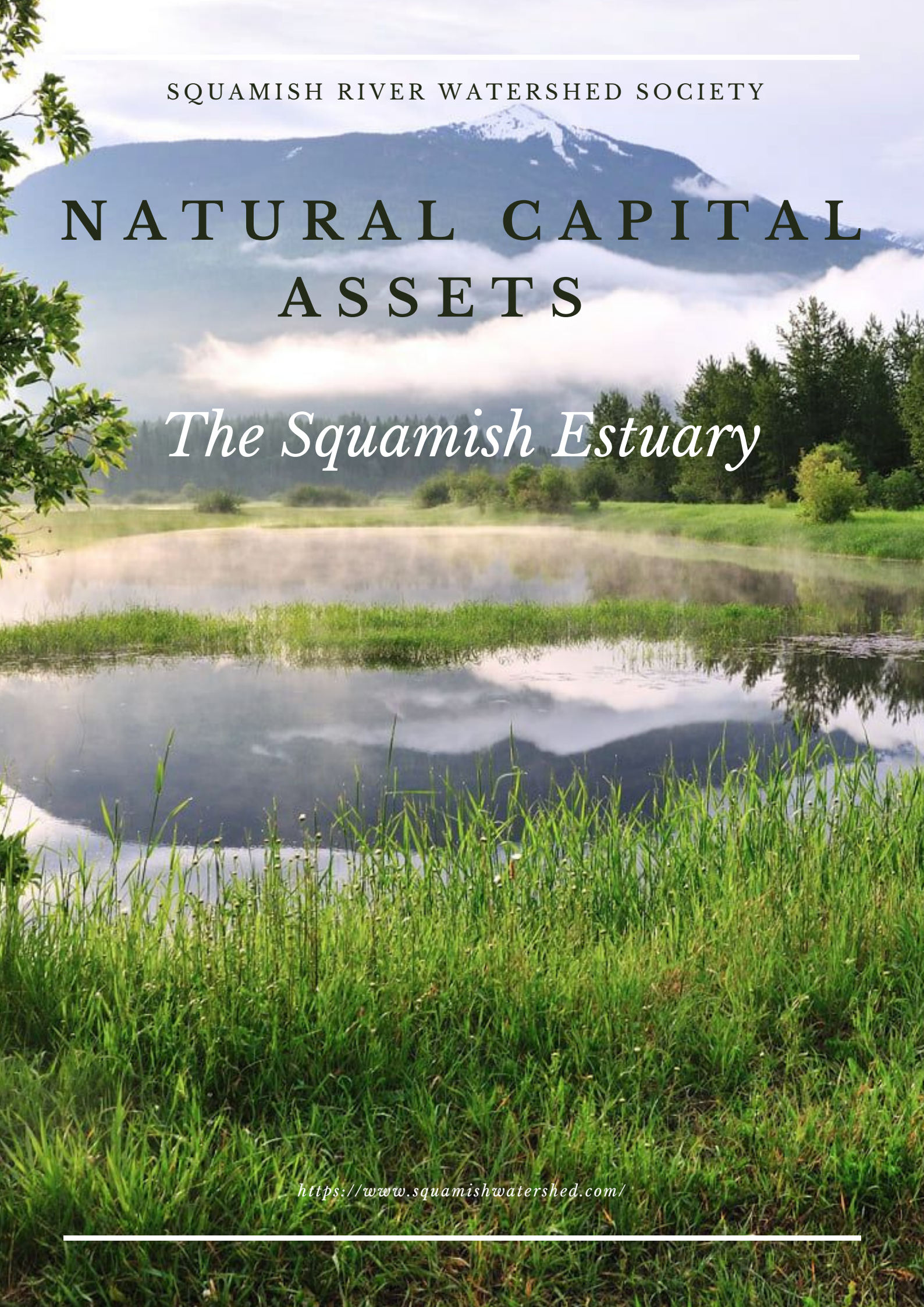

SQUAMISH RIVER WATERSHED SOCIETY

NATURAL CAPITAL ASSETS

The Squamish Estuary

https://www.squamishwatershed.com/

"

The environment provides some $72tn a year of "free" support to the global economy. That's more than four times the size of the US economy."

~ **Inger Andersen** Director General, International Union for Conservation of Nature

Acknowledgements

This report was prepared for the Squamish River Watershed Society, based on input and feedback received from local stakeholders as part of the ongoing collaborative process to determine the value of the Squamish Estuary

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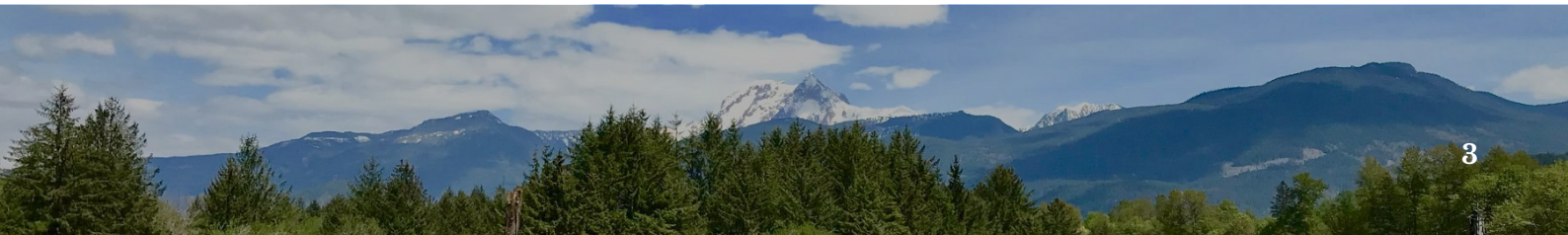


