Restoring Wetlands in the Somenos Basin

Prepared for:

The Somenos Marsh Wildlife Society

by:

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Executive Summary

The work of this document is the fruition of the aspirations and endeavors of the Somenos Marsh Wildlife Society (SMWS). My employment with SMWS is to explore the possibility of restoring a wetland complex within the Somenos Basin that will restore water quality and aquatic habitat. With a background in geography, I have compiled this report using an inductive holistic approach in order to generate a macro-perspective design strategy that flows through a phased Principal Recommendation, along with several alternative recommendations. My results should be used to guide the direction of future, more in-depth projects.

The project goal for this report is: *To enhance the function and utility of the Somenos Basin using restorative wetland techniques.* The project's scope limits the study with two stipulations: development must be within the boundary of the Somenos Management Area, and the development must intercept a tributary creek. Through further refinement, an objective of this research aims to produce an ecological design solution that meets the project goal through a triple bottom line principal that benefits: the People, the Planet, and Profit. It is the recommendation of this report to meet the project goal and objectives through the implementation of the Principal Recommendation, which is to construct a complex of wetlands that intersects the Bings/Holmes Creek in the Somenos Basin in order to facilitate the restoration of aquatic habitat. The Principal Recommendation has been structured in a series of phased sequences that promotes efficient ecological enhancement, mitigation of potential environmental impacts, use of financial resources, and time to design and implement a master plan. This research and accompanying proposal are to be used as an model that can be replicated and used elsewhere within the same basin or watershed.

The desire to restore a wetland complex stems from problematic conditions of water quality and degraded aquatic habitat. Historically, the Somenos ecosystem has offered a wide range of ecological services that were enjoyed and used by wildlife and humans alike. A wide diversity of wildlife has been supported through a multitude of habitat types found within the Basin including: lacustrine, shallow water wetland, riparian area, swamp, marsh, woodland and fields. Almost all the ecosystems in the Somenos Basin are wetland in nature, and all other ecosystems function as integral riparian habitats. Wetland ecosystems are known to be one of the world's most productive systems, comparable to that of rainforests and coral reefs. Wetlands also filter water by removing sediments and pollutants. When water flows through the system, channel bends and vegetation intercept and reduce the velocity of water, allowing increased soil infiltration and facilitating environmental remediation of pollutants through specific biological metabolism mechanisms of vegetation and microbes in adjacent soils.

Unfortunately, wetlands are diminishing all over the world. The strength and longevity of today's wetlands are in a very precarious situation. The Somenos Basin is an example of a worldwide phenomenon in which wetlands are being lost due to urban encroachment, being drained to create agriculture land, and are being degraded from poor water management practices. A majority of the wetlands around the Somenos Lake were drained in the early 20th century to create land for agriculture production. Over time, anthropogenic development has undermined the ecological services offered by the Somenos Basin and have, in fact, hindered the ecosystem's vitality.

As the widespread effects of climate change are being realized, the scientific community is reminding us how vital wetland environments can be in helping naturally mitigate and adapt to some of the negative consequences associated with climate change by sequestering carbon, improving water quality, and mitigating the effects of floods and droughts. This perspective has allowed us the opportunity to reevaluate the importance of wetlands to not only biotic communities, but to our human communities as well. The Municipality of North Cowichan is making important strides to protect the natural environment through Official Community Plans, policies, and conforming to the Province's Best Management Practices. This project gives the opportunity for North Cowichan to help sustain a healthy ecosystem by restoring function of Somenos' wetland systems. If the Principal Recommendation is achieved, habitat area will be increased, water conditions will improve, and the Somenos Basin will become a healthier and stronger ecosystem. This will propagate cascading benefits, not only for the environment, but also for: the District of North Cowichan as a climate change/flood mitigator; to residents and tourists that can experience and learn about a landscape of biodiversity and ecological restoration; and to farmers by increasing the compatibility between agriculture and wetland environment.

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1.0 BACKGROUND

1.1 Introduction

Nestled within the Cowichan Valley on Vancouver Island, British Columbia, the Somenos Lake and its associated floodplain ecosystem offer a beautiful and diverse landscape that has been used throughout history to support an abundance of wildlife and human uses. There are nine at-risk species found in the Somenos Basin, and a population of anadromous salmonids. The Somenos Basin is also part of the Pacific Flyway for migratory birds and is designated as an Important Bird Area, giving international status and recognition (Williams & Radcliffe, 2001, p. 26).

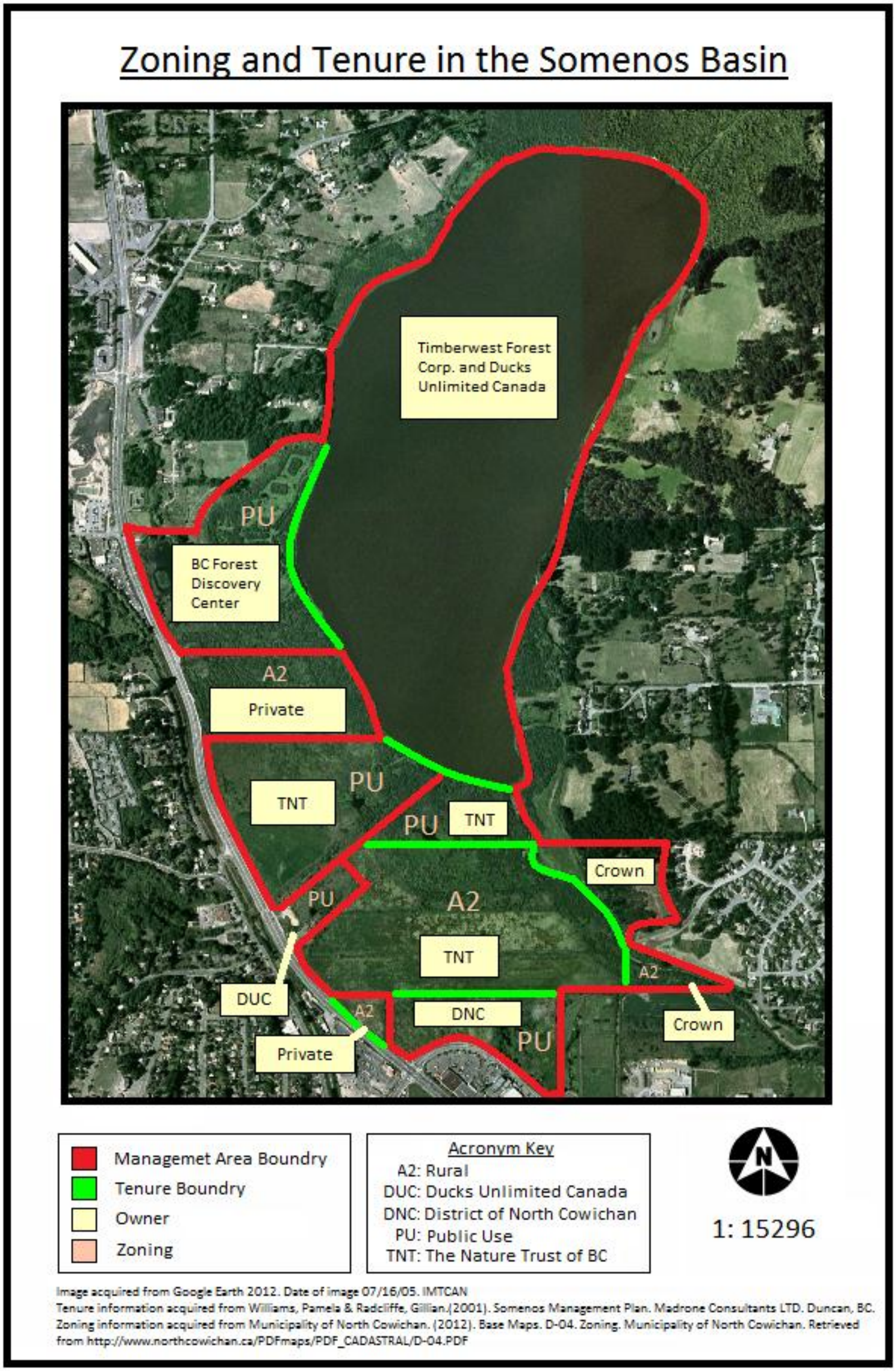
The health of the Somenos Basin has been tainted by human influences. From the late 19th century until present day, the pursuit and proliferation of human settlement patterns and industry have contributed to the disruption of symbiotic balances between humanity and nature. A common result of traditional industry and urban development is environmental degradation and the loss of potential biological productivity. The floodplain once extended well into the city of Duncan, until urban encroachment filled in large portions of it. Important marsh and riparian areas have been drained or altered to produce better farmland. Human alterations to the watershed have put stress on the local hydrological system, and the predicted effects of global climate change will only exacerbate the dire situation. The Somenos Management Committee represents the land owners and several stakeholder groups that are actively involved in an effort to manage and conserve this fragile ecosystem.

1.2 Scope

The scope of the project is defined by the research goal*: To enhance the function and utility of the Somenos Basin using restorative wetland techniques.* To achieve the goal of this research, the scope is defined by a set of two parameters:

1. The project must be within the boundary of the Somenos Management Area (see Map 1).
2. The land base must intercept a tributary creek.

The resulting ideal location for wetland restoration is the southwestern portion of the Somenos Basin located in the Nature Trust of BC's property (see map #2). This is an optimal location due to the adjacency of the Bings/Holmes Creek, the low-relief topography, being annually inundated, and the fact that this area was a wetland in the past. From this point onwards, this area will be known as the "*Project Site*".


Zoning and Tenure in the Somenos Basin
Timberwest Forest Corp. and Ducks Unlimited Canada
PU
BC Forest Discovery Center
A2
Private
PU
TNT
PU
TNT
Crown
PU
A2
TNT
A2
DUC
A2
DNC
PU
Private
Crown
Managemet Area Boundry
Tenure Boundry
Owner
Zoning
Acronym Key
A2: Rural
DUC: Ducks Unlimited Canada
DNC: District of North Cowichan
PU: Public Use
TNT: The Nature Trust of BC
N
1: 15296
Image acquired from Google Earth 2012. Date of image 07/16/05. IMTCAN
Tenure information acquired from Williams, Pamela & Radcliffe, Gillian.(2001). Somenos Management Plan. Madrone Consultants LTD. Duncan, BC.
Zoning information acquired from Municipality of North Cowichan. (2012). Base Maps. D-04. Zoning. Municipality of North Cowichan. Retrieved from http://www.northcowichan.ca/PDFmaps/PDF_CADASTRAL/D-04.PDF

Map #1

1.3 Tenure/Stakeholders

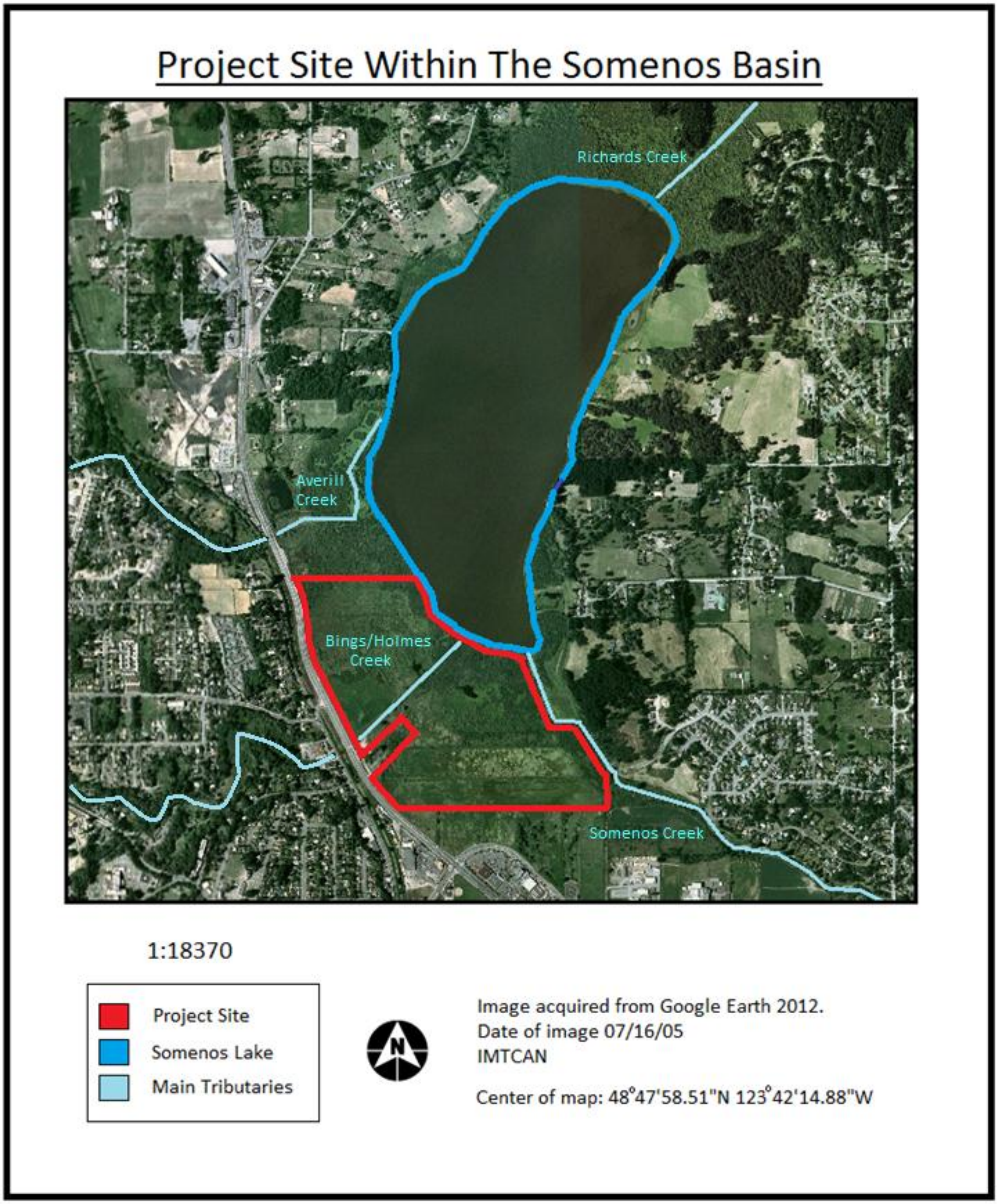
Tenure in the Somenos Basin is subdivided among several owners including: private, government agencies, business, and agency groups (see map #1). There are two important property leases to be aware of within the Somenos Management Area. The property containing the Averill Creek has been leased to Ducks Unlimited Canada by the BC Forest Museum. Secondly, the property in the southwest portion of the Somenos Basin is currently owned by the Nature Trust of BC whom purchased "7.5ha in 1976, 14.6ha in1977 and another 27ha in 1989 for a total of 49.1 ha." (Clermount, 2007). The property owned by the Nature Trust of BC is leased to the Ministry of the Environment for 99 years, expiring in 2088. Along with tenure is a long list of associated stakeholders including: Cowichan Tribes, the Ministry of Water, Land and Air Protection, the Somenos Marsh Wildlife Society, the Cowichan Watershed Council, the Cowichan Naturalist Society, Oceans and Fisheries Canada, the Pacific Streamkeepers Federation, and the people who utilize the basin as an outdoor recreation and a learning center.

1.4 Geography

The Somenos Basin is located in the Municipality of North Cowichan, British Columbia. The fields of the Basin are highly visible east of Highway 1. The lowlands around Somenos Lake are designated as Agriculture Land Reserve (Willis, Cunliffe, Tait, 1981, p.2). The Project Site property is zoned PU- public use, and A2- Rural (Municipality of North Cowichan, 2012).

