sea co-benefits assessment (this project):** outlines recreation, culture and the local economy as important co-benefits of natural assets recognized by the Town.

Table 6: Potential corporate LOS for stormwater management

Through the S2S Project and previous studies, there is a solid foundation of data and information about stormwater services being provided by natural assets in the Aquifer 560 Watershed to develop stormwater LOS. Asset management is a process of continuous improvement, and data gaps can be filled as part of continuous improvement efforts. LOS measures will evolve over time.

As next steps, the Town could finalize LOS measures to track, note whether data currently exists and whether information is known about the current LOS being delivered. Once current LOS has been identified, the Town will be able to work towards defining its desired LOS.

6 Conclusion and Recommendations to Advance Natural Asset Management in the Aquifer 560 Watershed

Effective stewardship of natural assets helps local government to be more resilient, deliver affordable services in a changing climate, reduce costs, and provide an alternative to "building their way out" of infrastructure challenges. Natural assets can provide both critical infrastructure services and co-benefits that add to community quality of life. Natural Asset Management (NAM) is a subset of the broader field of nature-based solutions. NAM enables nature to be conceptualized, accounted for, restored, protected, and managed as a vital asset to ensure its viability for the long-term.

A key consideration for NAM is that ecosystems rarely align with political boundaries and jurisdictions. Many entities rely on natural assets that are under the ownership and/or jurisdiction of others. Therefore, collaboration amongst many entities, and action at a watershed scale, is ultimately required for effective NAM.

The Town of Gibsons deemed nature its most valuable asset in 2014 and is an innovator of NAM. They continue to be a 'living lab' for NAM and their efforts have inspired many others. The S2S Project considers NAM at a watershed-scale and also explores surface water–marine interactions in the context of NAM, an area of research which had not been undertaken. Results to date are highly relevant to many other communities in Canada and potentially beyond.

The S2S Project presented an opportunity to take a holistic, evidence-based, watershed-scale approach to:

- Maintain and enhance multiple services.
- Enhance and complement long-standing efforts to reduce flooding risks – both terrestrial and coastal.
- Prepare for and adapt to changing precipitation patterns in a changing climate described above, which will amplify existing risks.

Based on evidence, the S2S Project will contribute to substantially lower lifecycle costs than relying solely on engineered solutions. It will also provide co-benefits that correlate with health, protected and well-managed ecosystems.

6.1 Recommendations to Advance Natural Asset Management in the Town of Gibsons

Recommendation #1: Use findings from this project to prioritize capital projects

Timeline: **Short-term**

This project provided insight into the stormwater benefits of potential afforestation or restoration projects in different locations and assessed the co-benefits that natural assets provide. The Town already has a list of NAM projects in the pipeline for implementation (or currently being implemented). It is recommended that staff assess the list of priority projects considering new information gained from this project and if required, re-prioritize to manage costs and risks of stormwater services and other co-benefits.

Recommendation #2: Update land use policies and by-laws to mitigate high risks to natural assets from development pressure

Timeline: **Short-term**

The scenarios modelled in this project considered how of a range of potential, mostly land use-related, changes would impact stormwater services. Scenario 2 considered the impact of urban development on stormwater services in three locations: the Shaw Rd South/Gospel Rock area, the Whitetower/Shaw Rd area and the Park Rd East and West area. **The total capital cost to replace stormwater services provided by the existing natural assets in these locations would be roughly $1.5M**, which does not account for ongoing operating and maintenance costs of constructed stormwater ponds. It is in the Town's interest to leverage natural assets, where possible, to manage the lifecycle costs of stormwater services in new and existing developments.

Overall, it will be important to ensure alignment between the new OCP and the results of this assessment to ensure that land use policies, bylaws and DPAs consider and manage risks to natural assets effectively, and in accordance with best management practices.

Recommendation #3: Strengthen multi-jurisdictional collaboration and governance

Timeline: **Short-term**

Ensure effective management of natural assets outside of the jurisdiction of the Town of Gibsons to protect critical stormwater services and other co-benefits they provide to the community (e.g., through monitoring initiatives in collaboration with the Province of B.C.).

Recommendation #4: Use findings from this project to inform the Urban Forest Strategy

Timeline: **Short Term**

This project prompted the Town to collect LIDAR data in 2021 to document canopy cover in the Watershed. The canopy cover data can be used to inform the Urban Forest Strategy, which is currently being developed. The stormwater valuation and co-benefits assessment from this project can also be used to inform the strategy.