EXECUTIVE SUMMARY

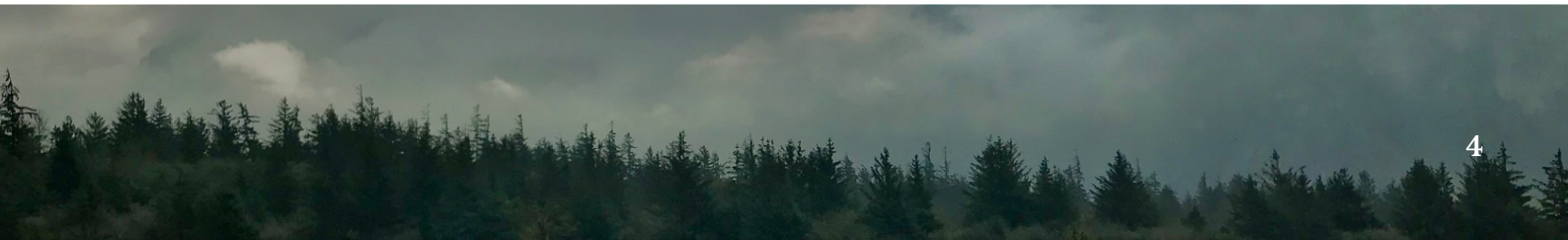
Estuaries, where freshwater meets the sea, are some of the most biologically productive and valuable ecosystems on earth. This report explores the economic value of the Squamish Estuary, through natural asset inventory. The estuary is a significant natural asset, providing services such as fisheries, nutrient cycling, waste treatment, climate regulation, clean water, disturbance regulation, indigenous values, habitat, recreation and tourism.

Ecosystem goods and services are commonly undervalued in economic analysis. It is risky to assume that nature can continuously be drawn from without costs or losses. Nature seems to provide its services for free.

Formally integrating nature into asset management at the strategic level of local government leads to more informed financial and asset management decision-making. Many communities have turned to the Municipal Natural Assets Initiative (MNAI) as a next step in natural asset management. In MNAI projects, inventories are the first step in delivering core municipal services in an economically and environmentally responsible manner.

There is potential to significantly increase the value of the Squamish Estuary through restoration. An estuary restored to its natural state would better mitigate the effects of climate change and generate future revenue through carbon credits as an offset project. Removal of the training berm could increase salmon survival, thereby benefitting commercial, recreational and First Nations fisheries. An intact estuary would also have increased water filtration, waste treatment, and sediment stabilization.

This report estimates the value of ecosystem goods and services provided by the Squamish Estuary to be over $12.6 million/year. With high value natural assets such as the estuary, Squamish would greatly benefit from completion of the natural asset management (NAM) cycle, among other recommendations. Municipal natural asset management offers a sustainable solution to the complex challenges municipalities face, with aging infrastructure, urban growth, declining budgets and climate change.



PART 1 - INTRODUCTION

What is natural capital?

Natural capital refers to the stocks of water, land, air, and renewable and non-renewable resources on Earth.[1] This term is an extension of the economic concept of capital. The collective benefits supplied by natural capital assets are known as ecosystem goods and services. These assets provide all people the means for healthy lives and underpin all economic activity.

What are ecosystem goods and services?

Ecosystem goods are tangible items measured by flow, volume, weight, or quantity. For instance, the quantity of water produced per second, or number of fish returning to spawn, can be measured by the physical quantity produced by an ecosystem over time. These goods can be valued by multiplying the quantity by the market price. However, extraction of goods can affect the ability of the remaining ecosystem to provide services. Understanding these intersecting ecosystem values is essential to inadvertently avoid inadvertently destroying more value than is provided. By evaluating the full suite of ecosystem goods and services, economic tradeoffs can be better understood.[1]

Unlike ecosystem goods, *ecosystem services* such as flood protection or climate change mitigation are not tangible items. Ecosystem services are conditions and processes through which natural ecosystems, and their species, sustain human life. Many services, such as oxygen production, soil regulation, and storm protection cannot be sold in markets or privately owned. However, markets for some ecosystem services are developing, such as carbon offset markets.

Why is it important to measure natural capital?

Our natural environment provides key ecosystem goods and services - breathable air, drinkable water, food for nourishment, security from floods and sea level rise, for instance. Natural systems also provide essential economic elements, such as oxygen, water and resources.

If these valuable goods and services are lost, people sustain significant economic costs and a decline in quality of life. The service previously provided by natural systems for free must be replaced by costly, engineered structures. In some cases, no expenditure can replace lost ecosystem goods and services. In addition, all built capital requires natural capital inputs of material and energy. There is a blind spot to the economic importance of ecosystems, with natural capital left out of asset management. Without measuring natural capital, we do not know how much value is being lost through degradation or how value could be accumulated through restoration.

1 - Molnar et. al. (2012).

Why is this study a priority?

This study is relevant and timely because climate change and biodiversity loss pose an immediate and costly threat to coastal communities, such as Squamish. These findings can be used to support ecosystem accounting, inform municipal policies on natural assets, make informed development decisions and assist in the evaluation of financial assurances to decommission and restore sites.

Restoration has the potential to increase the value of Squamish's natural capital assets, while minimizing long-term costs.

A **Living Document**

This study provides a rough estimate of economic value, based on data obtained from the David Suzuki Foundation's Nearshore Natural Capital Valuation and Sound Investment studies[2]. Due to resource restraints, the values are based on existing studies completed for comparable ecosystems and the estimated size of the estuary (673ha) is used in caluculations. In addition, indigenous environmental and cultural services could not be valued because adequate valuation methods do not exist. It is recommended that this be used as a living document, open to new information as it arises.

2- Molnar, 2012; Molnar, 2015

PART 2 - OVERVIEW OF STUDY AREA

The Squamish Estuary is the most northern point of Howe Sound. Estuary habitats include marshland, sand and mudflats, flood channels, and intertidal drainage channels.

In 2007, the Squamish River Estuary was designated as Skwelwil'em Squamish Estuary Wildlife Management Area under the Provincial Wildlife Act. This marks the Squamish Estuary as a site where wildlife, fish and habitat values are of regional, provincial, and national significance. It was established to conserve and manage habitat for:

- Endangered, threatened, sensitive, or vulnerable species
- Critical life-cycle phase of a species, such as spawning, rearing, nesting, or winter feeding
- Migration routes or other movement corridors
- Areas of very high productivity or species richness

History of Development

The Squamish River Estuary was cut off from its fresh water source, when BC Rail developed the Squamish River Training Dyke. The Squamish River was dredged and the dredge material was used to infill the estuary in preparation for a coal port development. The Department of Fisheries and Oceans (DFO) and public outcry stopped the proposed coal port from proceeding. The river dredge was dumped, burying 15 ha of estuary under a large pile of debris, remaining this way into the late 1990s.