The Somenos Basin is a part of the Cowichan Watershed. The Basin is comprised of: lake, marsh, swamp, agriculture, forest, woodland, riparian area and has "low geomorphological relief" resulting in "extensive riparian lowlands" (Rehbein, 2004, p.108). The area is a product of natural geomorphic and biological process, primarily glaciation and mass glacial wasting. The multitude of habitats and abundance of water found in the Somenos Basin makes it integral to local biodiversity and surrounding ecosystems, including the Cowichan Estuary and the Chemainus Estuary. The Basin's wetlands provide good habitat for fish when they migrate from the Cowichan River and Somenos Lake to the flooded areas around Somenos Lake during the fall and winter.

There are three tributary creeks that drain into the Somenos Lake: Richards Creek, Averill Creek and Bings/Holmes Creek (see map 2). The Somenos Lake drains to the southeast by the Somenos Creek, which adjoins with the Cowichan River flows into the Salish Sea. Richards Creek is the largest tributary and supports a large number of Coho salmon; however, Richards Creek is unfortunately outside the current Somenos Management Area (see Section 2.4.10 *Additional Recommendations*). Averill Creek is the smallest tributary in the Somenos Basin, and is located within the Ducks Unlimited Nesting Area. Due to size and poor channel structure, this creek has a limited potential to support salmonids. Bings/Holmes Creek, the second largest tributary creek, supports a substantial population of salmonids (Williams & Radcliffe, 2001, p. 23). Coho smolt migrate from the lake from April-May, and the remaining Coho fry and trout seek refuge in Summer months in cooler portions of the lake/tributaries (Williams & Radcliffe, 2001, p. 23).


Project Site Within The Somenos Basin
Richards Creek
Averill Creek
Bings/Holmes Creek
Somenos Creek
1:18370
Project Site
Somenos Lake
Main Tributaries
N
Image acquired from Google Earth 2012.
Date of image 07/16/05
IMTCAN
Center of map: 48°47'58.51"N 123°42'14.88"W

Map # 2

1.5 Human Values

First Nations/ Archaeology

Wetlands are a part of our planet's natural wealth. They provide a multitude of services for wildlife and humans alike. As a cherished ecosystem, the wetland has coincided with human civilizations for over 6000 years (Ramsar, A, 2012). Humans have been attracted to wetlands because of the abundance of resources they have to offer such as: foraging opportunities, water, materials to make shelters, and transportation routes. Additionally, wetlands form on gradual slopes or flat areas, which is ideal for settlements.

The project site is in the traditional territory of the Cowichan Tribes. Archaeological evidence shows occupancy dating back to 4,000 years ago (Williams & Radcliffe, 2001, p.31). The word "*Somenos"* comes from the Cowichan First Nations word "*Somena",* which is one of thirteen original cities of the Cowichan people located on the shores of the Somenos Creek (BioAyer, 1999, p. 2). *Somenos* is reported to be plural word meaning "resting place" by the Cowichan First Nations. Canoe men of the Cowichan First Nations would use Somenos Lake as a resting place as they moved to destinations up stream. The marsh area is also used by waterfowl as a resting place during migrations (Radcliffe, 1990, p. 4).

European Settlement

European settlement of the Cowichan area began around 160 years ago (Williams & Radcliffe, 2001, p.31). Europeans brought with them new land uses, industry, and development techniques. Specifically, new developments that occurred in the Somenos Basin included small industries, lumber mills, school house, roadways, agricultural fields, school yard, and commercial/residential/industrial properties (Delcan & Current Environmental, 2012, p.34).

A new change that perhaps exhibited the largest effect on the land was agriculture. Today, active agriculture occurs on the north and south floodplain of the Basin. Within the Project Site, the currently farmed crop is primarily reed canary grass, and a small amount of manna grass.. The lands adjacent to the Somenos Lake were at one time wetlands. Around the turn of the 20th century, these lands were ditched, diked and drained to create agriculture land (Williams & Radcliffe, 2001, p.4). This common technique was in vogue in the late 18th to early 19th century across North America (Biebighauser, 2011, p.7; Rehbein, 2004, p.30). Under natural conditions, rivers migrate from their sources and meander slowly, sinuously spreading out over floodplains. These same floodplains are optimal for farmers due to these areas having access to fresh water, being conveniently flat, and typically have high organic and soil nutrient content (Rehbein, 2004, p. 16). Over centuries of human history, people have learned that ditching and draining these wetlands provides greater arable land and higher crop yields; however, it is now known that these changes "made to a site's natural drainage pattern can have severe impacts on streams and nearby wetlands" (MWLP, 2004, p. 7). To drain a wetland, farmers would typically use ditches and drain tiles. Ditches were dug to convey water off the land, which would be made just below the water table to create depressions where water would pool. Drain tiles typically made out of clay would be inserted beneath the soil to direct water to the channel. To increase drainage, the ditch would typically be straight, narrow, have sharp sides, and be clear of any vegetation (Biebighauser 2012). Water that once spread out slowly and relatively shallowly across broad floodplains is now concentrated into increasingly smaller areas (Ramsar, A, 2012).

Reed canary grass as a crop is well suited for regularly inundated soils. Primarily sold as animal bedding, the grass has a low economic return. In the lower Somenos Basin, reed canary grass is generally harvested twice a year, once in June/ July, and once in September. Increasing high water levels that remain throughout the summer growing season limit agriculture productivity as saturated soils decrease the area of farmable land and restrict the access of large farming equipment. If crops are not harvested by June, then they become over mature. If the first harvest is prolonged too far into the season, it can cause lost crops for the fall harvest when flood levels return (Williams & Radcliffe, 2001, p. 14-15). To circumvent the problem of inundated agriculture fields, traditional methods of increasing drainage by dredging, clearing streamside vegetation, and straightening the channels. Traditional methods of using biocides and fertilizers to increase crop production are not used for agriculture in the Somenos Basin (Reid, 2012).

Other than agriculture, the Somenos Basin is primarily used as natural amenity for recreation, education and tourism. The Basin offers great tourism opportunities used by many visitors who come for outdoor recreation. In 2008 Watts Walk, the first phase of the Open Air Classroom initiative was completed. Watts Walk is a 150m walkway and a 5m by 5m viewing platform that overlooks the Somenos Marsh, located in the southwest corner of the basin. The boardwalk and Open Air Classroom seeks to educate people on ecosystem management and environmental awareness (Somenos Marsh Wildlife Society, 2012). The Principal Recommendation of this project, and accompanied by a proposed nature center, seeks to expand the tourist potential. Visitors are able to come to the Somenos Basin to experience a landscape of biodiversity and learn about nature, as well as ecological restoration.

1.6 Hydrology

Located within the Cowichan watershed, the Somenos Basin acts as a large nexus point as water moves from the heights of the surrounding mountains to the shallows of the Salish Sea. Due to the surrounding low-relief topography (see Map 3), the Somenos Lake and surrounding wetland environments offer a pivotal catchment area, by means of the three tributary creeks that feed into the Somenos Lake and drain over 7000 hectares of land (Williams & Radcliffe, 2001, p. 14). The Basin stores masses of fresh water which facilitates a lush and biodiverse environment.

The 20th century saw development of the Basin, where anthropogenic forces such as: residential and commercial expansion, agriculture, road construction, diking, and forest harvesting, and increased demand for water have independently and collectively affected both water quality and quantity. Over time, as development of the Cowichan watershed increased, the environmental potential of the Somenos Basin has decreased. One of the most conspicuous results of this loss in habitat is an exacerbation in flooding events. Ditching and draining wetlands to create agriculture land alters the hydrological cycle. Since wetlands and their surrounding soil accept water and let it slowly release, the wetland moderate both droughts and floods. Draining wetlands removes this function. For example, on the Yangtze River in China, “flooding has become more frequent and more damaging as a direct result of floodplain loss, especially when combined with the loss of vegetation cover in the river’s drainage basin” (Ramsar, A, 2012).

North Cowichan's Official Community Plan (OCP) of 2011 notes:

> Past development practices that did not respect natural drainage and storage patterns disrupted flows. More rapid spring runoff has resulted in lower water table levels, and increased water temperatures in lakes, rivers and streams, which impacts salmon and other fish habitat. Crowding of wetlands by residential development has contributed to flooding during major rain events
>
> - DNC, A, p.5

The municipality has made steps toward protecting their water resources, including mandates that all new roadways are to include sediment traps, and all new parking lots are to have sediment and oil traps (Reitsma, 2012). The OCP advocates for on-site stormwater management and the result is that bioswale development can now be seen across North Cowichan. Evidence that North Cowichan is gradually improving their water management paradigm is evident by the Cowichan Valley Regional District Water Management Plan (Westland Resource Group, 2007), which shows their commitment to conform to the Best Management Practices set out by the BC provincial government (for more information on Best Management Practices, see Section 2.5.7 *Best Management Practices*).

The Somenos Basin floods annually from October to May in depressions. Flooding of the Somenos Basin historically took place prior to European settlement; post European settlement however, high water levels were seen as an issue, and have been recorded as such for around 100 years (BioAyer, 1999, p.2). Early European settlers credited annual flooding to beaver activity. To prevent flooding, extensive ditching and draining works were undertaken (BioAyer, 1999, p. 2-3). Despite efforts to increase drainage and streamflow of the Somenos Basin by dredging and straightening the tributary streams, water levels have remained relatively stable, despite increased conveyance of water (Williams & Radcliffe, 2001, p. 14). In fact, when Somenos Creek was dredged in the 1980's, the improvements were no longer discernible by the early 2000's (Williams & Radcliffe, 2001, p. 32) (See Figure 1). The main cause of flooding in the Somenos is through backwatering of the Cowichan River during periods of high discharge (Rehbein, 2004, p.110). The backwatering acts as a water dam, preventing drainage causing Somenos Lake to "overflow their banks and fill surrounding lowland, mostly agriculture fields, with water" (Rehbein, 2004, p.110).

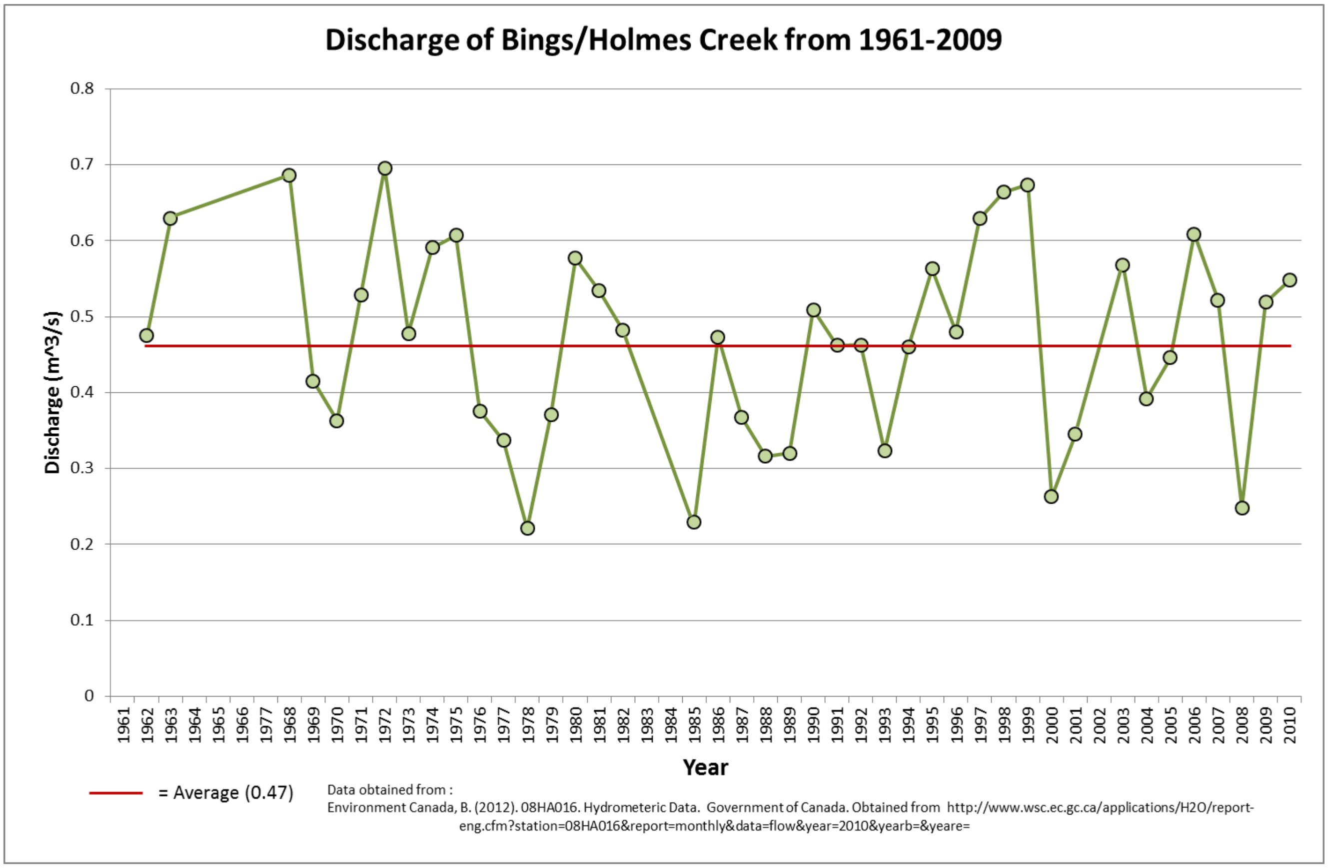


Figure 1: The fluctuation of Bings/Holmes Creek throughout time.

Rising water level

An increase in water level in the Somenos Basin has been noted (Fletcher, 2012). This can be attributed to one or a combination of the following five factors including:

1. Decreased basin area – resulting in the same quantity of water being held in a smaller place.
2. Decreased land elevation – erosion from aeolian/hydrological processes and/or the decomposition of the humic soil layer from soil aeration.
3. Increase in water input – changes in weather and precipitation, change in hydrology due to resource extraction and/or an increase in stormwater, or an increase in flooding due to climate change and logging upstream (causes floods highs to be higher and lower water levels to be lower).
4. Decreased discharge – there has been substantial work on the Somenos Creek to increase discharge; backwater flooding however (caused by high water levels in the Cowichan River), is actively known to occur during peak flows.
5. A change in the basin's ground permeability - increased sedimentation from flooding and land development upstream.

The direct cause of increased water table levels is presently unknown, and should be further investigated; knowledge urban development however, has decreased the Basin's area, and evidence that the Somenos Lake used to be much deeper and has filled in overtime with detritus and alluvium (Edwards & Greig, 1988, p. 6) suggests that urban expansion and sedimentation play a big role.

Key Hydrological Issues

Anthropogenic changes in the watershed, coupled with the effects of climate change, have created some problematic issues for water quality, quantity and aquatic biota. The Somenos ecosystem used to be one of the most prominent salmon spawning regions on all of Vancouver Island (Fletcher, 2012). Unfortunately, the water and habitat condition of Somenos Lake has degraded over time, causing a sharp decline in fish use (Fletcher, 2012).