Recommendation #5: Advance development of a stormwater utility

Timeline: **Short to Medium-term**

The Town of Gibsons should ensure sufficient funding for natural asset and engineered stormwater infrastructure assets to achieve desired stormwater LOS. Gibsons currently relies on general taxation and grant funding to cover the cost of stormwater services, which is insufficient to manage capital, operating and maintenance costs. A high priority for the Town is to establish a stormwater utility to secure funding for NAM work and other stormwater service costs. The utility would collect revenue in the form of parcel taxes or user fees.

Recommendation #6: Ensure measures are in place to mitigate high risks related to green waste dumping and invasive plant species

Timeline: **Short-term**

Green waste dumping is among the top risks to the foreshore, creeks, the urban forest, and riparian areas in the watershed. Mitigation measures currently being taken include the development of education and awareness messaging to residents to prevent dumping, particularly in the riparian areas and the foreshore. It is recommended that the Town track and report on extent of dumping and review whether additional enforcement measures are needed to reduce this risk.

Invasive plant species are also a high risk to natural assets in the Watershed. It is recommended that the Town continue its efforts to find a suitable location and process for disposal to address this high risk to native species and ecological health.

Recommendation #7: Communicate the results of this project and build awareness of the service delivery value of the Watershed

Timeline: **Short to Medium-term**

A unique characteristic of NAM is that good management practices need to be undertaken by both the private and public sectors to achieve service delivery objectives. It is critical that the public be aware of the value of services provided by natural assets in the Watershed, and that they understand the actions they can take to protect and manage those services.

It is recommended that the Town communicate the results of this project and continue its broad efforts to educate the community about the value of the Watershed and good NAM practices.

Recommendation #8: Address data and information gaps to improve knowledge about the role of the Watershed in stormwater service delivery

Timeline: **Continuous Improvement**

The S2S Stormwater Modelling Component report recommends several actions the Town can take to address data and information gaps identified.

- Collect more flow data at more stream locations by taking measurements during a storm with stream flow measurement equipment. The intention would be to accurately estimate the contribution from different tributaries or disaggregate impacts to inflows from rural versus developed areas, areas with different infiltration rates, or forest versus riparian areas.

- Put rain gauges out in a forest for areas with/without canopy and compare the data to obtain a local % canopy interception.
- Take field measurements to measure depth and area of wetlands and stormwater ponds so a set of storage curves can be developed to understand the storage/area relationship.
- Take local soil infiltration measurements. The highest priority is the 12.7 ha of soils in Soames Creek Watershed that is listed as very poorly drained in the Provincial soils database since they have a large impact on the hydraulic results for Soames Creek.
- Measure cross-sections of the creeks for more accurate modelling.
- Conduct 2D modelling to permit model coupling more easily between terrestrial and coastal flood dynamics.
- Use land use classifications to estimate updated imperviousness values and improve the coverage of the Sensitive Ecosystems Inventory via ground truthing.

Recommendation #9: Build understanding of the hydraulic connection between surface and groundwater to support aquifer protection

Timeline: **Continuous Improvement**

Awareness of which areas of the Creek are recharge areas for the aquifer is critical to ensure they are monitored and protected from contamination long-term. It is recommended that the Town build on this study and develop an ongoing monitoring program to track changes to and health of aquifer recharge areas, and to build its understanding of the hydraulic connection between surface and groundwater in other parts of the Aquifer 560 Watershed.

Recommendation #10: Validate condition of natural assets to support prioritization of natural assets restoration and management

Timeline: **Continuous Improvement**

The project prompted the Town to formally assess the condition of Charman Creek riparian areas, which had 27 known engineered structures in various locations and some badly eroded areas. The assessment helped build the case for restoration and led to the Town being awarded grant funding of $6M for creek restoration projects in Lower Gibsons.

The Town would benefit from validating the condition of natural assets in Chaster Creek and other parts of the watershed, including forests, riparian areas, and wetlands, to help prioritize future restoration projects and other lifecycle management needs.

Recommendation #11: Strengthen collaboration with the Squamish Nation

Timeline: **Continuous Improvement**

The Squamish Nation is aware of this project and have been involved in conversations related to the co-benefits assessment on cultural and other services the Watershed provides. As a result of this project, there are new opportunities to collaborate on NAM.

These efforts are demonstrating the benefits to the Town and Squamish Nation of working together and may lead to new opportunities to combine western science with Traditional Ecological Knowledge to support protection and management of natural assets.

Recommendation #12: Continue to build staff capacity in NAM

Timeline: **Continuous Improvement**

This project helped to facilitate the Town's overall progress in NAM. The Town benefits from having a full-time, dedicated Natural Asset Technician, which is both rare and innovative in the municipal sector.

Cross-functional coordination and collaboration will be needed to support further integration of NAM in the Town's operations and decisions. It is recommended that the Town continue to support education and training internally, ensuring that appropriate resources are dedicated to continuous improvement of NAM.

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