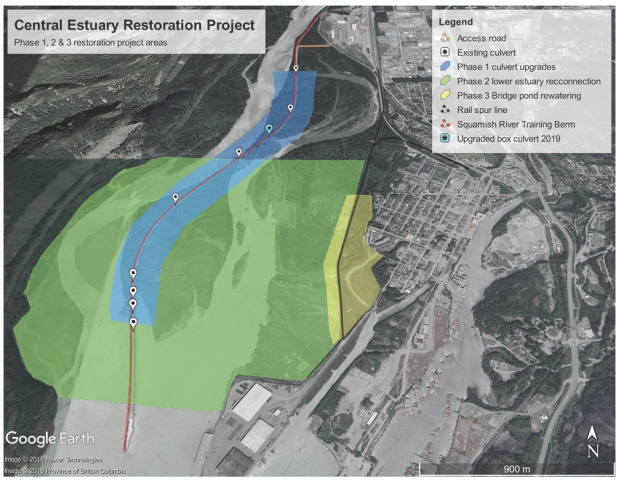
Restoration Efforts

In the past 20 years, the Squamish River Watershed Society (SRWS) has added value to the estuary through restoration projects focused on trails, eelgrass, carbon sequestration, heritage & wildlife trees and fish access. Since 2001, over $5 million in grants and government funding has been awarded to restoration efforts.

In 2017, the SRWS, in partnership with Squamish Nation and DFO, secured $1.6 million in funding for the Central Estuary Restoration Project (CERP). CERP builds on the previous restoration efforts to restore fish habitat, tidal connectivity, and overall estuarine function throughout the Squamish Estuary. This project was designed in three phases, focused on restoring habitat to support Pacific salmon, particularly juvenile Chinook (*Oncorhynchus tshawytscha*). Juvenile Chinook are a species-at-risk[3], and a primary food source for the endangered Southern Resident Killer Whales.

CERP is funded through support from Coastal Restoration Fund, BC Hydro's Fish and Wildlife Compensation Program, and Pacific Salmon Foundation. The project falls under the national Ocean Protection Plan initiative to restore coastal aquatic habitats. Options to improve rearing conditions for juvenile salmonids in the Squamish estuary were defined in consultation with DFO and the Squamish Nation as follows:

- Phase 1: Upgrade existing culverts in the training berm to improve fish access
- Phase 2: Modify the lower section of the training berm to reconnect the lower estuary with the Squamish River
- Phase 3: Install a flow control device under the CN rail spur to re-water historical channels



Phase 1 of the project was implemented from 2018-2020 and includedthe replacement and upgrade of two under-performing corrugated steel culverts. These old culverts were replaced with two larger fish friendly concrete box culverts that now allow accessibility from the Squamish River to the nutrient rich central estuary for out-migrating juvenile salmonids.

3- COSEWIC, 2018

While Pacific salmon habitat restoration and reconciliation efforts with Squamish Nation are the primary focus of CERP, re-connection of the Squamish River floodplain may offer additional value. Some of these benefits could include:

- improvements to water quality
- improvements to flood mitigation and coastal resilience
- restoration of natural sediment deposition, marsh accretion, and carbon sequestration -
- capping of persistent pollutants and
- supporting species at risk.

Actively restoring damaged coastal estuaries involves alterations of structures and processes in order to restore degraded hydrologic, physical, chemical, and biological functions.[4]

Current Status

Phase 2 of CERP, set for fall 2021, will involve deconstruction of up to 1 km of the lower training berm, also known as the Spit. The plans are subject to approval by the regulators. This next step will restore the integrity of the Squamish River Watershed, while improving access and habitat for chinook salmon. A recent hydrodynamic and sediment transport model prepared by SNC-Lavalin investigated the impacts of berm removal on the Squamish estuary and surrounding area. The project continues to study whether there will be impacts on these processes (e.g. wave height, sedimentation).

It will be up to recreational groups to come up with alternative accesses to the remaining training berm, as ecosystem restoration remains a priority in the Skwelwil'em Squamish Estuary Wildlife Management Area.

Key Stakeholders

Decision-makers within the provincial government and District of Squamish will find the information in this report informative for Squamish's municipal natural asset management efforts.

The Squamish River Watershed Society, in partnership with Squamish Nation and Fisheries & Oceans Canada, is working towards restoration of the Squamish Estuary. As a Wildlife Management Area, conservation of the Squamish Estuary also falls under provincial jurisdiction. The District of Squamish and Squamish Nation will continue to manage the relationship with Squamish Windsports Society.

4- Palmer, 2009

PART 3 - NATURAL ASSET MANAGEMENT

Defining Municipal Natural Assets

Municipal natural assets are the stock of ecosystems goods and services relied upon by a municipality, regional district, or other form of local government for the sustainable provision of municipal services. As stated in the Squamish OCP, "significant natural assets include the Squamish Estuary, Baynes Island Ecological Reserve, and the Mamquam Blind Channel."[5]

Municipalities are recognizing that natural assets such as estuaries, forests, streams and foreshores can provide clear advantages over engineered infrastructure[6]. Many of the benefits that our ecosystems provide would be very expensive or impossible to replicate. For instance, natural assets can increase community resilience to extreme weather events. In coastal regions, estuaries reduce the impacts of storm surges, flooding and erosion, while providing a range of other valuable benefits – cleaner water, enhanced habitat and recreational space.

Strong management of natural assets offers a sustainable solution to the complex challenges faced by municipalities, such as aging infrastructure, urban growth, declining budgets and climate change. In the past, natural assets have not been viewed equally to engineered assets, nor have they been included in financial management plans. Like any asset, natural assets need to be carefully protected and managed to ensure a sustainable supply of services. If natural assets are not managed responsibly, their value degrades as does their ability to provide services from which humans, and all other species, benefit. Therefore, natural assets providing municipal services in Squamish, should be identified and accounted for in decision-making.