Stormwater

Stormwater is the overland water runoff created by the use of impervious surfaces. As rain falls on developed areas that use building materials (such as pavement, concrete, metal, and glass), incoming precipitation is prevented from infiltrating into soils onsite. In conventional stormwater systems, water becomes surface runoff which is collected, transferred, and conveyed through stormwater infrastructure via drains and pipes. Then, the water is disposed of in rivers, channels, grassy areas, or any other drainage ditch areas, thereby breaking the water cycle irrevocably. This method can be very problematic in multiple ways. Under natural conditions, when it rains, water infiltrates through the soils thereby replenishing groundwater, or by supplying stream baseflow; when stormwater moves across impervious surfaces however, it increases the mobilization and transportation of pollutants such as: PCB (polychlorinated biphenyl), PAH (polycyclic aromatic hydrocarbon), CFC (chlorofluorocarbon), BPA (bisphenol A), heavy metals, road salts, sediments, fertilizers (which contribute to eutrophication) and other deleterious substances (McGuire, & Wyper et al, 2010). This water is rapidly piped away as stormwater, where it receives little (if any) treatment before it reaches the environment. As Patrick Condon says in his textbook *Seven Rules:*

> It only takes a small amount of pavement in the watershed to kill fish. In the Pacific Northwest, an analysis of a multitude of urban stream revealed that fish counts in urban streams began to fall off when only 10 percent of the urban watershed was covered in pavement and rooftops. When reaching impervious surfaces levels of 30 percent and above- the minimum coverage conceivable for even low-density suburban development- the news is even worse. At this level, in most cases fish populations have collapsed and salmon runs have been extinguished
>
> - p.136

Besides the pollutant content, a high water quantity surge is also considered pollution. When stormwater is quickly piped away from an urban area and into an aquatic environment, the water has less time to cool down, and the water enters the environment at a high velocity causing erosion, enlargement, and aggradation of streamside channels (McGuire, & Wyper et al, 2010, p.24). Erosion adds to turbidity which degrades the health of riparian areas. The turbidity of water is a measurement of suspended particles. A higher turbidity equals an increased ability for water to: heat up, choke the gills of fish, and smothers salmon eggs. The malevolent effects of poor stormwater management can be far reaching. When interacting with water, one must remember that any harm done to one part of the system can affect further downstream components of the hydrological cycle. Examples for this are the accumulation of human made toxins found in the ocean, “for example, stormwater runoff is the chief source of PCBs that directly threaten the survival of local orcas” (McGuire, & Wyper et al, 2010, p.18).

Perhaps one of the most notable challenges with the traditional stormwater system is that it “fails to respect natural systems and water cycles” (McGuire, & Wyper et al., 2010, p.6). Traditional stormwater is viewed as a site specific problem that must be dealt with, rather than a resource to work with. Rainwater management (or Integrated Water Management) seeks to improve on the standard stormwater management model by working in harmony with natural water cycles, taking into account all the dynamics of the entire watershed. Rainwater management incorporates “the entire landscape, soils, vegetation, and pervious and impervious cover. It takes into account ecosystem dynamics, complex hydrological relationships, and natural water cycles” (McGuire, & Wyper et al, 2010, p.47) and applies “green infrastructure” and low-impact development (LID) techniques. LID techniques focus on attempting to maintain natural hydrologic systems by focusing on the reduction of impervious surfaces, and increasing water infiltration on site. Green infrastructure seeks to utilize vegetation and soils to act as bio-filters that both increases infiltration and filters pollutants contained in water. The rationale for using LID techniques are that they “are not only environmentally superior, they are often cheaper. In addition, they can provide incalculable benefits in the form of enhanced urban green space as well as improved urban aesthetics and recreational opportunities.” (McGuire, & Wyper et al, 2010, p.7). The District of North Cowichan is taking important strides to achieving a more holistic approach. Outlined in the District of North Cowichan’s OCP of 2011 is the desire to for new development projects that “foster rainwater infiltration through the use of absorbent landscaping, swales, rain gardens, pervious paving, green roofs, infiltration trenches, and other appropriate methods”(A, p.89).

For further information on stormwater/rainwater management, successful stories, and policies including local/provincial legislation, and financing much needed infrastructure projects through property taxes, see the report: McGuire, Gordon, & Wyper, Neil et al. (2010). Re-inventing Rainwater Management A Strategy to Protect Health and Restore Nature in the Capital Region. Victoria, BC.

Water Quantity

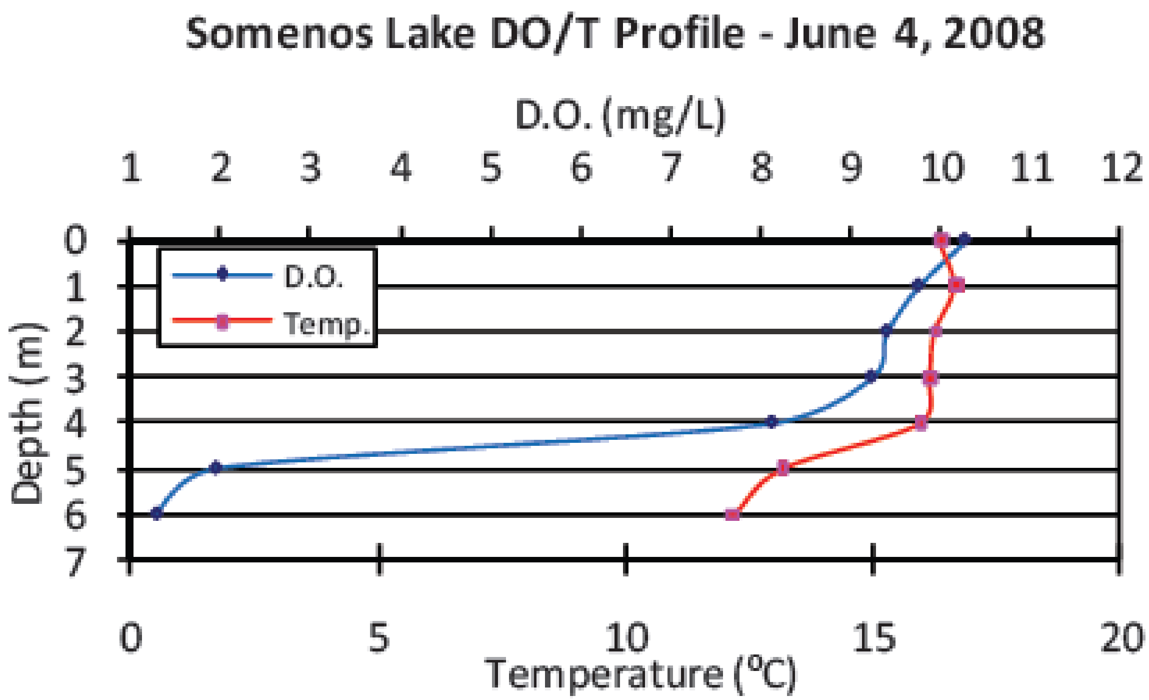
The importance of water as a resource is ever growing as the world’s readily available water supply is exceeded by the demands of the Earth’s human population In North Cowichan, increased demand for water stems from water license withdrawal, interruption of ground water by development, compaction of ground water aquifers by landfill, removal of canopy cover in the watershed, and an increase in impervious surfaces. Conserving a freshwater resource using techniques of stormwater harvesting with point source water management and retention/purification using wetlands, can potentially make water a self-sustaining resource for urban environments.

Water Quality

Deteriorating Water quality is jeopardizing the Somenos Basin’s ability to provide great habitat for wildlife. An analysis of water from the center of Somenos Lake was taken in April of 2001 (Williams & Radcliffe, 2001, p. 63-64). Results showed a total nitrogen content of 0.71mg/L and phosphorus content of 0.064 mg/L which “is indicative of a highly productive environment” (Williams & Radcliffe, 2001, p. 15). What this translates to is that Somenos Lake is eutrophic. The Somenos Lake is a summary of all feeder tributary streams including: runoff from uplands (septic and agriculture), storm drains, ditches, waterfowl excrement, and decomposition from vegetation (Williams & Radcliffe, 2001, p. 15). When water bodies become artificially enriched (typically through sewage or fertilizer runoff), a process called eutrophication occurs. An excessive amount of nutrients for plant growth are available, which causes phytoplankton blooms, which in turn starve other aquatic plants and animals of oxygen and light, eventually killing those that cannot tolerate such conditions. The Somenos Management Plan of 2001 noted the lake has been eutrophic for at least 15 years (Williams & Radcliffe, p. 15).

Associated with eutrophication is depleted dissolved oxygen levels (DO). A dissolved oxygen level of 5mg/L= is optimal, and a dissolved oxygen level of under 3mg/L creates a problematic condition where most fish cannot survive for prolonged periods (Williams & Radcliffe, 2001, p. 15). DO is influenced by the nutrient load of the water and the depth of the water - as shallow water level heats up and potential dissolved oxygen decrease. Shallow water enables wind to mix whole water columns, therefore mixing oxygenated water with anoxic water. With warm water temperature, there is an increase in algae growth, resulting in further oxygen depletion. Conversely, when there is less solar radiation available in the fall, the algae decomposes, which also decreases the dissolved oxygen in water (Williams & Radcliffe, 2001, p. 16). Cool water from tributary streams sustains cool water flow which increases DO. Somenos Lake tributaries provide essential cool water refuge for salmonids. On high temperature days, the eutrophic nature of the water goes anoxic, with algae blooms stating in May when water temperatures can exceed 20 degrees Celsius - well above the preferred water temperature for salmonids species (Williams & Radcliffe, 2001, p. 23).

In the summertime, surface water temperatures can exceed 30 degrees Celsius (Williams & Radcliffe, 2001, p. 15). The temperature of a lake is an important ecological indicator. “By measuring surface temperature, we can record and compare readings from season to season and year to year. Surface temperature helps to determine much of the seasonal oxygen, phosphorus, and algal conditions” (Carter, 2011, p.2). High temperatures associated with shallow waters can pose another problem. Many aquatic species are sensitive to temperature thresholds. When the temperature is too high, certain species cannot survive, and other species with a high degree of mobility, such as a Coho salmon, will attempt to find more suitable areas to live (see Figure 2).



Retrieved from :

Carter, Kristi. (2011). The Importance of Somenos Lake & its Watershed. BC Lake Stewardship and Monitoring Program. BC Lake Stewardship Society, & Ministry of Environment.

Figure 2

Dissolved oxygen (DO) and temperature (T) readings were collected on Somenos Lake from 2007 - 2010. The graph on the right shows DO (blue line, refer to top axis for values) was 10.3 mg/L at the surface and 1.3 mg/L at 6 m on June 4, 2008. T (pink line, refer to bottom axis for values) was 16.4 ºC at the surface and 12.2 ºC at 6 m. Data from 2007 - 2010 indicate the lake has very low DO levels in the bottom waters throughout the summer. If deep-water oxygen becomes depleted, a chemical shift can occur in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This internal loading of phosphorus can be natural, but is often the result of phosphorus pollution. Lakes displaying internal loading have elevated algal levels and generally lack recreational appeal. Somenos Lake is suffering from internal loading.

- Carter, 2011, p.3.

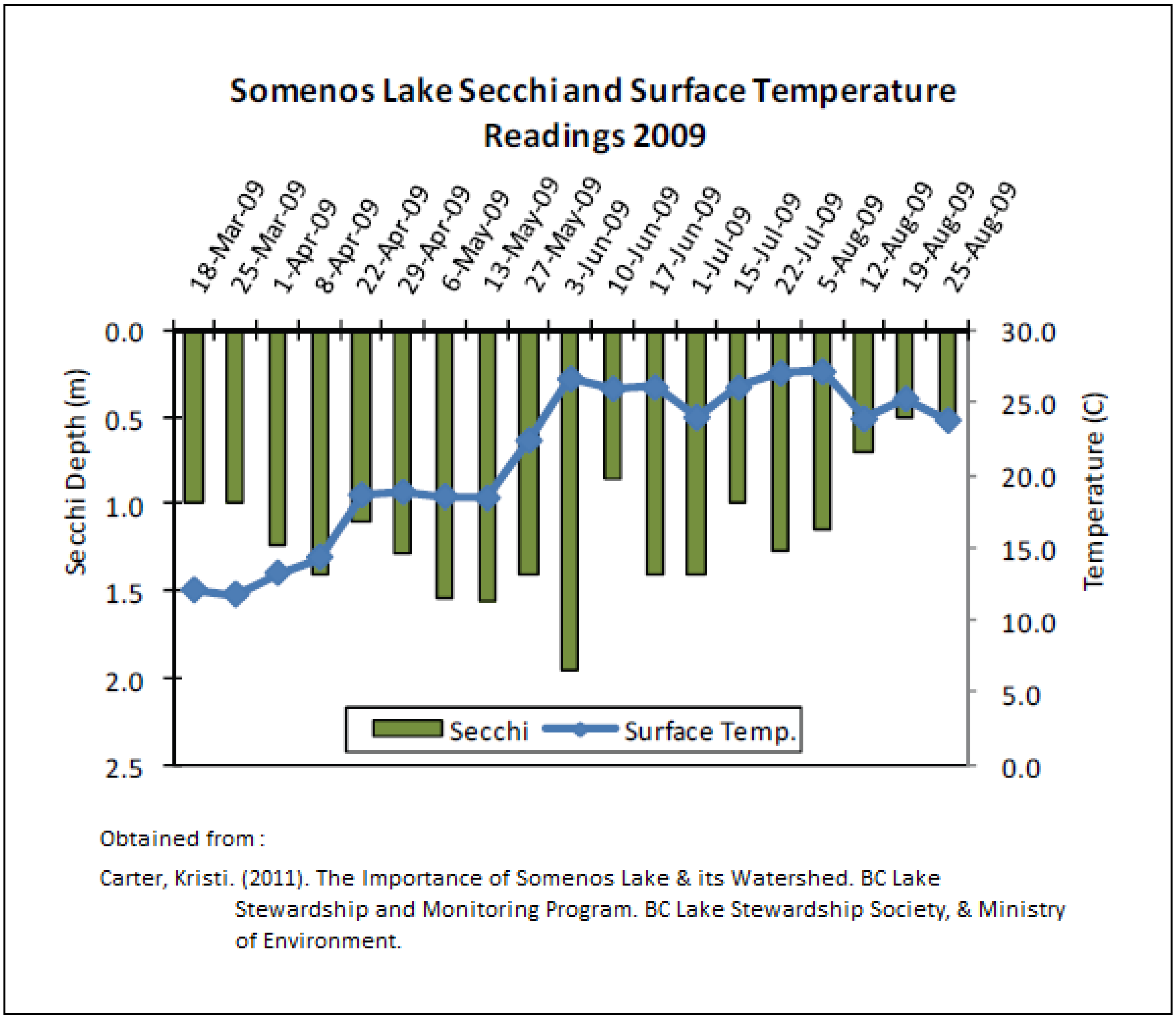


Figure 3

Another measure of productivity (level of eutrophication) is water clarity (see Figure 3). The more productive a lake, the higher the algal growth and therefore the less clear the water becomes. The clarity of the water can be evaluated by using a Secchi disc, an 8 inch diameter black and white disc that measures the depth of light penetration" (Carter, 2011, p.2). In general, Secchi depth decreases as water temeratures increase (Carter, 2011, p.2).

Pollution to water bodies can be summarized by two sources: point source and non-point source. Point source pollution originates from the "pipe" when municipal or industrial effluent is piped into an ecosystem. Non-point source pollution occurs over broader areas and may be hard to isolate. Common contributors to non-point source pollution include: "shoreline modification, urban stormwater runoff, onsite septic systems, agriculture, and forestry" (Carter, 2011, p.3). Every component of a watershed has an important function in maintaining good water quality and a healthy aquatic environment. The proximity of Highway 1 to the Somenos Basin is a source of several problematic issues related to water quality including heavy metals, hydrocarbons, and road salt (for recommended course of action, see Section 2.5.10 *Further Recommendations*). Forestry exacerbates the effects of pollutants by weakening the watershed (see Section 1.9 *Vegetation* for more details).