5- Cairns , S. 2020

6- District of Squamish, 2018.

Municipal Natural Asset Initiatives

The Municipal Natural Assets Initiative (MNAI) is shifting the way municipalities provide essential services[7]. The MNAI team offers scientific, economic and political strategies to support local governments in identifying, measuring and accounting for natural assets in financial planning and asset management. MNAI also supports development of innovative, sustainable and climate resilient infrastructure alternatives at substantial savings.

There have been two cohorts of MNAI communities to date (2016 -2017 & 2018-2020), with the town of Gibsons having kickstarted natural asset management in British Columbia. MNAI has also guided the approaches of Nanaimo, Grand Forks, Courtenay, Sparwood and West Vancouver. Each community chose a natural asset of interest and the MNAI team supported local governments through the entire natural asset management (NAM) cycle. NAM cycles have assessment, planning and implementation phases. Inventory of natural assets is the first step in phase 1 of the NAM cycle. An inventory is a quick and economical first step to launch natural asset management.

Natural Capital Valuation Framework

This is an evaluative framework that enables decision-makers to identify, measure and value local impacts and dependencies on nature. There are four value categories within this framework. For natural capital assets, the total economic value of an ecosystem can be calculated as:
Total economic value = Use Value + Indirect Use Value + Option Value + Non-Use Value

Value types

• *Use value* refers to the benefit users receive from direct use of the environment.
e.g. consumptive - catching fish in an estuary *or* non-consumptive - bird-watching

• *Indirect use value* arises from services that users get indirectly, a distance away from their origin.
e.g. flood control and water filtration functions of estuaries benefiting other communities

• *Option value* is a user's willingness to pay (WTP) to preserve the possibility of future resource use.
e.g. restoring juvenile salmon habitat for an increased return of adult salmon

• *Non-use value* reflects what users are willing to pay to protect resources they will never use.
e.g. protecting an aquatic species-at-risk out of environmental stewardship, unrelated to direct or indirect use

7- O' Neill, 2017

Valuation methods

In economic valuation, use values are generally the clearest to measure because there are associated market prices and measurable consumption rates. For instance, recreational use is clear, as it can be measured by the number of visits, visitors and sites. Indirect use values are more difficult to estimate because, a) quantities are often a challenge to measure and b) they are not usually market traded. Option values and non-use values are the most difficult to measure because they are not reflected in observable behavior. It also is true that many coastal economic activities that generate little revenue still hold significant economic value.

The following are well-established methods to quantify benefits of ecosystem goods and services. These methods were used to estimate the total economic value of the Squamish Estuary.

Table 1. Valuation methods to determine the quantity of natural capital [8]

Valuation method	Description
Direct market methods	
Market price	Estimates the economic value of ecosystem goods and services that are traded in markets. *e.g.* the value of subsistence fisheries can be based upon the market value of commercial fisheries.
Replacement cost	Estimates value of ecosystem services based on the costs of replacing ecological services or the cost of providing engineered services. *e.g.* engineered waste treatment systems can be replaced with wetland services.
Avoidance cost	Estimates value of ecosystem services based on the cost that would have been incurred without these services. *e.g.* storm protection provided by vegetated foreshores protects coastal property damage.
Production approach	Estimates value of ecosystem services based on the economic value of the service contributing to the production of market goods. *e.g.* water-quality improvements increase commercial fisheries yields, resulting in higher fishing incomes.
Revealed preference methods	
Opportunity cost	Estimates value of ecosystem services based on the next best alternative use of resources. *e.g.* travel time is an opportunity cost of travel because this time cannot be spent on other pursuits.
Travel cost	Estimates value of ecosystem service based on cost to visit the ecosystem. *e.g.* recreational areas can be valued by what visitors are willing to pay to travel there.
Hedonic pricing	Estimates value of ecosystem service based on ecological services that directly affect market prices. *e.g.* housing prices near nature reserves tend to exceed fully developed areas.
Stated preference methods	
Contingent valuation	Estimates value of ecosystem service by surveying users about value *e.g.* people stating that they are willing to pay for increased protection of forest and beaches.
Group valuation	Estimates value of ecosystem service through a group of stakeholders discussing societal values. *e.g.* a First Nation group comes together to discuss the cultural, social and economic values of an area.
Conjoint analysis	Estimates value of ecosystem services by asking the public to rank different services or ecosystem conditions. *e.g.* choosing between different tax increases for varying levels of flood protection associated with estuary remediation.

8- Molnar, 2012

PART 4 - ECOSYSTEMS GOODS & SERVICES OF THE SQUAMISH ESTUARY

Ecosystem goods and services occur at global to local scales, from climate regulation and carbon sequestration at the global scale, to flood protection, soil formation, nutrient cycling, waste treatment, and pollination. This section explores the value of ecosystems goods and services within the Squamish Estuary, as well as threats to these natural assets.

Fisheries

Estuaries are key lifecycle ecosystems for the maintenance of fish populations. The Squamish estuary accounts for 96% of estuarine habitat in the Howe Sound, providing habitat, rearing sites and food for anadromous fish populations of six river systems (i.e. the Squamish, Mamquam, Cheakamus, Elaho, Ashlu and Stawamus). The brackish waters of the estuary acclimatize salmonids to Pacific Ocean salinity.[9] Nearshore sedge provides intertidal and subtidal habitat for fish, as well as invertebrates, birds and mammals. It is estimated that over 80% of all recreationally-caught fish species rely on these ocean nurseries at some point in their lifecycle.[10]

Adult (left) and juvenile (right) Chinook salmon, *Oncorhynchus tshawytscha*

Historically, Squamish was a major harvest area for salmon, steelhead trout and herring. Fisheries not only fed local populations, but were also key economic drivers, with products shipped worldwide. A representative year for B.C.'s commercial salmon fisheries translates to $30 million in value for harvesters, with a post-processing value of over $100 million.[11] The 1997 wholesale value of commercially caught salmon associated with the Howe Sound was valued at over $3,000,000.[12] This value has changed with salmon populations decline. While commercial fisheries have a well-established market value, the value of recreational and First Nations subsistence fisheries is more challenging to measure. The non-market value of these fisheries could be determined by production approach valuation (see Table 1). It is also important to consider the value of ecosystem goods and services that support salmon growth, such as clean water, habitat, and nutrient cycling.