1.7 Pedology

The unconsolidated soils found in the Somenos Basin have their origins from the latest glacial advance and mass wasting in the last period of glaciation that covered Vancouver Island. Generally, this ice mass "moved in a south to southeast direction, and its climax stood at least 1,500 meters thick" (Delcan & Current Environmental, 2012, p.32). The result of this glaciation process was a large, wide spread deposition of coarse grained sediments, and to a lesser extent, fine grained sediments (clay and silt) (Delcan & Current Environmental, 2012, p.32). The low clay content allows for high amounts of infiltration and groundwater recharge of wetlands, causing an increase in potential for hydrological bioremediation (Biebighauser, 2012.)

The production of hay bales farmed at the Project Site has decreased significantly over time. The farmer attributes the lower productivity to declining soil fertility (Williams & Radcliffe, 2001, p.18). Soil test conducted in 1991 "indicated the soils on The Nature Trust of BC properties at Somenos Lake have low levels of nitrogen, phosphorus, and potassium (Williams & Radcliffe, 2001, p. 18). Declining soil fertility is odd when considering that the water in the Somenos Basin is high in the same nutrients. See Section 3.0 *Appendix* for information on how nutrients in the water can be used to fertilize crops.

1.8 Wildlife

It should be noted that this report does not include a fully inclusive list of the biota present in the Somenos Basin. Other extensive biological research has already been conducted, and to repeat this information here would be redundant; rather, this report presents a succinct list of biota with specific significance to the project proposal. For more information on the wildlife present in the Somenos Basin refer to:

Willimans, Harry, & Radcliffe, Gillian et al. (2003). Somenos Marsh Ecosystem Mapping and Ecosystem Mapping and Ecosystem Management Plan With special emphasis on the Garry Oak Protected Area. Duncan, BC.

Pakstas, Monika. (2008). Migratory Waterfowl in the Cowichan Valley.

Williams, Pamela & Radcliffe, Gillian. (2001). Somenos Management Plan. Prepared by Madrone Consultants LTD. Duncan, BC.

Birds

The Somenos Basin is a part of the Pacific flyway used by migratory birds (Pacific Flyway Council, 2012). Attractive to a variety of bird species throughout the year, the Somenos Basin experiences mostly songbirds in the summer and waterfowl (such as ducks, geese and swans) in the winter. The basin is important to wintering and migratory waterfowl. During winter periods, waterfowl can be recorded in numbers of over one thousand (IBA, 2012). Common waterfowl species include: "geese, Mallard, Widgeon, Shoveller, Grebe, Pintail, Ring-Necked Duck, and Bufflehead. Numerous other birds use the area and include Red-tailed Hawk, Great Blue Heron, Peregrine Falcon, and Bald Eagle. In fact, "just over 1% (25 pairs) of the Canadian population of the nationally venerable *fannini* subspecies of the Great

Blue Herron breed and winter in the immediate vicinity" (Williams & Radcliffe, 2001, p. 26). Shallow water and ample area for feeding grounds are both important for waterfowl. In the Somenos Basin, birds like Trumpeter Swans and Great Blue Heron use flooded agriculture fields as shallow water feeding grounds habitat (Williams & Radcliffe, 2001, p. 15). Normally, birds of this type would be utilizing wetlands to meet their needs. "In North America, 80 percent of breeding bird populations and 50 percent of protected migratory birds depend on wetlands" (Mitsch, & Gosselink, 2000, p. 575). Inundated agriculture fields are being lost due to shrub encroachment, which consequently causes a reduction on feeding habitat quality and quantity (Williams & Radcliffe, 2001, p.26).

In a "unpublished survey of farmers by the Ministry of Agriculture, Food, and Fisheries, Canada Geese are cited as the number one pest species causing considerable damage to agriculture crops" (Williams & Radcliffe, 2001, p. 27). It is reported that some farmers may be worried that an improvement in geese habitat will result in larger populations (Fletcher, 2012). When asked about this problem, biologist Tom Biebighauser said that restoring wetland habitat in the Somenos Basin would provide more habitat and food, attracting birds from farmer's fields.

Fish

Salmonids spawn in lake and marsh, and their fry are reared therein (Williams & Radcliffe, 2001, p. i). Fish from Somenos Lake enter the marsh system and inundated meadows during winter floods. Some fish, particularly the large ones, return to Somenos Lake leaving as waters the recede (Williams & Radcliffe, 2001, p. i). Somenos Lake contains fish species such as Brook Trout, Brown Catfish, Brown Trout, Chum Salmon, Coho Salmon, Cutthroat Trout, Pumpkinseed, Rainbow Trout, Sculpin, Steelhead, Stickleback (general) and Threespine Stickleback. Lower Bings Creek is noted for its large population of Coho juveniles. "Densities of 10 fry/m^2 have been observed, and late summer fish as large as 30 cm have been recorded" (Burns, 1999, p.52). In particular, Coho fry rear in the Somenos Lake in the spring months and move to the tributary creeks in mid-summer when the lake warms (Burns, 1999, p.52). Cold water refuge is imperative for their survival (Williams & Radcliffe, 2001, p.23). In the summer and early fall, Somenos Lake often becomes anoxic. "A major fish kill occurred in early Sept. of 1989. Several hundred young Coho and trout moved into Bings Creek to avoid high temperatures (24 degrees plus) and low oxygen (<1 ppm)" (Burns, 1999, p.52).

> It can be stated that the tributaries are the backbone of salmon fry production in the watershed, and these streams offer an important refuge for rearing fish during the warm water spring/summer periods.
> - Williams & Radcliffe, 2001, p. 24

The results of study conducted by biologist Tom Burns on the feasibility of increasing salmonid production in the Cowichan watershed listed the limiting factors for fish production as: "access and summer water quantity and quality. Barrier waterfalls are present on Lower Quamichan, Richards, Bings and Averill Creeks and all streams become either dry or dangerously low in the July-September critical discharge period. Water quality in the lakes, especially Somenos, becomes very poor" (1999, p.37). However, it was noted by DR Clough Consulting that "Streamkeepers should consider Bings Creek as an example of a residential stream that can still offer observable salmon runs. Streamkeepers should concentrate on protecting this vital asset through habitat projects in areas where they rear and spawn as well as improve the water quality in upland areas" (2010, p.15). The results of Tom Burns study on the feasibility of increasing salmonid production in the Cowichan watershed noted "despite use intensity and some very compromised fish habitat in parts of the basin, a great deal of capability and potential remain – some of the highest in the region" (1999, 37).

Beavers

Beavers have been known for altering wetlands from one type to another (Biebighauser, 2022, p. 79). Beavers regularly dam streams causing localized flooding, which has a significant effect on water levels. Historically, removing beaver dams (or the beavers themselves) has proven to be an ineffective management tool. After costly removals and relocations, dams are rebuilt at a fast pace, which presents an ongoing maintenance issue (Williams & Radcliffe, 2011, p. 27). Beaver dams are usually washed out when the Cowichan River floods and backflows up the Somenos Creek. The dams are rebuilt in the following summer in the same location for several years (BioAyer, 1999, p. 9). See Section 2.5.5 *Considerations for Potential Project Issues* for more information.

Vegetation

The Somenos Basin displays a multitude of habitats which supports a wide variety of plant species. Vegetation that is either submerged, emerging, or in riparian area, is vital to the health of the entire ecosystem. Human development in and around the Somenos Basin has had substantial impacts on the ecology of the area (Williams & Radcliffe, 2001, p.18). There once existed a large stand of Sitka spruce trees, but they no longer remain due to past logging (Williams & Radcliffe, 2001, p.20). Infrastructure developments have filled in old wetlands, minimizing biodiversity and allowing disturbed areas to be infested with invasive plants such as Scotch Broom (Williams & Radcliffe, 2001, p.20). Land development in the southeast portion of the Somenos Basin has severely damaged a collection of rare Garry Oak trees, resulting in the creation of a Garry Oak Protected Area to ensure the survival of this majestic species (Williams & Radcliffe, 2001, p.18). When compared to the rest of the Somenos Basin, the Project Site has a low biodiversity, due to agriculture activity that has stripped the land, drained wetlands and introduced a nonnative grain monocrop. The crop farmed at the Project Site is reed canary grass (*Phalaris arundinacea*).

Other areas of the Somenos Basin, including the fringes of the Project Site where there is dense vegetation, exhibits a wider variety of vegetation including:

- Reed managrass (*Glyceria grandis*)
- Tall Mannagrass (*Glyceria elata)*
- Spiral rush (*Juncus sp.*)
- Spike rush (*Eleocharis*)
- Smart weed (*Polugonum coccineum*)
- Skunk cabbage (*Lysichitum americanus*)
- Hardhack (*Spirea douglasii*)
- Scouler's willow (*Salix scouleriana*)
- Red osier dogwood (*Cornus stolonifera*)

- Red alder (*Alnus rubra*)
- Nootka rose (*Rosa nutkana)*
- Ninebark (*Physocarpus*)
- Back hawthorn (*Crataegus douglasii*)
- Common hawthorn (*Crataegus monogyna*)
- Red and blue elderberry (*Sambucus racemosa*)

Around the Project Site, there is a limited presence of a mature overstory canopy. What does exist is at the fringe of the agriculture fields and in very close proximity to creeks/channels:

- Pacific willow (*Salix lucida*)
- Scouler's willow (*Salix scouleriana*)
- Garry Oak (*Quercus garryana*)
- Black cottonwood (*Populus balsamifera ssp.*)

Some introduced escapees include:

- Crabapple (*Malus spp.*)
- Plum (*Prunus Americana*)
- Hazelnut (*Corylus avellana)*

Common aquatic species are:

- Yellow water lily (*Nuphar lutea*)
- Bladderwort (*Utricularia*)
- Muskgrass (*Chara*)

Of special importance for wetland vitality is riparian vegetation. "Riparian vegetation is fundamental to the maintenance of healthy aquatic ecosystems. Vegetated riparian areas play critical roles in: providing woody debris that contributes to channel complexity and maintains microclimate conditions; buffering the effects on water quality of flow changes, such as increases in stream power and erosion, and changes in water temperature; buffering streams from sedimentation and pollution in surface runoff; contributing food and nutrients in the form of insects and organic litter fall; stabilizing soils through root matrices; and providing shade and cover to control temperature and manage predation" (MWLP, 2004, p.9).

Forest harvesting in a watershed decreases: canopy cover, water retention potential, and channel complexity (Ministry of Water, Land and Air Protection, 2004). Diminished forest stands, allows for an increase in aeolian erosion and a stronger potential to carry sediment loads downstream, contributing to turbidity problems.

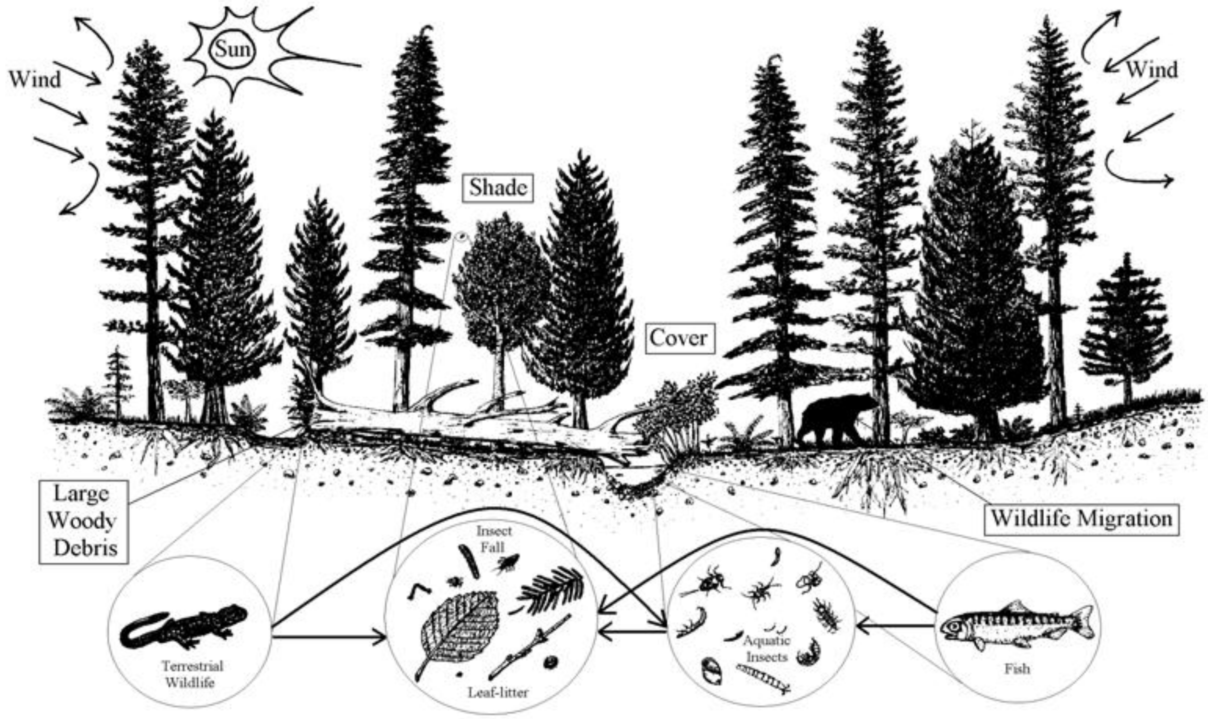


Image 1 Ministry of Water, Land and Air Protection. (2004). p. 10

Increasing pressures from urban, infrastructure, and industry expansion and in and around the Cowichan watershed has resulted in numerous impacts on the Somenos ecosystem resulting in an area that overall currently "support[s] a low level of ecological biodiversity" and where "existing riparian structure is typically fragmented and limited to the channel banks of Somenos Creek or supply watercourses" (Delcan & Current Environmental, 2012, p.34). The loss of biodiversity can be largely attributed to the reduction of habitat area and the simplification of structural diversity over time. Development of the Somenos floodplain, including building urban and resident settlements, has dramatically reduced the area of the habitat. Past forestry practices and the draining of wetlands to create agriculture fields have simplified the biological diversity. An example of the loss of biodiversity is the loss of the Sitka spruce stand and the now threatened Garry Oak area.

Disturbance from increasing human development adjacent to the marsh can displace species and/or reduce breeding success. The impact of uncontrolled dogs or cats as pets is also a significant factor effecting breeding waterfowl and songbirds (Williams & Radcliffe, 2001, p. 26)

There are a number of at-risk species found in the Somenos Basin. At concern species are listed as *red* or *blue* based on the provincial Conservation Status Rank assigned by the Ministry of Environment's Conservation Data Centre (CDC). The Red-list includes ecological communities, and species that are extirpated, endangered, or threatened; the Blue-list includes communities and species considered to be of special concern" (Delcan & Current Environmental, 2012, p.37).

In the Somenos, there are 4 red-listed and 2 blue-listed plant species and three blue-listed animals:

- Red-listed plants: Tall wooly-heads (*Psilocarphus elatior*), Howell's Triteleia (*Triteleia howellii)*, Deltoid balsamroot (*Balsamorhiza deltoidea*), Yellow montane violet (*Viola praemorsa spp. praemorsa*); Blue: Vancouver Island Beggarticks (*Bidens amplissima*), Howell's violet (*Viola howellii*).

- Blue-listed animals: Green Heron (*Butorides virescens*), Propertius Duskywing (*Erynnis propertius*), and the Red-legged frog (*Rana aurora*)

Delcan & Current Environmental, 2012, p.39.

"Native species are essential to the healthy functioning of the ecological webs that support all life" (Rehbein, 2004, p.2). However, further threats to biodiversity arise from the introduction of invasive species. Invasive species are opportunistic and can readily colonize an area that has been disturbed.

- Invasive animal species: grey squirrel (*Sciurus carolinensis*), eastern cottontail (*Sylvilagus floridanus*), American Bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*)

- Invasive plant species: purple loosestrife (*Lythrum salicaria*), yellow flag iris (*Iris pseudacorus*), English ivy (*Hedera helix*), holly (*Ilex*), Himalayan blackberry (*Rubus armeniacus*), gorse (*Ulex europaenus*), daphne (*Thymelaeaceae*), Scotch broom (*Cytisus scoparius*), Japanese knotweed (*Fallopia japonica*)

Williams & Radcliffe, 2001

For a more detailed list of plant species in the Somenos Basin, consult:
Williams, Harry, & Radcliffe et al. (2003). Somenos Marsh Ecosystem Mapping and Ecosystem Management Plan With Special Emphasis on the Garry Oak Protected Area. Madrone Consulting. Duncan, BC.
Williams, Pamela & Radcliffe, Gillian. (2001). Somenos Management Plan. Prepared by Madrone Consultants LTD. Duncan, BC.

1.9 Wetland Ecosystem Services

Canada contains roughly one fourth of the world's wetlands (Government of Canada, A, 1991). "Over a seventh of Canada's wetland resources has been lost to human development since the 1800; agriculture drainage accounts for 85% of the known losses" (Government of Canada, A, 1991). "Wetlands are defined by three, main components: a) presence of water at surface or within root zone; b) unique soils produced by anaerobic conditions; and c) vegetation adapted to the wet conditions" (Mitsch, & Gosselink, 2000, p. 28). The following list is a compilation of the ecosystem services provided by wetlands in the Somenos Basin. Wetland environments offer a multitude of environmental and social benefits for free. The dollar price of a wetland can be assessed by determining how much it would cost to remove the wetland, and adding that to the cost of the associated human made technique that provides the same service.

Flood Control: Wetlands function as flood/drought moderators. As falling precipitation intercepts a wetland area, biophysical components (such as the trees, soil humus, and mosses) allow for mass amounts of water to infiltrate and be stored; subsequently, this allows water to percolate and be released slowly through the soil. This in turn reduces the speed and volume of runoff entering water bodies, causing downstream areas to experience declined fluctuations in water table level (Ramsar, A, 2012). Wetlands contribute to peak flow reduction and can be crucial for municipalities like North Cowichan that experience reoccurring flooding.

Aquifer Recharge: Wetland ecosystems such as the Somenos act like great environmental sponges; that is, wetlands soak up and retain water. Water infiltrates through the permeable top layer of the soil, and then percolates through the soils vadose zone (unsaturated) and into the zone of saturation below. This process plays a vital role in recharging groundwater and aquifers. Increasing the groundwater potential in the Somenos Basin would help ameliorate severe summer water conditions such as low flow and high temperatures.

Sediment and Nutrient Retention/Removal: Wetlands play a fundamental role in nutrient capture and turbidity control. When water enters a wetland system, a narrow, fast-flowing river channel will spread out gently, and the speed of discharge suddenly slows down when the water is allowed to flow over a wide valley floor, where dense stands of wetland vegetation (such as reed beds or floodplain forests) act as physical barriers to slow flows and trap sediment. Sinuosity of wetland channels can greatly enhance this benefit. The incorporation of settling ponds is another mechanism that will slow down the flow of water and retain sediments.

Water Purification: Wetlands have an amazing and auspicious ability to “lock up” pollutants through their sediments, soils, and vegetation. Wetlands can significantly help remove high levels of nutrients like agricultural runoff, and effluent waste. Wetlands also possess the ability to remove toxic substances from water bodies such as heavy metals, toxic organic compounds, industrial discharge, removal of pathogens, and mining tailings (Ramsar, A, 2012).

Biodiversity: Wetlands are among the world’s most productive ecosystems, being extremely rich in biodiversity, and are comparable to that of rainforests and coral reefs, although wetlands cover a relatively small area of the Earth’s surface compared to some other ecosystems. “An immense variety of species of microbes, plants, insects, amphibians, reptiles, birds, fish, and mammals can be part of a wetland ecosystem” (EPA, A, 2012) and many wetlands provide a habitat for species of plants and animals that are endemic (completely wetland dependent). The Somenos Marsh network supports important and rare vegetation species and animals. The biodiversity of the Somenos is threatened under the pressure of anthropogenically altered landscape. This is a worldwide phenomenon as The Millennium Ecosystem Assessment found that “damage to and loss of wetlands is more rapid than that of other ecosystems. As a result, species dependent on both freshwater and coastal wetland are declining faster than those reliant on other ecosystem types” (Ramsar, A, 2012). Generally speaking, the raison d'être for the decline in biodiversity in wetlands is attributed to: drainage and infilling for agriculture or construction, climate change, pollution, and the spread of invasive species (Ramsar, A, 2012). The Somenos Basin does exhibit strong biodiversity; however, all the anthropogenic forces listed above are present in the Somenos Basin.

Climate Change Mitigation: As the effects of global climate change begun to become apparent on a global scale, fragile ecosystems such as wetlands will be among the first to be drastically effected (Ramsar, A, 2012). Wetlands can be fragile because they depend on a complicated, yet delicate set of natural balancing dynamic equilibriums in order to function properly. Paradoxically, "well-managed wetlands can also provide one of our best insurance policies against some of the most damaging effects of global warming" (Ramsar, A, 2012). That is, when attempts are made to not only avoid or minimize other "non-climate" effects to wetlands, but to also restore, conserve, and create new wetland environments, the wetland ecosystem can combat the effects of climate change by assisting in mitigation and adaption to changing climate conditions (Ramsar, A, 2012). Wetlands function as carbon sinks, where vegetation and soils sequester carbon dioxide, and help mitigate carbon dioxide in the air. Wetlands offer precipitation adaption capabilities through their ability to hold, slow down and store water, thus acting as a flood/drought ameliorator. Coastal wetlands intercept and absorb deep ocean storms and surges, and thus help protect inland environments from the destruction of storms. Additionally, wetlands provide vital corridor nodes between environments that will assist animals and plants in transitioning to new environments in response to changing climatic conditions.

Recreation and Wildlife Viewing Opportunities: The natural splendor of wetlands is emanated through their beauty and lush biodiversity, making them great areas of recreation and ecotourism. Attracting people to wetlands is fundamental in fostering public knowledge that is essential in propagating wetland appreciation and conservation. The amount of public interest in a wetland depends on several factors including size, location, biodiversity, and quality. Somenos Lake used to be a popular swimming spot prior to 1970. However, as the lake become increasingly eutrophic, algae blooms in the water begun to deter swimmers (Williams & Radcliffe, 2001, p. 15). Recreation in a wetland is a double edged sword. Recreation in a wetland by enthusiasts can nurture an appreciation of wildlife and nature; however, even a kayaker can unintentionally cause disruption by forcing birds from their nests, which can cause excessive heating or cooling of eggs, leading to mortality. Recreation in and around wetlands should follow techniques used in proper wildlife viewing, where people are expected to respect certain boundaries, whether that be by distance, or through certain times of the year to ensure the vitality of certain biota (to see how the public could be informed, see Section 2.5.10 *Additional Recommendations*).

1.10 Connection to the Cowichan Valley Regional District Flood Management Plan

From 2008 and ending in the summer of 2009, Northwest Hydraulic Consultants worked on a project with the Cowichan Valley Regional District, Cowichan Tribes, the Municipality of North Cowichan, and the City of Duncan, to "update the existing floodplain management mapping and to develop an Integrated Flood Management Plan for the Lower Cowichan-Kosilah River Floodplain including major tributaries" (NHC, 2009, p.1). In 2008, a hydrodynamic flood model named MIKE-FLOOD was instigated and calibrated in the Cowichan floodplain. On November 20th, following more than a week of rain mixed with high temperatures and snow melt, severe flooding was experienced in the Cowichan Valley. The flooding affected critical urban infrastructure including forcing residents in over fifty homes in North Cowichan and Duncan to evacuate, as well as the Joint Utility Board sewage treatment plant, where "fully treated effluent from the lagoons flowed into the river" (NHC, 2009, p.1). Flood waters mixed with a "leaky stormwater pipe" at the City of Duncan Public Works Yard which drained deleterious materiel into the Cowichan River (NHC, 2009, p. 7). Two arterial roads, four schools, sanitary sewers, RCMP office, emergency health services, and homeless shelters were evacuated as well. The flood affected around 450 residents (Delcan & Current Environmental, 2012, p.8).

According to the report by Northwest Hydraulic Consultants "the simulation of the November 2009 flood confirms that the model is capable of predicting flood extents, water levels, and provides insights into the progression of floods in the Lower Cowichan Valley. The model performed exceptionally well, with modeled and observed lateral extents, and high water levels matching extremely closely. The model should be seen as a valid and useful tool for flood management planning for the region." (2009, p. 10). However it is noted that "a flood frequency analysis indicated the 2009 flood event was not particularly severe, having a return period of approximately 7 years" (NHC, 2009, p.5).

The results of the 2009 flood led to the need to developing a flood upgrade plan. The rationale for a flood upgrade plan comes from the need to "protect critical community infrastructure and prevent harm to sensitive habitat as well as surrounding residential and commercial properties that are vulnerable to flooding" (Delcan & Current Environmental, 2012, p. 2). The upgraded dike system will be designed to a 200 year flood standard, and additionally, since the Fukushima tsunami/earthquake disaster of 2011, the dike must comply with new provincial seismic design criteria.

"Climate change will be managed in the short-term through the use of freeboard designed into the dike. Long-term changes include right-of-way included in land acquisition to allow potential increase in dike crest elevation if needed" (Delcan & Current Environmental, 2012, p.54).

The dike work around the Somenos ecosystem include two new developments

1. Beverly Street dike: 1,847m in length; affecting 3.41hectares of land
2. York Road dike: 21m in length ; affecting 0.04 hectares of land
   (Delcan & Current Environmental, 2012, p.3)
   See section 3.0 *Appendix* for further details.

The accompanying pump station will be located at the northern extend of York Road. The footprint of the York Road dike will be approximately 420m^2 including the raising of road approaches on York Road. There is an expected 71m^2 encroachment into the water courses located behind into the east boundary on the Fun Pacific Golf Center (Delcan & Current Environmental, 2012, p. 19). In 2009, Northwest Hydraulic Consultants determined the dike to be "constructed to a finished elevation ranging from 9.60m-9.75m, which is equivalent to the new 200 year flood level plus 0.6m freeboard. Freeboard is additional elevation built into the dike as a safety factor" (Reitsma, 2012). The dikes will be constructed to a height varying from 1.0 m to 3.8 m above existing ground using a combination of low permeability fill and general fill" (Delcan & Current Environmental, 2012, p.19).

The pump station functions "only during flood events when water cannot drain through the dike" (Delcan & Current Environmental, 2012, p. 19). When flood waters reach a critical threshold, the pump station will be turned on to defer the flood water onto the Somenos side of the dike, conveying water away from the urban core. The deferred water is to be discharged in a way that prevents erosion. Currently, some of the urban stormwater runoff from North Cowichan drains via gravity fed drain pipes and discharges into the fields above Beverly Street creating polluted pools of water (Fletcher, 2012). Installing dikes and pump stations would create a barrier to displace this stormwater. To counteract this, a culvert will be installed to allow the stormwater to pass through the dike (Reitsma, 2012). In order to sustain the impervious integrity of the dike during flooding conditions, when flood waters reaches a particular threshold, a flap on the Somenos side of the dike will close the culvert. Pump stations will then become active to defer flood water and winter stormwater.

The diking development will naturally have to encroach into sensitive wetland/riparian habitat. The development of this sensitive and ecologically important area is "not expected to have significant negative cumulative effects" (Delcan & Current Environmental, 2012, p. 3) because:

1. Most impacts are considered temporary.
2. Impacts are expected to naturalize with restoration measures in place.
3. Approximately 0.39 hectares of permanent habitat alteration can be suitably offset with compensation.

Delcan & Current Environmental, 2012, p.3.

The developers seek to mitigate ecological loss using the ideology of "zero net loss" of riparian or aquatic habitat. This is achieved by enhancing the watercourse by way of planting riparian vegetation, and exploring the potential for flow augmentation. Without using counter mitigative measures, "encroachment into sensitive habitat is expected to have an adverse effect on water and wildlife resources" (Delcan & Current Environmental, 2012, p.3). The report from Delcan & Current Environmental Consultants notes that the Somenos Creek is dominated by bushes and shrubbery, and lacks substantial overstory vegetation that would assist in streamside complexity and shade (2012, p. 24). As part of a compensation plan, there "exists an opportunity to restore a more natural stand structure" (Delcan & Current Environmental, 2012, p.24). Further compensation may come in the form of enhancing riparian habitat by removing invasive plant species and planting suitable natives, including trees. A pivotal method of compensation comes from the contestable method of "improving riparian function" and "enhancing fish habitat" by removing clumps of reed canary grass for increased water conveyance, and increasing stream bank stability (Delcan & Current Environmental, 2012, p.25). This method is contestable, because an engineered stream meant for increased water conveyance is straightened, has removed vegetation, and the stream channels are reinforced by riprap. Traditionally, an engineered stream has decreased channel diversity and complexity, which decreases the suitability of fish habitats. The removal of invasive vegetation and the planting of trees would, on one hand, benefit a riparian streamside habitat. On the other hand however, the removal of invasives such as reed canary grass from within a stream channel would benefit water conveyance and could potentially hinder fish habitat.

The effects the proposed diking will have for the Somenos Basin have only been estimated through computer modeling. Even through the results of the MIKEFLOOD modeling proved to be accurate, the exact effects will not be fully known until there is a flood event post development. Thus far, despite mitigation techniques, the diking development poses to accelerate the flood/drought polarity experienced within the south Somenos Basin. For example, hydrodynamic changes that are brought on by the pumps and the effects of the dike wall acting as a water retaining barrier. It is logical that this will increase the water capacity potential in the Somenos Basin during flood activity. The increase in the amount of water that the Somenos Basin would have to accommodate with its size is feasible. However, due to the hydrodynamic mechanisms of water- primarily gravity, capillary forces, and soil suction (Davie, 2002, p. 60-61), the additional runoff water is expected to coalesce and reside in close proximity to the outlet. It is then logical to assume that during flood events, the dike and pump stations would exacerbate flooding in south Somenos Basin, and would prolong the inundation of agriculture fields. Conversely, the new diking system seeks to improve “river conveyance and movement of the confluence downstream [which] will result in lower water levels in the Somenos basin earlier in the spring and later in the fall.” (Delcan & Current Environmental, 2012, p.12).

It is important to note that “if there are insufficient funds to construct the pump station it may be deferred” (Delcan & Current Environmental, 2012, p.19). It was voiced at a Cowichan Stewardship Watershed Roundtable meeting (June 21, 2012) that the new provincial seismic standards might produce additional unexpected additional costs, whereas some development around the Somenos Basin may be postponed. The goal is to have all projects complete by March 2014 (Delcan & Current Environmental, 2012, p.30).