9-Molnar, 2015.
10- Lellis-Dibble, 2008
11- Pacific Salmon Foundation, 2011
12- Pacific Salmon Foundation, 2005

The training berm is currently limiting salmonids from accessing the central estuary. Prior to berm construction, Chinook salmon populations were as high as 15,000/year. Populations declined to as few as 500 in the 1980s.[13] With restoration, they have risen to 5,000, but there is still a ban on fishing for Chinook in the Howe Sound, due to low returns. Opening up the estuary to the Squamish River, would allow juvenile salmon to reach this key lifecycle habitat, increasing survival rates, fisheries revenue and sportfishing opportunities. Protecting key lifestyle habitats such as estuaries and supporting habitat connectivity in conservation is key to enhancing natural asset value.

Nutrient Cycling

All living things depend on the nutrient cycles of carbon, nitrogen, phosphorus and sulphur in large quantities, with other elements required in smaller quantities. Organisms facilitate the movement of nutrients within ecosystems and turn them into biologically available forms. These are cycles that human actions have most impacted. Degradation of estuaries reduces their ability to retain nutrients. Nutrients are lost as runoff and cannot benefit biota dependant on estuary habitats. Salmon are of particular interest, as they return nutrients from the ocean to coastal rivers and forests.

The total value of nutrient cycling for the estuary could be estimated using the production approach and replacement cost valuation methods. **It is estimated that nutrient cycling in the estuary is valued at $189,113/year.**[14]

Waste Treatment and Disease Regulation

Microorganisms in sediments and mudflats of estuaries break down organic waste and filter pollutants. Eelgrass and sedge act as filters to stop pollutant runoff and sediment from entering marine ecosystems.

Though intact estuaries are effective in treating excess nutrients and wastes, large oil spills can be economically and ecologically devastating to these sensitive habitats. In 2006, 29,000L of fuel leaked from the Westwood Annette cargo ship after it struck a pier at the Squamish Terminals adjacent to the Squamish Estuary. The oil dispersed into Howe Sound, affecting the shoreline and wildlife of the Squamish estuary. Cleanup efforts cost more than $100,000.[15]

Habitat degradation, food web alteration and overloading of nutrients or pollutants can disrupt waste-processing and disease-regulating services. This increases the associated economic costs of wastewater treatment. Disturbed ecosystems are also less resilient to disease. People can be exposed to disease in coastal areas through contact with bacterial or viral agents while swimming, ingesting contaminated fish, seafood or water. The total value of these services in the estuary could be estimated using the replacement cost and contingent valuation approaches. **Replacement cost estimates value at $2-4 million/year.**[16]

1013 Pacific Salmon Foundation, 2015. 14- Molnar, 2015 15- Molnar, 2015 16- Molnar, 2015,;

Climate Regulation

The Council of the District of Squamish recently declared a Climate Emergency. The District is focused on maintaining carbon neutrality within corporate operations as part of the commitment to the Climate Action Charter[17]. There are also actioned updates within the OCP. Specific climate change mitigation measures that the District is undertaking include:

• *Establishing a Climate Leadership Team to work with the Mayor, Council and a Consultant to develop a Community Climate Action Plan for insight into Squamish's greenhouse gas emission sources, to establish bold actions to reduce emissions and capitalize on available economic opportunities to work towards carbon neutrality.*
• *Developing a Community Carbon Marketplace, allowing the District to offset corporate emissions with local emission-reducing projects.*

Climate change is particularly threatening to estuaries. Emission reductions, re-naturalization of developed habitats and conservation of existing habitat is necessary to avoid an increase in damages associated with climate change[18]. If the rate of carbon sequestration, emissions, and population growth remains at current levels, Squamish will experience a range of problems from decreased air quality to sea level rise. Through conservation and restoration, there is increased potential to sequester and store carbon in the estuary, effectively contributing to the proposed Community Carbon Marketplace and carbon neutrality targets.

17- Roulston, 2020 18- IPCC, 2014

I. Carbon Sequestration

Carbon sequestration is nature's ability to capture carbon dioxide from the atmosphere, mitigating the impacts of climate change. The ocean's vegetated habitats rank among the most productive and efficient carbon sinks on the planet. Aquatic environments such as estuaries can sequester carbon at 90 times the rate of a comparative forest area.[19] These environments sequester carbon within standing biomass, but most carbon is stored within soils, which can hold carbon for thousands of years if undisturbed. In the Pacific Northwest, estimated carbon sequestration rates of saltmarshes range from 0.9-3.52 tons C/ha/yr. [20]

The Intergovernmental Panel on Climate Change (IPCC) values sequestered carbon at $60.97 per ton per hectare per year. For every ton of carbon released into the atmosphere, it costs the economy $60.97 in physical, social and natural capital annually to offset the damage done by rising carbon dioxide levels. **In the Squamish Estuary, this equates to an estimated $40,500 in avoided cost per year.** [21]

II. Carbon Storage

Carbon storage is nature's ability to hold carbon in reservoirs such as organic matter, sediment and rock. Estuaries provide an abundant, long-term, and safe carbon storage opportunity. Large woody debris and accumulating sediment store carbon deposited by estuary plants and wildlife. **For carbon storage in the estuary, the estimated value based on the avoided cost method is $20,190/year.** [22]

19- Molnar, 2012 20 Crooks., 2014 21-Molnar, 2015 22-Molnar, 2015

III. Carbon Policy

Carbon policies are evolving to position habitat restoration and conservation projects economically, based on their ability to absorb carbon dioxide and mitigate the impacts of climate change. Voluntary and compliance based carbon markets that support carbon off-set projects through emission trading are showing rapid economic growth. Compliance markets traded $140 billion for 5 gigatons of emissions in 2011, and were forecasted to increase to about $3 trillion by 2020.[25] Voluntary carbon markets allow organizations to take responsibility for their emissions and purchase offset credits. Protocols to certify blue carbon offset projects in the carbon market are also being developed (see Blue Carbon).

In the fall of 2021, the federal government plans to launch a carbon offset program, allowing municipalities to earn credits for projects that reduce emissions.[26] This includes biological sequestration projects. A municipality would be able to earn offset credits to sell to regulated industries to reduce impact.

By investing in local carbon capture projects, such as estuary restoration, economic opportunity will remain in the community. Carbon credits represent a reduction in GHG emissions in one location in order to compensate for emissions made elsewhere. Selling credits from the estuary could provide a significant, long-term model for funding of ongoing restoration, stewardship and disaster response. This would also reduce the number of offsets that the District would need to purchase for carbon neutrality in operations.

IV. Blue Carbon

Blue carbon is carbon captured by oceans and coastal ecosystems. Through the Blue Carbon Project (BCP), the SRWS is working on a blue carbon monitoring plan to support the development of blue carbon offset protocol in British Columbia. The project is evaluating the amount and potential value of carbon stored in estuary habitat in Squamish. The BCP was recognized by Federal Environment Minister, Leona Aglukkaq, for playing an essential role in Canada's environmental agenda. Data from this project could inform future offset proposals.

25- Calel, 2011

26- Zimonjic, 2021

Disturbance Regulation

Estuaries provide ecosystems goods and services that reduce the impacts of disturbances such as floods, sea level rise, erosion, and sedimentation.

I. **Flooding & sea level rise**

Squamish is a community vulnerable to increased coastal flooding. With sea level rise, the slope of rivers is being reduced creating greater flood threats, particularly at high tide. In 2003, flooding in Squamish cost approximately $30 million ($45 million in 2021 dollars) and directly affected over 800 people.[27] Approximately $100,000 worth of work was required to repair the damages done by a 2014 flood event.[28] These damage repair costs will exponentially increase with climate change and sea level rise.

With the OCP goal of maintaining 200-year flood protection standards along the Squamish River and a call for a comprehensive approach to climate change, restored estuary services could contribute to these District objectives.

Maintaining and protecting the training berm from sea level rise over the long term will be increasingly costly, according to the Integrated Flood Hazard Management Plan. The bottom portion of the dike is diverting the river but it is not providing flood protection.[29] In contrast, an intact estuary ecosystem could act as a buffer to riverine flooding and sea level rise. For instance, there is a link between large woody debris and estuarine shrub growth to reduce flooding.

Avoided cost and hedonic pricing methodologies are used to value the service of disturbance regulation (see definitions in Table 1).[30] A hedonic approach could measure the value of sedge for storm protection through price differentials, whereas an avoided cost study could estimate the value of estuaries for flood protection by surveying the amount of flood damage avoided by intact estuaries services.

27- -Community Risk Assesment Report, 2015 28- District of Squamish, 2015 29- KerrWood Leidel Association Ltd., 2017 30- Thonon, 2006

II. Sedimentation and Erosion

A natural river channel will migrate back and forth across its floodplain over time by shifting sediment from one side of the river to the other. Two general sedimentary environments occur within the Squamish Estuary, the intertidal zone and the delta front. These environments have been altered by the construction of the training berm, dredging of navigable channels, disposal of dredge spoil and log storage activities.[31] Removing the training berm would allow sediment to be held in the central estuary, increasing carbon storage. Lyngbye's sedge would stabilize this accumulating sediment in the central estuary.

The impacts of training berm removal on navigation and sedimentation in the Squamish Terminal berth or shoreline of District of Squamish dikes are currently being assessed. A recent study conducted by SNC Lavalin revealed the the removal of the berm will allow for natural sedimentation function in the estuary. [32]

Training berm erosion will continue to increase due to storm surges and sea level rise. Removing the berm would lead to long-term savings on operation, maintenance, repair, and upgrading. Additional cost savings may be available if material from the training berm is used in other projects.

Clean Water

Water regulation, supply and treatment is a valuable ecosystem service provided by the estuary. Sedge grass and eelgrass meadows not only filter water of pollutants, toxins and excess nutrients, but also absorb carbon and stabilize sediment. Estuary water treatment services limit pollution in municipal storm runoff from entering the Howe Sound. Nutrient levels are directly affected by adjacent land use, so this service is a key buffer to prevent excess nutrients from entering the ocean. [33]

In Squamish, the value of estuary water supply could be estimated by surveying residents on their willingness to pay for cleaner water, travel cost methods to value improvements in water quality through travel expenditures, or avoidance cost to value water supply by comparing the cost of naturally filtered water with that of an alternative water source. **This service value was estimate to be at least $286,025/year.** [34]

31- Hoos et al. 1975 32- SNC Lavalin , 2021 33- Raldous, R. , 2012 34- Molnar, 2015

Education

The estuary is an outdoor classroom for educational institutions, community groups, and eco-tourism companies throughout the year. Every school in the District uses the estuary for experiential learning, with the SRWS bringing over 600 children and 200 volunteers, teachers and parents into the estuary for place-based learning and stewardship activities. Post-secondary institutions such as Quest, BCIT, UBC and Simone Fraser use the estuary for ecological monitoring and restoration studies. BCIT's Ecological Restoration Program relies on the estuary as a key study site.

Organisations such as the Squamish Environment Society, Squamish Birders, Eagle Watch, Squamish Streamkeepers, Squamish Trail Society, Over the Hill Hikers, Hearts in Motion, Nordic Poles and Squamish Scouts use the estuary on a regular basis. Photographers, paddlers, artist groups and daycares also learn here.

The Squamish River Watershed Society runs outreach programs to connect students, seniors and working professionals with estuary restoration projects. They also offer "by request" workshops on the estuary and its preservation/restoration. With insufficient grant funds, $100/hr is charged to keep programs accessible. Approximately, 2500 people use the estuary for experiential educational programs each year through the SRWS alone. This does not include external groups or visitors. Stanley Park Ecological Society charges $249 per 25 students for a similar two hour program in the estuary.