2.0 The Proposed Project

2.1 Project overview

It is the aim of this project to restore wetlands in the Somenos ecosystem, working within the stipulations of the scope. It is the anticipation that the project will propagate systemic cascading benefits for wildlife and humans alike. If the project is deemed successful, then there exists the opportunity to use this project as an exportable model of habitat restoration to be used throughout the Somenos Basin and other like ecosystems. The restoration of wetlands will help treat water through environmental remediation techniques (see Section 2.5.3 *Environmental Remediation*) which will not only help ameliorate water conditions in the Somenos Basin, but will generate benefits further downstream. This project seeks to treat factors of water quality by increasing dissolved oxygen, decreasing water nutrients and pollutants, and decreasing water temperature. The supplementary benefits of wetland restoration can help establish a strong community of anaerobic microorganisms (good for nutrient cycling and food chain), increase aquatic habitat for fish including salmonids, create more wetland, riparian, and terrestrial habitat, reduce flooding, recharge aquifers, mitigate climate change, and increase tourism by providing a greater opportunity for nature enthusiasts to experience wildlife.

In the Cowichan Valley, some urban developments have been built on wetlands, minimizing ecological habitat area. Effluent waste from stormwater is piped and channeled into local water bodies that degrade water quality. This decreases the potential of the ecosystem to produce vital ecological services. The Somenos Basin poses as an annual flood threat. Problems include agriculture and urban runoff, fish kills, degraded fish habitat, degraded water (high temp, low DO, eutrophication), and lowered recreational activities (swim, boat, and sport fish). A major goal of this project is to develop flood control measures that assist in strengthening the environment.

The goal of this research and project is: *To enhance the function and utility of the Somenos Basin using restorative wetland techniques.* The scope of the project defines wetland restoration to be situated along the Bings/Holmes Creek. It is the aims of this project to serve as a successful model of environmental remediation that improves water quality and aquatic habitat that is expandable throughout the Somenos Basin. This project seeks to:

- Restore damaged areas and systems
- Improve productivity of fish and wildlife through environmental remediation
- Increase biodiversity
- Improve the overall condition of the water
- Increase public education and interpretive opportunities
- Increase opportunity for scientific and inventory research
- Benefit the local economy

2.2 Agriculture Versus Wetland

Located in the property of The Nature Trust of BC, the Project Site currently incorporates two main land uses; agriculture, and waterfowl habitat. Since 1976 when the Nature Trust of BC bought their first parcel of land, “the focus of agriculture has been to support wildlife and in particular wintering waterfowl” (Williams & Radcliffe, 2001, p. 32). Well maintained agricultural fields that flood in the wintertime provide habitat and grass seed which is a rich food resources for wintering waterfowl. Wetlands on the other hand, naturally offer an abundance of food that attracts a wide diversity of wildlife. Although they are manmade appropriations, the agriculture fields that are flooded for several months of the year are actually classified as ephemeral wetlands (Biebighauser, 2011, p.8). Natural wetland environments offer a “combination of shallow water, high levels of nutrients, and primary productivity is ideal for the development of organisms that form the base of the food web and feed many species of fish, amphibians, shellfish, and insects. Many species of birds and mammals rely on wetlands for food, water, and shelter, especially during migration and breeding” (EPA, A, 2012). Although agriculture fields provide winter habitat and food for waterfowl, the ephemeral wetland environment that it produces is relatively simply and only available during the winter. Wetland and agriculture land uses found in the Somenos Basin have intrinsically conflicting structural differences. To propagate one land use is to sacrifice, as an opportunity cost, the efficiency of the other. For example, if it was decided that agriculture were to be the priority, then the clearing of dense vegetation and extensive draining and ditching work would be required to increase the productivity of the land, allowing regular farming with large machinery. In 1981, a typical engineer’s perspective on how to handle a high water table is expressed by the report by Willis, Cunliffe, and Tait, which states “the uncertainty of the land being suitable for agriculture purposes in spring and fall has a limiting effect upon is usage. The problem then becomes one of ensuring that storms currently causing prolonged flooding can be handled by the drainage systems to the extent of bringing inundation of agriculture lands to acceptable levels” (p.3). Conversely, waterfowl are adapted to annual water fluctuations which are considered to be ideal habitat (Nelms, 2007, p. 18). Creek alterations reduce the ability for the watercourse to act as a year round rearing habitat for fish. Clearing, widening, and straightening of Bings/Holmes and Somenos creek would be beneficial for drainage and agriculture, but would be negative for fish populations. Traditional methods that improve the drainage of agriculture seek to lower the water table level by removing vegetation cover and changing the natural hydrological flows by creating ditches, which result in a reduction and simplification of aquatic habitat, and thus limiting the capacity for wetland ecosystem services. If waterfowl habitat were to be the priority, then more complex environment including inundated wetlands, meandering channels, and tree stands free from biannual farm mechanization would be ideal.

In a 2007 report by the Nature Trust of BC, it was stated under *Current Management Issues*: "maintaining water levels in Somenos Lake" and "returning pastures back to arable land after multiple breaches of stream banks and flooding of fields" are of Despite mitigation techniqueshigh management priorities (Clermout, 2007, p.3). This indicates a priority to manage annual excessive water through traditional drainage techniques. And yet under *Management Goals and Issues* the report lists: "to preserve and protect the Somenos Flats and Marsh area for fish and wildlife species" and additionally "to maintain biological diversity and where compatible sustain traditional uses" (Clermount, 2007, p.3-4). The land in the Somenos Basin where The Nature Trust of BC's property is situated is known to be "geomorphically dynamic and subject to seasonal mainstream inundation" (Delcan & Current Environmental, 2012, p.36-37). The project site is flooded from October to May and may be exacerbated by North Cowichan's diking development. Currently, water at the Project Site is seen as a problem as opposed to a resource. Saturated fields pose several problems for traditional agriculture. Most high quality grasses cannot tolerate prolonged flooding. Reed canary grass is farmed in the Somenos basin, because it is a flood tolerant species; however, reed canary grass does not have a high market value. Inundated soils limit the productivity of traditional crops. Typically, grain farmers in the Cowichan region can attain three harvests per year. In the Somenos Basin, high water levels that remain well into the growing season limit farming to two harvests a year at best. In the 1980's the first harvest was in June, but due to prolonged high water levels, the first cut is now in the middle of July, and the second cut is in early September (Williams & Radcliffe, 2001, p.14). Inundated soils prevent access of large farming equipment. This means that prolonged inundated soils cause prolonged harvest times. In wetter years in fact, the first harvest can only be achieved when the grains are over-mature, and the second harvest may even be lost to early winter flood levels. Annual flooding of agriculture fields creates a constant battle on the fringe of the agriculture plots. When prolonged soil inundation leads to less farmer access, willow scrub and other pioneer species quickly succeed and take over the land. This requires constant and perpetual vegetation removal, which is very costly to manage. As a result, the size of the agriculture fields fluctuates over the years. There is however, a steady downward trend (see Figure 2).

The inability to maintain hay field production in the lower Somenos Basin has led to "deteriorating habitat" conditions (BioAyer, 1999, p.5). Attempting to support both high functioning traditional agriculture and high functioning waterfowl habitat is structurally incongruent and will result in a net loss of land efficiency, while generating only moderate success. In order to maximize land efficiency at the Project Site, the property owner must figure out how to best allocate their resources. In addition to the agricultural uses of the inundated lowlands, there are other proposed uses which include development of waterfowl and fisheries resources "by way of diking and channeling along the lakeshore to achieve year round flooding" (Willis, Cunliffe, Tait, 1981, p. 31). "Willow-shrub wetlands are succeeding many of the marsh areas, reducing habitat for Great Blue Herons, wintering swans, geese, and ducks… creating marsh habitat out of marginal farmland is therefore beneficial for counteracting biodiversity loss in the region" (Rehbein, 2004, p.121). Restoring a complex of wetlands would greatly benefit the environment, but a problem occurs when restoring wetlands means taking the land out of agricultural production, which can put conservationist and farmers at odds (Rehbein, 2004, p.1). There exists an opportunity for wetlands and agriculture to coexist. “Wetlands have a huge potential for providing food crops for people whilst remaining an absolute haven for wildlife” (Fern, 2000, p.123). The reconciling factor between wetlands and agriculture is a structural balance between ecological restoration, remedial agriculture, and alternative agriculture crops that offers “an innovative alternative that can allow wetlands and agriculture to work synergistically” (Rehbein, 2004, p.1.).

“In a freshwater marsh, primary productivity often reaches 6000g/m^{2}y” which is “higher than the productivity of many farm crops under intense cultivation” (Rehbein, 2004, p.4). The productivity of a wetland can be used to benefit agriculture. To increase the economic return on agriculture production, one solution is to use alternative cops that are situated for wetlands and provide a good return on investment.

Listed below is a series of crop alternatives. A few of the most applicable agriculture alternatives are types of berries. In a report by Christina Rehbein (2004), she suggests a wonderful marketing angle for a berry agriculture situated in a wetland environment. The idea is based of agrotourism, where bird and wildlife-watching can be mixed with a “pick-your-own” operation (Rehbein, 2004, p.82). This marketing angle would entice more people to view the Somenos ecosystem while being able to make an honest profit from nature enthusiasts.

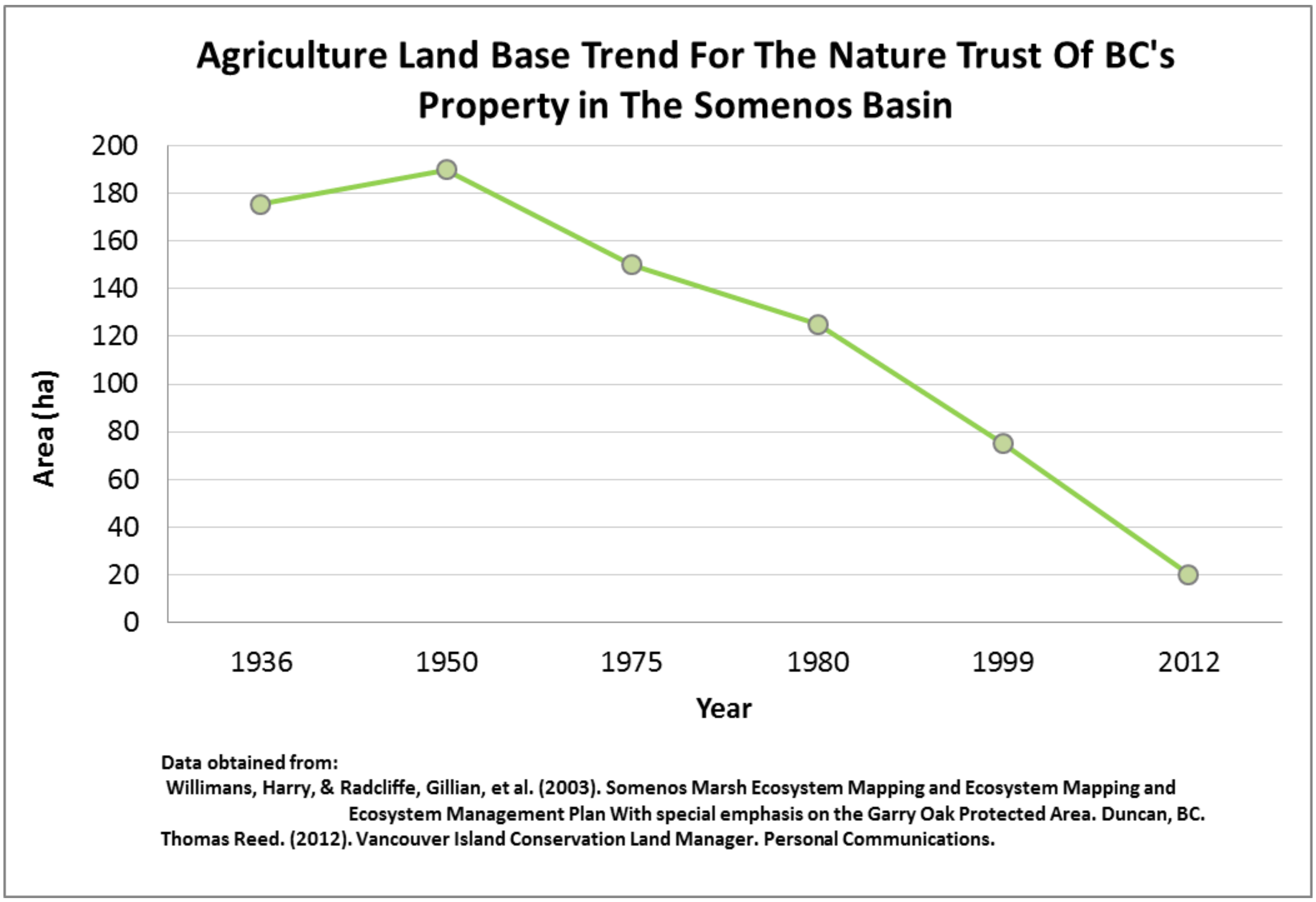


Figure 2

Alternatives

It is the recommendation of this report that reed canary grass production is to be aborted, and an alternative crop should be pursued. The following is a list of crop alternatives that can be grown in the Somenos Basin. These alternatives offer a dynamic approach to farming in the Basin. Compared to reed canary grass, some of the below crops can be grown in a smaller area and produce more profit. This would allow a portion of the farmed land to be a restored into wetland, and allow another portion to be farmed for a higher return of money.

- Native sedges - Chineese waterchestnut (*Eleocharis dulcis*) has commercial value but a poor market. It can also be used for mulch. Fields can also be used as feed for waterfowl during the winter (Rehbein, 2004, p. 49).
- Jerusalem artichoke (*Helianthus tuberosus*) - Crop has high yields (16-20 tonnes/ha for tubers, 18-28 tonnes/ha for foliage). The starch the tuber creates a sugar called *inulin*, which is a replacement sugar for diabetics. Its sugars can also be used as an effective biofuel. It is native to Eastern Canada despite large potential, there is a small market. Can be a weed (Duke, 1983).
- Hemp (*Cannabis sativa*) - Hemp products offer an overabundance of uses including: fiber, textiles, food, and fuel. Hemp grows well in a variety of soils. Hemp will not tolerate droughts and floods. Many uses require a special processing factory, which is unavailable on Vancouver Island. Requires a license through Health Canada (Mooleki, McVicar et al, 2006, p.1-3). Crops may be subject to vandalism. It will require public education.
- Urban farming - The property offers ample urban farming opportunities. Poor soil quality will limit production. Typically, urban farmers are generally financially unable to maintain agriculture fields from invasive species colonization and succession to willow scrub.
- Wild rice (*Zizania*) - There are high labour associated to maintaining and harvesting. High processing costs. Can clog channels (Rehbein, 2004, p. 49).
- Blueberries (*Vaccinium corymbosum*) - High commercial value. Tolerates moist soils. Native to estern Canada. Resilient to flooding. Likes acidic soils (Rehbein, 2004, p. 49).
- Raspberry (*Rubus Ideaus*) - High commercial value. Risky because of root rot problems (Rehbein, 2004, p. 49).
- Strawberries (*Fragaria ananassa*) - High commercial value. May rot in the winter (Rehbein, 2004, p. 49).
- Elderberry (*Sambucus*) - Low market value. Native plant. Hardy and easy to maintain. Provides good food for birds allowing more lucrative crops to be left alone (Rehbein, 2004, p.82).
- Wasabi (*Wasabia japonica*) - requires moist soils. High-end market. Requires shady conditions (Rehbein, 2004, p. 49)
- Rhubarb (*Reheum rhabarbarum*)- Likes moist soils. Good market. Can stay in the ground for many years (Rehbein, 2004, p. 49).
- Honey . High commercial value. Raised hives can be arranged in any type of soil (Rehbein, 2004, p. 49).

This report recommends the following as the best choices for alternative agriculture: blueberries, urban farming, and honey. All three have a low environmental impact and have high economic return and work well within a wetland environment.