The estimated value of nature-based education is $22,209/year. This stems from the Howe Sound natural capital study, which provides a per hectare value for this service.[35]

35- Molnar, 2015

Recreation & Tourism

Intact ecosystems attract people for recreational and tourism activities, while also leading to increased property values and eco-tourism opportunities. Recreational fishing, eagle raft tours, kayak rentals, whale and bird-watching, are activities that would not occur without an intact estuary, healthy wildlife populations, and clean water. Squamish's dramatic natural beauty and outdoor recreation potential, near Vancouver, make it a popular tourism and recreation destination.

While windsports increase summer Spit visitation, no formal economic, social or environmental impact assessments have been conducted by the Squamish Watersport Society (SWS). The value of activities in contrast with the costs of training berm maintenance and salmon habitat fragmentation remains unclear. Annually the District spends approximately $70,000 on maintaining safe, public access to the berm.[36]

Wildlife viewing of salmon and interdependent species is a significant part of Squamish's tourism industry, effectively boosting the local economy. Companies such as Coastal Stoke Paddle Boarding Tours and Eagle River tours rely on wildlife for business. Squamish also draws freshwater, saltwater, guided and remote anglers, with access to four species of Pacific salmon, Bull trout, Steelhead trout and Cutthroat trout. Recreational anglers spend over $550 million annually on fresh and saltwater sport fishing in B.C. Squamish is known for excellent guided fly-fishing and eagle watching[37]. The exact value of Squamish fisheries has not yet been measured.

Travel cost and contingent valuation are valuation methods for recreational services. Hedonic pricing is often used to estimate aesthetic value. These methods measure the associated costs of recreation, willingness to pay for increased recreational services, and price differentials in housing located near recreational sites. Many coastal activities are available at little to no cost, especially to local users, with tourists paying to travel to these areas. Therefore, local users usually enjoy the greatest economic benefit from coastal goods and services.

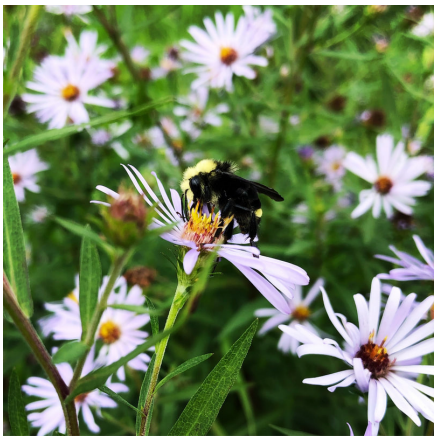
36- Aldous, 2016

37- Explore Squamish , 2020

Habitat

The habitat of the Squamish Estuary, upon which much of life in the Howe Sound depends, has been reduced by almost 50% since the 1960s. Habitat is the biophysical space where species needs are met — a healthy ecosystem provides physical structure, food availability, appropriate chemical and temperature regimes, and protection from predators. A habitat can provide refugium and nursery functions. A refugia refers to general living space for organisms, while nursery habitat is specifically habitat where all the requirements for successful reproduction occur. Of significant concern are intersections of land and water— the riparian corridors, estuaries and eelgrass meadows — as key lifecycle habitats.

The Squamish Estuary (673 ha) was declared a Wildlife Management Area (WMA) in 2007.[38] The primary goal of the WMA is to protect and maintain fish and wildlife populations and habitats. Therefore, management of recreational activities must focus on minimizing recreational impacts to fish and wildlife. The Squamish Estuary is also an Important Bird and Biodiversity Area (IBA). It provides wintering, migration, feeding and breeding habitat for waterfowl and shorebirds. The estuary supports provincially significant species such as eulachon, steelhead and salmon. To capture the value of endangered species, MNAI is developing a Species at Risk Tool to allow local governments to integrate species at risk and critical habitat considerations into their natural asset management frameworks.[39]



There is also notable value in pollination and pest control (e.g. mosquitos), provided by habitats that host a diversity of organisms. For instance, in Washington, the economic value of birds for pest control was determined to be $1,473 per square kilometer per year.[40]

The production approach could be used to determine habitat value. This approach measures the ability of healthy habitats to enhance income. For instance, the value of healthy estuaries for commercial fisheries could be estimated with this method. Estuaries have a high per hectare value as a habitat refugium, with a value $290 per hectare per year.[41] **At this rate, the estimated value of Squamish estuary habitat services is at least $195,170 ($290 x 673ha).**

38- Government of B.C., 2007 39- Cairns, S., 2020 40 Şekercioğlu, C., 2017 41- Molnar, 2015

Indigenous Values

The estuary has had significant value for the Squamish Nation since time immemorial. Cooperative management of the Squamish Estuary WMA aims to protect traditional use and cultural value of the land and water. Deactivation of the Spit aligns with Squamish Nation reconciliation efforts. The Squamish Nation is deeply connected to the land and waters of the estuary, encompassed in their traditional territory. Fishing is very important in Squamish culture. Over 60 species of fish, beach food, and marine mammals are traditionally known and used.[42] The Squamish Nation values secluded places for:

- traditional cultural practices
- wildlife, fish and healthy habitat
- clean air
- clean water for drinking, for the ecosystem and for ritual bathing
- resources from which Squamish members can earn a living, such as vegetation and tourism
- places to heal, recover and re-connect with the land.[43]

In evaluation, connections that Indigenous peoples have with the land has mostly been framed within physical cultural heritage. By identifying culturally significant sites, using archaeological techniques, other Indigenous values have been lost.[44] This strategy does not serve Indigenous peoples well because there are recreational, aesthetic, subsistence and spiritual values beyond culturally significant sites.[45] There are currently limited methods to evaluate Indigenous cultural and environmental values, so they are likely being undervalued. MNAI also acknowledged this gap and is developing a First Nations Cultural Assets Tool to ensure recognition of the value of First Nations cultural assets, and activities compatible with those assets and values, in natural asset management.[46]

Squamish Nation ceremonial event to release juvenile Chinook Salmon in the upper watershed at Elaho River (photo credit is C. Nahanee, July 3, 2019)

42- Pacific Salmon Foundation, 2005
43- Squamish Nation, 2021
44- Jackson, 2006
45- Gratani, 2016
46- Cairns, S., 2020

Total Ecosystem Value

A study on Howe Sound watersheds revealed an estimated annual value of $800 million to $4.7 billion in ecosystem services[47]. Within the Howe Sound, Squamish ecosystems have a financial value that can be measured without the need for additional development or extraction.