2.3 Working in Concert with the Cowichan Basin Water Management Plan

A water management plan (WMP) is a holistic superstructure that works by proactive management rather than reacting in an ad hoc fashion. The core of any WMP is for the conservation and wise management of water in a given area. A WMP often focuses on whole watershed management; and consequently, only works at maximum efficiency when all components are aligned. This means that when working with a water management plan in effect, any work done to or around water bodies should be done within the interests of the WMP.

The Cowichan Basin Water Management Plan is a partnership with: Cowichan Valley Regional District, BC Ministry of Environment, Fisheries and Oceans Canada, Catalyst Paper Corporation, Cowichan Tribes and the Pacific Salmon Corporation and other stakeholder groups. The primary objective under the Cowichan Water Management plan is to "protect ecological function of [the hydrologic] system, balance water supply… and increase the understanding of the Cowichan Basin system and its water issues" (Westland Resource Group, 2007, p.4).

The Cowichan Basin Water Management Plan outlines six goals for watershed management (Westland Resource Group, 2007, p. 11-22). The proposed wetland restoration complex will help achieve five out of the six goals of the WMP. Listed below are the five goals and how wetland restoration in the Somenos Basin will help achieve the goals.

1. **Maximize efficiency of water use.**
   Subsection of Goal 1 include: "Ensure local governments and institutions are leaders in water conservation", and "Promote land use that increases water use efficiency". If the municipalities in the Cowichan watershed work as a consortium with other organizations such as the Somenos Marsh Wildlife Society and the Ministry of the Environment, then together the consortium can use the restoration of the Somenos wetlands as a premium example of how government working with other institutions, can be leaders in land development that promotes water efficiency and conservation.
2. **Manage water supply to meet human needs and minimize impacts of low water.**
   Subsection of Goal 2 include: "Store sufficient spring runoff to support human use and sustain river flows during summer and fall", "Actively manage spring and summer water levels to minimize the potential for lakeside properties to be adversely affected", and "Manage land and resources to avoid adverse effects on Basin hydrology (quantity and timing of runoff)". With the increase of wetland area, there will not only be a subsequent increase in the storage capacity of water, there will also be an inherent stabilization between droughts and floods, which helps sustain the water supply year round and assisting in the protection of lakeside properties from damage associated with flooding. A convenient way in which water can be stored for human use is with the addition of a subterranean cistern where water can be stored for irrigation. For more information on a subterranean cistern see Section 3.0 *Appendix.*
3. **Ensure sufficient water is available to sustain aquatic and riparian ecosystems throughout the year.**
   Akin to the way increased wetland area can help achieve Goal 2, a wetland restoration project will provide more water, habitat, and sustenance for its surrounding aquatic and riparian ecosystems year round.

4. **Reduce the impacts of high water levels, respecting the importance of winter floods to natural systems.**
   Subsection of Goal 4 includes: “Maintain winter water levels that are high enough to protect organic soils” and “promote stormwater management that emphasizes infiltration and detention and minimizes impervious surfaces to avoid increases in peak flows”. Flooding in the Cowichan area is a common phenomenon and must be addressed when an urban center is located within a close proximity. Wetlands, unlike traditional engineering techniques such as diking and ditching, focus on the infiltration water into soils. Inundated soils can protect soil from erosion and store water that moderate the effects of droughts and floods, while at the same time facilitating and accentuating certain ecological benefits that flooding provides to natural systems.
5. **Educate, engage, and empower citizens in water management.**
   Empowering citizens with the knowledge of proper water management techniques can take many forms. A very rational and effective way to increase the public use of the Somenos Basin is to add a nature center. A nature center would be ideal because it would be a centralized source of information that would assist visitors in learning and experiencing both environmental and hydrologic management techniques (see section 2.5.10 *Additional Recommendations* for more information on the Nature Center).
6. **Establish clear, accountable, and responsive water management decision processes and governance structures**.
   Due to the nature this report, the sixth goal is beyond the scope of this project.

2.4 Field Work

Field work is the physical presence at a site that offers a unique opportunity of assessment that cannot be replicated through secondary information. Field work was essential in determining if wetland restoration is feasible in the Somenos Basin. It was vital to determine the hydrologic dynamics of the Bings/Holmes Creek, stormwater effects, adjacent land uses, and topography.

1. Bings Creek Investigation **-** July 4, 2012
   To better comprehend the dynamics of Bings/Holmes Creek and the stormwater that drains into it, I decided to track the river from near its origin (Mt. Prevost), to its mouth in the Somenos Basin. I made six stops, took photographs and jotted down notes. Actually being able to go and visit the site and surrounding area gave me a unique perspective that elucidated many issues. In the summertime, the Bings/Holmes creek can be dry near its origin, and yet still contain sufficient amounts of water further downstream closer to its mouth where it enters Somenos Lake. The adjacent land uses that the majority of the creek flows through are: farmland (low impervious surfaces; however, a presumed increase in fertilizer and biocide use), and urban area (high impervious surfaces, high potential for deleterious materials to be conveyed by stormwater into water bodies), and highway (high potential for hydrocarbons and heavy metals). The When I reached Canada Avenue, in close proximity to Highway 1, I was surprised to see an extensive grassed bioswale adjacent to the RCMP station. When I crossed Canada Avenue, the effects of the grassed bioswale seemed to be challenged as I found plenty of oil in the Bings/Holmes creek.

Table 1

Site Number	Location	Description
1	Drinkwater Rd	Stream dry. Large size regolith. Signs of creek bank erosion.
2	Cowichan Lake Rd	Flow of water. Moderate Flow. Moderate to low vegetation.
3	Holiday Lane	Meanders. Healthy stream bank. A large amount of vegetation
4	Mary Street	Culvert under bridge. Settling pond. Slow flow. Lots of vegetation
5	Canada Avenue	Grass bioswale. Slow flow. Presence of oil in water
6	Highway 1	Culvert beneath Highway 1. Moderate/fast flow. Presence of oil

Image 2 Grassed bioswale surrounding the Bings/Holmes Creek by Canada Avenue and the RCMP office

Image 3 Oil in the Bings/Holmes Creek, in between Canada Avenue and Highway 1

2. Wetland Feasibility with Tom Biebighauser- July 21, 2012:

It was important to make sure that a wetland could logistically be built at the Project Site. I enlisted the help of Thomas Biebighauser, an American biologist whom has successfully restored over 1400 wetlands in American and Canada (Biebighauser, 2011, p. 182). Mr. Biebighauser conveyed to me that there are two kinds of constructed wetlands: surface water and groundwater. Surface water wetlands are depressions in the ground and consist of compacted soils that are high in clay. Groundwater wetlands on the other hand, are primarily fed by baseflow through groundwater reservoirs. As well, he described to me the different criteria needed to build a successful wetland. Wetlands occur on similar topography. For a wetland to retain water you must build it with a base slope of 6% or less. This means that over 10m, there should be a 0.6m elevation difference. Wetlands with a slope of 6% or higher require tiered steps (Biebighauser, 2012). To determine if a wetland could be made on the Project Site, Tom Biebighauser and I performed field work at the Nature Trust of BC's land on the left hand side of Bings/Holmes Creek. Test holes were dug to test for the presence of ground water, and elevations of ground water below the soils surface were taken.

Table 2

Hole	Location (decimal degree)	Level	Description
1	48.79102 lat -123.7113 log	N/A	15cm top soil, then sandy loam. Dug 45cm hole, found no ground water. Good farm land. Dominated by reed canary grass.
2	48.79143 lat -123.71085 log	18cm	Appeared to be old ditch/channel. 10cm of topsoil. Gleyed soil below (indicative of water logged soil). Excellent place to restore wetland. Dominated by reed canary grass. Presence of bull rush
3	48.79162 lat -123.71081 log	23 cm	7 cm of top soil, lots of organics. Surface mud cracked
4	48.79246 lat -123.71145 log	6 cm	Willows present (indicative of wet ground). Silt- sand loam. Excellent place to restore wetland
5	48.79232 lat -123.71113 log	10 cm	9 cm of high organic top soil. Silt loam. Excellent place to restore wetland

Topographic survey of the land was done at four test sites to determine the proposed flow of water through the wetland complex. A surveyor and meter stick were used in the process. They surveyor was at a fixed stationary height, and the meter stick, the variable, would touch the ground at different sites. The further the depression in the ground, the further down the meter stick would go, yielding a higher height on the meter stick. Since water flows in the path of least resistance, a difference in height relative to the existing Bings/Holmes Creek was calculated.

Table 3

Site	Location (decimal degree)	Height	Difference in Height	Description
	48.79081 lat -123.71152 log	0.0000m	N/A	On shoulder of Highway 1. Base reading
1	48.79073 lat -123.71061 log	4.0843m	0.0000m	Bings/Holmes Creek
2	48.79074 lat -123.71061 log	3.6880m	0.3963m	Bings/Holmes Creek bank
3	48.79168 lat -123.71071 log	4.2976m	-0.2133m	Middle of field
4	48.79237 lat -123.71069 log	4.4805m	-0.3962	Edge of field, close to willow scrub /Somenos Lake

A basic soil test was done. Generally, the soil was determined to be sandy loam, and in locations where there was a higher water table (and/or locations with a lower elevation) it was found to be a sand-silt loam. This soil allows good infiltration which will facilitates good stream treatment (Biebighauser, 2012). In summary, the land at the Project Site is very suitable for wetland restoration. The Project Site can accommodate numerous wetlands of various sizes. The soils and hydrology will support emergent as well as ephemeral wetlands.

Image 4 Tom Biebighauser testing a soil sample. This sample was sandy loam.

Image 5 Kyle Rasmussen digging a test hole 2.

3. Holmes Creek with Eve Savory- August 3, 2012:

The first Bings/Holmes Creek field work carried out did not yield very much information on storm water outlets. I learned afterwards that most storm drain outlets are either submerged, in culverts, or release at adjoining unnamed tributaries. In order to find a specific storm drain outlet that I could study, I contacted the engineering department at North Cowichan. They suggested I contact Eve Savory whom owns property off of Mary Street, adjacent to the Bings/Holmes Creek. Eve Savory was able to relate a wealth of information through her own testimony. She has seen many changes throughout her time living on the property. Fallow fields visible from site 1 (adjacent to the Bings/Holmes Creek, west of Mary Street) were farmed in the 1920's when ditching and drainage works were done to improve the productivity of the land. Between 2004- 2009 many trees on the west side of the property were cut down to build townhouses, and to allow clearance for a nearby hospital helipad. The townhouses were approximately 10m away from the unnamed stormwater channel. Site 2 was the terminus end of a culvert that runs under Cowichan Lake Road. This area has been structurally reinforced with riprap. The settling pond at site 6 is fairly recent development (approximately around 2009). Before the development, this area was prone to flooding. Flood waters would add sediment log jams. There has been considerably less flooding since the development. In Eve's recollection, the settling pond was dug to about 3m. Approximately three years after, when I was there, the settling pond was around 1m deep.

Table 3

Site	Description	Water Body
1	Viewed Bings/Holmes Creek from afar. Medium size riparian area surrounded by farm land. Eve Savory mentions how the Creek has shrunk in size over many years	Bings/Holmes Creek
2	West end of property. Culvert and drain from under hospital. Riprap placed. No signs of head cuts	Unnamed stormwater channel
3	Mid property. Storm water channel. Evidence of erosion. Head cut visible.	Unnamed stormwater channel
4	East side of property. Wetter soils. Skunk cabbage (indicative of wetland environment)	Unnamed stormwater channel
5	Prior to Mary Street. Stormwater culvert crosses beneath driveway. Empties in small, unnamed tributary channel that leads the Bings/Holmes Creek. Channel has extensive skunk cabbage. Trickling water.	Unnamed stormwater channel
6	Settling pond off of Mary Street. The pond is roughly 4-5m^2. Water doesn't appear to moving. Sediment is very noticeable on the bottom. Salmon smolt and crayfish visible. Some algae.	Bings/Holmes Creek
7	Other side of Mary Street. Confluence of the settling pond passes through a culvert beneath the road. Water is moving much faster. Toad and salmon smolt are visible. A large presence of algae.	Bings/Holmes Creek

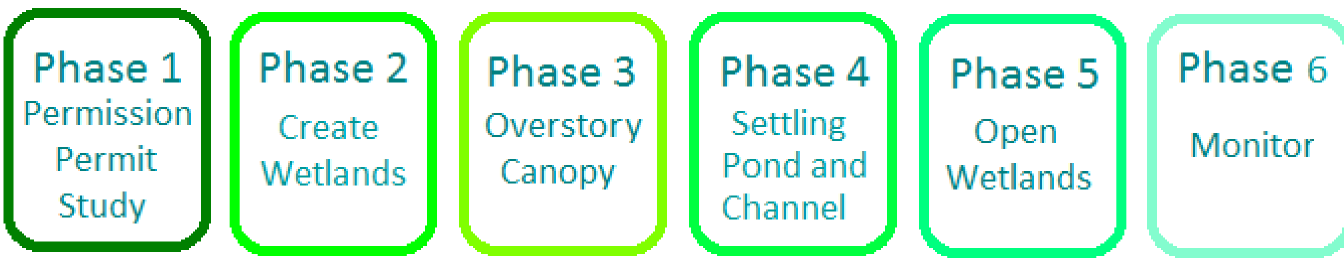
Image 6 Site 6 at Mary Street

2.5 Project Recommendations

2.5.1 Principal Recommendation

The following recommendation is listed in a staged, chronological sequence. The structure of a phased sequence order has been has been designed for the ease of implementing the Principal Recommendation through a series of stages that promotes efficiency of: ecosystem enhancement, mitigation of potential environmental impacts, financial resources, and time to not only design and implement a master plan, but to also for physical construction.

Principal Recommendation



Phase 1: Acquire development permission from the Nature Trust of BC. Develop a consortium of partners. Delineate an organization or create a commission to oversee the project's design, construction and implementation. Acquire funding, authorization, and permits. Perform in-depth scientific studies on pedology, hydrology, and biota (especially salmonids) in order to create effective remedial wetland designs. Changes to a system can only be measured by understanding prior conditions and relating this data with conditions post developmental change. Without data, all that is left is a subjective impression of how a system is doing. Data allows specific measurable goals to be met. Numerical data can be used to quantify cost savings and other efficiency standards. By knowing empirically how well a development is fairing, it is possible to gauge future designs and actions. Failing to collect data misses these important opportunities. Suggested variables to research and inventory pre-development and post-development include: flora and fauna counts/ distributions (area and invasive/native), salmonids counts (smolt, fry, and returning adults), small mammals counts, avian counts, hydrometric data (flow, nutrient load, dissolved oxygen, temperature, turbidity), water table level, influence of management practices at a local government level, and public interest/knowledge of conservation efforts. It would be beneficial to draft the master plan for the Somenos Basin wetlands restoration project within this Phase.

Phase 2: Since wetlands can be developed independently, begin development work by creating a series of emergent (year-round) and ephemeral (short-term) water wetlands. Invasive plants must be carefully removed, and native plants rehabilitated. Wetlands will require active vegetation, as restoration cannot rely on natural colonization. Scatter desired graminoid seeds and plant specific vegetation for phytoremediation and bird feed during the winter (see Section 2.5.3 *Environmental Remediation*).

An ideal time for planting is in the fall or in springtime. Usually planting is done in the fall so the plants are given ample time to establish themselves before the growing season. Planting in the spring however, is recommended because of damage done to young plants by wintering waterfowl (Rehbein, 2004, p.19). Follow planting times for remedial agriculture/alternative agriculture.