Estimating the value of ecosystems, even imperfectly, will help to make more informed management decisions. A 1997 study on natural capital conservatively estimated the value of ecosystem services performed by estuaries to be $33,878 per hectare per year[48]. Based on this study method and 2021 dollar conversions, the Squamish Estuary would have an estimated value of approximately $8 million/year.

Total ecosystem value was also determined by adding the value of individual ecosystem services (Table 2). These values were determined using 96% of the value estimated for estuaries in the *Molnar, 2015* study, as the Squamish Estuary account for 96% of estuary habitat in the Howe Sound. **This total estimated value of ecosystem services is over $12.6 million.**

Table 2. Summary of values of ecosystem benefits

Ecosystem service type	Estimated value per year	Total value per hectare per year	Valuation method	Relevant case studies
Disturbance Regulation	1,090,260 - 4,978,854	$1,620 – $7,398	Avoided cost	Leschine, T.M., et al., 1997
Habitat	$195,170	$290	Production approach	Johnston, R.J., et al., 2002
Recreation and Tourism	$351,979- $456,967	$523 - $679	Hedonic pricing and travel cost	Johnston, R.J., et al., 2002
Education	$22,209	$33		Johnston, R.J., et al., 2002
Clean water	$286,025	$239 – $425	Contingent valuation	Bockstael, N.E., et al., 1989
Indigenous environmental values	unknown	unknown	unknown	To be discussed with Squamish Nation
Fisheries	$95,073 (non-market food provisioning) $3,000,000 (market value)	n/a	Production approach	Molnar, M. 2015. David Suzuki Foundation; Environment & Land Use Committee Secretariat, 1980
Carbon sequestration	$18,171	$27	Avoided cost	Duarte, C. et al., 2005
Carbon storage	$20,190	$30	Avoided cost	Nellemann, C., et al., 2009
Waste treatment	$3,366,346	$1,640 – $5,002	Replacement cost	Wilson, S.J., 2008
Nutrient cycling	$189,113	$281	Production approach	Newell, R.I.E., et al., 2005
Total	**$12,628,118**			

47- Molnar, 2015

48- Costanza et. al., 1997

PART 5 - RECOMMENDATIONS AND CONCLUSION

Recommendations

The following are suggested next steps for the use of this Squamish Estuary natural asset report. Whatever the method, emphasis remains on efforts that increase protection and restoration of salmon populations for the benefit of the ecosystems, economy, and community who depend on them.

Recommendation #1: Incorporate natural capital into District of Squamish asset and financial management

The inclusion of natural assets in financial reporting will allow for more accurate decision-making. The District should incorporate natural asset maintenance and climate action emergency response into financial planning. This report has identified the qualitative economic inventory of estuary goods and services. Further research could build on these findings to determine the value of Squamish's natural capital assets in detail.

Recommendation #2: Develop a Squamish natural asset management framework in partnership with MNAI

Though this report provides a qualitative inventory of the Squamish estuary's natural assets, next steps in the NAM cycle could be undertaken, in partnership with an organization such as MNAI. It is likely Squamish is underestimating our natural value and ignoring impacts to these assets. To join this program would be to follow the lead of neighboring communities, who have reaped the benefits and savings associated with utilization of ecosystems services.

Recommendation #3: Prioritize restoration of natural systems over engineered solutions

Climate adaptation and disturbance regulation should stem from restoration of estuary goods and services, before turning to engineered alternatives. Projects such as vegetation studies, natural stormwater and foreshore management projects, blue carbon and stream rehabilitation could maintain and increase the value of these natural assets. A healthy ecosystem will provide goods and services to the surrounding area, with minimal inputs.

Recommendation #4: Remove part or all of the training berm

Phase 2 of the Central Estuary Restoration Project (CERP) involves modifying the lower section of the training berm to reconnect the lower estuaryto the Squamish River. Reconnecting these habitats will increase salmon survival, as well as all ecosystems services linked to salmon. Sedimentation change due to berm removal will not significantly impact the Squamish Terminal. The benefits of removal far outweigh the costs.

Recommendation #5: Establish the estuary as a significant carbon sink, to benefit from the carbon market

Carbon storage in the estuary could generate carbon offset credits. Offset potential could be determined by calculating the amount of carbon stored in biomass and soils. Credits from the estuary could provide a significant, long-term funding model for ongoing restoration, stewardship and disaster response. This would also reduce the number of offsets that the District would need to purchase to be carbon neutral in respect of their operations.

Conclusion

Squamish needs to recognize nature as the foundation for a healthy and resilient economy, as well as the basis for a high quality of life. With informed management, natural assets such as the estuary can be used to mitigate future economic and societal challenges.

Healthy coastal estuaries provide resilience to flooding and storm surges. They also provide adaptation to sea level rise and coastal erosion, conserve and enhance biodiversity, and support marine industries, recreation, and cultural activities. When estuaries are degraded or lost, the ecosystem services provided by those habitats are lost as well, creating negative socioeconomic impacts.

Though the exact value of ecosystem goods and services is unknown, the **total estimated value is over $12.6 million/year**. Disturbance regulation, carbon sequestration, fisheries and water filtration provided by intact ecosystems contribute significantly to natural asset value. Habitat and indigenous values do not yet have established valuation methods. **The total estimated value is likely significantly higher due to these limitations.**

This inventory is an effective and inexpensive first step to launch natural asset management in Squamish. Incorporation of natural capital assets in the District's financial framework is an essential next step in moving towards a carbon neutral, biodiversity rich, wellness focused town for all.

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