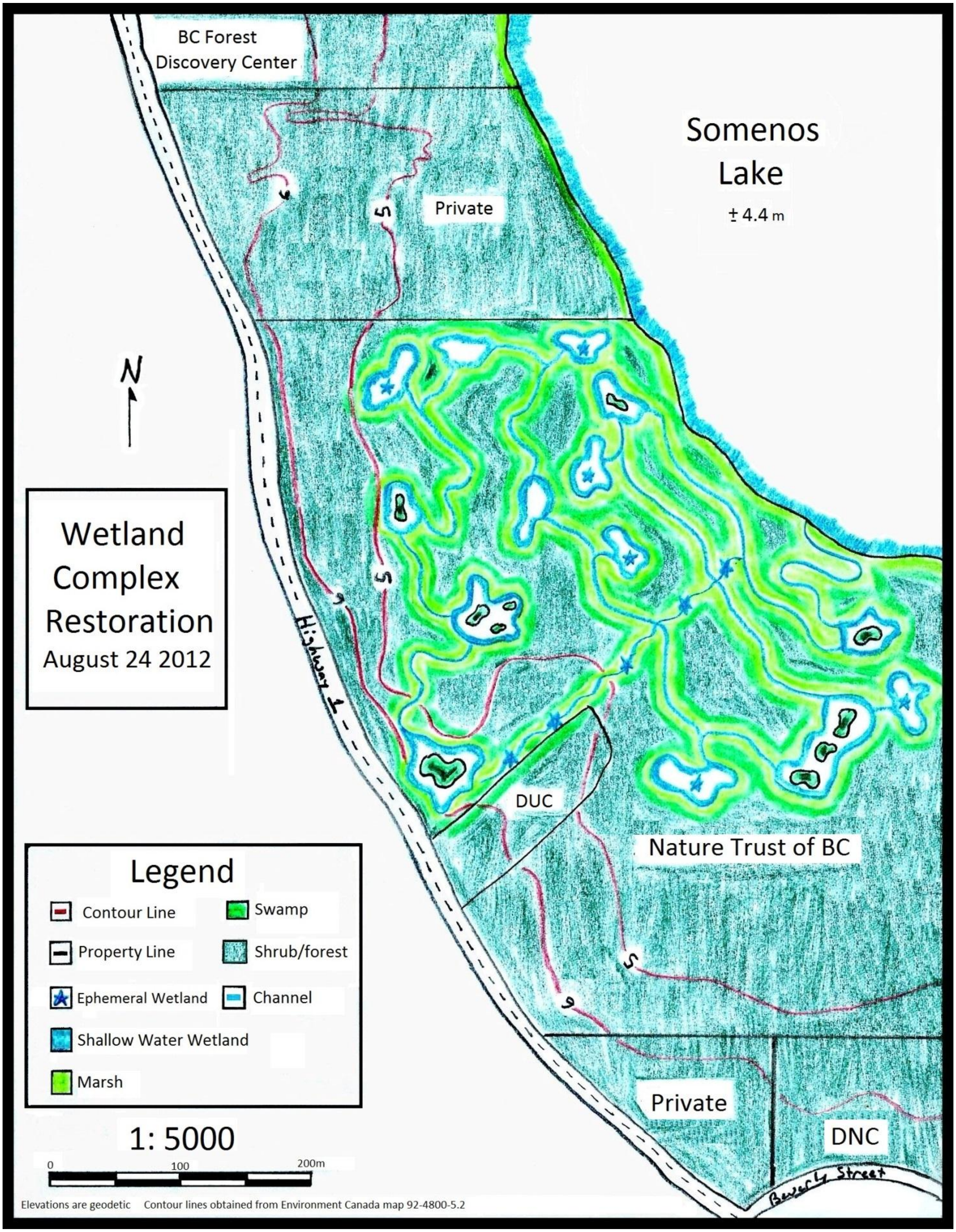
Phase 3: Work on developing overstory canopy. Plant tall shrubs and trees along riparian zone 2-5 meters from creek banks, especially on the south and west side to provide habitat and keep creek cooler and less prone to being clogged by dense herbaceous vegetation in the summer.

Phase 4: Create a settling pond and develop sinuous channels which meander through the property connecting the series of wetlands, which will improve fish habitat and streamside complexity. Allow riparian area to establish. Determine a date for the last harvest of reed canary grass. Reed canary grass is considered as an invasive plant (Rehbein, 2004, p.78) that will reestablish itself unless the final cut is extremely thorough.

Phase 5: Open up the wetland complex to the flow of Bings/Holmes Creek. Retire old channel by preventing flow with clay plugs. Turn old channel into a wetland.

Phase 6: Monitor the effects of development. Establish scientific and monitoring research. It must be remembered that “a newly planted site takes years before nutrients, soil development and wildlife usage are optimized” (Rehbein, 2004, p. 128). Some effects may be discernible after one year, and some effects may require longer time scales (five to ten years). Perform any maintenance if required.

The end goal of the Principal Recommendation is to divert the Bings/Holmes Creek through a restored wetland complex on the Nature Trust of BC’s property in the south Somenos Basin. A complex of wetlands would be connected by a central meandering channel. Bings/Holmes Creek would enter the system and via settling pond where a majority of sediments would be removed. This would improve the condition of the water by decreasing velocity, spreading out the water over a larger surface area, and decreasing the amount of pollutants through environmental remediation techniques. Restoring wetlands on the Nature Trust of BC’s property will not only create a healthier aquatic environment, but will also increase the potential aquatic habitat area in the Somenos Basin. An increased wetland area equals an increased potential for the area to hold water, mitigating peak flow and the effects of floods and droughts.


BC Forest
Discovery Center
Somenos
Lake
± 4.4 m
Private
Wetland
Complex
Restoration
August 24 2012
Highway 1
DUC
Nature Trust of BC
Legend
Contour Line
Swamp
Property Line
Shrub/forest
Ephemeral Wetland
Channel
Shallow Water Wetland
Marsh
1: 5000
0
100
200m
Private
DNC
Beverly Street
Elevations are geodetic
Contour lines obtained from Environment Canada map 92-4800-5.2

Map 3

2.5.2 Wetland Construction and Design Criteria

To ensure the vitality and longevity of wetland restoration, it is recommended to conform to a set of wetland criteria. These criteria will aid in the creation of an efficient and a well-managed wetland complex.

- During Phase 2-4, the site should be isolated from all flowing water to mitigate potential environmental impact.
- "Put sediment control measures into place before starting any works that may result in sediment mobilization. This may require removing excavated material from the site and placing it in a stable area above the high-water mark or active floodplain of the stream, as far as possible from the channel. (MWLP, 2004, p. 89).
- It is recommended that excavated soils removed during the construction of the wetlands be used in the following way: to strengthen the soils around the constructed wetlands to facilitate healthy and strong riparian areas or to elevate agriculture fields.
- Design wetland complex for ample spawning gravel sites. "Sedimentation, washouts and dredging are common reasons for loss or degradation of spawning substrates. Replacement with clean, gravel and other sizes according to the stream gradient and flow is a common successful activity. The scale varies with the creek size; from small pails of gravel to truckloads with anchor rock placed by machinery" (DR Clough Consulting, 2010, p.6).
- Adopt a *zero net loss* policy for biota set out by the Government of Canada's national policy on wetland conservation (1991, p.5) Prior to any wetted channel being isolated or dewatered, it is highly recommended to do a complete salvage of fish, amphibian and. It is important that "an appropriately qualified professional must complete the salvage" (MWLP, 2004, p. 49).
- It is important to understand natural fluctuations and develop baseline information of the Project Site in order to gauge the appropriate future course of action. Recommended variables are: the biotic use of the area, water quality, water quantity, effectiveness of environmental remediation. Dig test hole. Take samples throughout the year. Base this with historical information.
- Develop a detailed topographic map at a scale of 1:5000
- Call the Municipality of North Cowichan before any excavation to make sure there are no buried power/sewage lines.
- Use of groundwater wetlands, no liners wanted. Tested for groundwater during field work (see section 2.4 *Field Work*) Small gradient on Somenos creek equals small changes having significant effects on flow.
- "Large wood debris (LWD) is the key element for most coastal streams habitat. It creates complexity through deep pools, protected banks and anchored substrates. Wood hides adult and juvenile fish and provides a substrate for aquatic insects. Large woody debris is often lacking or completely missing in east coast V.I. streams due to logging and floods" (DR Clough Consulting, 2010, p.6).
- Diversity of levels- A diversity of water levels produces a wide variance in habitat that "promote the production of different foods" and "attract different groups of wildlife" (Nelms, 2007, p. 18). A well-functioning wetland should include deep shaded water areas for fish and diving ducks (1-2 m), medium areas for Canada geese and swans to help neighbour farmers, shallow for dabbling ducks, and various shallow and slopping sections. If majority of water is too deep, it will deter many types of waterfowl.

Depths of 1.5 m or greater should not be more than 20% of total pond area or waterfowl will find alternative locations for food (Radcliffe, 1990, p. 34).

- Constructing a wetland system that is viable yearlong as suitable habitat for salmonids and other biota requires thorough understanding of the hydrologic fluctuations experienced throughout the year. The proposed wetland system would be fed by the Bings creek, and would have to accommodate the creeks annual fluctuations. The creek retains water year round and Based on a 5 year average, with data collect from Environment Canada (A, 2012), the proposed wetland would have to accommodate a yearly average discharge of 0.49 m^3/s, with a five year max instantaneous flow of 19.2 m^3/s. It is important to note that discharge measures how much water is moving through a channel, and not how much water is within a channel, even though the two measurements are interrelated. This is of importance because the topography in the Somenos Basin is rather flat which allows the water time and space to slow down. This does not, however, discount the fact that a large volume passes through and can be present in the channel at any given time. Adding length and meanders to the channelized stream would allow water more time and space to slow down, and would increase the surface area for infiltration. The combined effect would allow more water to be recharged into underground aquifers (equalizing annual fluctuations and increasing water filtration potential).
- Make a good habitat for animals. Give animals a place to hide from predators.
- Follow topography of the basin (see Map 3). Before the improvement works of 2000, the Bings Creek, due to sedimentation, deviated northward on to The Nature Trust of BC's property (Williams & Radcliffe, 2001, p. 32). Work with the topography and try to emulate the natural flow of water, and the path should be emulated and accentuated.
- Increase channel diversity and sinuosity.
- Submerged Snags (conifers- especially cedar, or cottonwood is recommended) are good for fish, amphibians, and biodiversity.
- Create woodland around wetland.
- Ephemeral ponds facilitate amphibians and diversity
- Create a variety of edge habitats including overhanging banks to provide cover for fish and mammals such as otter, mink and muskrat (Radcliffe, 1990, p. 16). Gentle slopes with irregularity variety
- Plant shrubs and trees for larger birds such as kingfisher, and provide security for heron.
- Settling pond: Wetlands are dynamic systems, and over time natural wetlands in a basin undergo a process of terrestrialization where wetlands fill in with sediment and succeed to terrestrial ecosystems (Rehbein, 2004, p.110). Additionally, "elsewhere on the land surface, a variety of geomorphic and biological processes combine to create new wetlands" (Williams & Radcliffe, 2001, p.3). It is recommended that a settling pond be installed between Highway 1 and the wetland complex to prolong changes brought on by sedimentation or pulse flood event that would change the course of the wetland complex structure, until such time that the wetland complex and riparian area is well established. The settling pond is to be designed to slow down the confluence of the Bings/Holmes Creek and capture most of the sediment prior to the wetland complex. A dense growth of cattails (*Typha*) is recommended for its fast establishment and ability to slow down water velocity, and its ability to sequester hydrocarbons. Right-of-ways should be granted to allow for dredging if desired.
- Work with a Qualified Environmental Professional to determine the best time to work
  → Coho and Cutthroat work window (August 1- September 15)
  → Typical avian breeding season (April 1 - August 1)

- → Bald Eagle initiation and eggs: Feb 5- June 25, young present: April 1- August 31 (Delcan & Current Environmental, 2012, p.48).
- → Great Blue Herron initiation and eggs: January 15- April 15, young present: April 15- September 15 (Delcan & Current Environmental, 2012, p.48).
- → Red legged frog breeding season in the spring, tadpole to adult stage occurs during July- August (Delcan & Current Environmental, 2012, p.40).

- Hire experienced heavy equipment operators to build wetland by utilizing an excavator and dozer with suggested specifications "the dozer should be equivalent to a Cat D5Gm, having 90 HP or greater, weighing at least 20,000 pounds, with metal tracks, a 6- or 7-way blade, and an inside C-frame. The excavator should be equivalent to a Kobelco 135SR or larger model having 90 HP or greater, metal tracks, weighing at least 28,000 pounds, and a bucket that is 42 inches wide or greater" (Biebighauser, 2008, p. 1).
- To revegetate and replace impacted riparian area, plant a variety of native trees, shrubs, and herbaceous plants appropriate to wetland conditions. There are four types of wetland vegetation that should be included in the design: wooded, meadow, emergent and submerged (Rehbein, 2004, p.18). A variety in vegetation creates a more dynamic habitat to support a wide variety of biota. Wooded vegetation gives considerable substrate structure, shade, and nesting opportunities. Meadow and emergent vegetation facilitates a wide range of riparian function including invertebrates and small mammals. Aquatic vegetation assists in establishing strong anaerobic microbial communities and adds to aquatic habitat and stream structure. Manually planting of nursery rootstock vegetation "may be the simplest and most feasible method" as it requires little equipment and creates the least disturbance (Rehbein, 2004, p.62). Work with a biologist to determine about ten to fifteen species that should be chosen for planting (Rehbein, 2004, p.62). The vegetation desired for the restoration of a well-designed wetland complex should seek to match natural authenticity through function, habitat, and herbivore consumption, while providing a capacity for remedial action.

2.5.3 Environment Remediation

The practice of environmental remediation targets specific biological metabolism mechanisms of particular microbial and vegetation species that can be used to ameliorate the target environmental pollutants. Environmental remediation works by several biological and chemical processes that combine together to remove contaminants from water bodies. "Removal mechanisms include cation exchange, chelation with wetland soils, binding with humic materials, precipitation as salts, as well as uptake by plants, algae, and bacteria" (Varnell, & Thawaba, & Solis, 2010, p.2). Environmental remediation can be broken into three large categories: bioremediation (microbial), phytoremediation (vegetation), and mycoremediation (fungi). Pollutants that can be removed are: hydrocarbons, heavy metals, organic compounds, biocides, solvents and excessive nutrients. Phytoremediation can supplementary effects as it can additionally treat several of water quality conditions including: turbidity, velocity, temperature, and pollutant removal. Wetlands in particular have a high potential to act as a sink for many contaminants and nutrients (Varnell, & Thawaba, & Solis, 2010, p.2). Hydrocarbons can be broken down and assimilated through microbial interaction in the soils around wetlands (Admassu, & Caldwell et al, 1996, p.6). Soils are also efficient at removing heavy metals where "exchanges between dissolved metals and humic acids in the substrate of the wetlands and can cause significant reduction in metal concentrations" (Varnell, & Thawaba, & Solis, 2010, p.2). Unlike the breakdown of biodegradable substances like hydrocarbons, heavy metals and farm nutrients are taken up by remedial vegetation where the substances bioaccumulate and "lock up" in the vegetative structures. Level of heavy metals "are commonly many times higher in plant stems, leaves and roots than in the wastewater being treated, clearly showing the effectiveness of wetland vegetation as a 'biofilter'" (Ramsar, A, 2012). Therefore, it takes some maintenance to cut down this vegetation and dispose of properly; otherwise the plant will someday die, and release the deleterious substances back into the environment. Cattails (*Typha*) are well known for their ability to lock up excessive farm nutrients. Cattails "provide an important tool for bioremediation of wetlands contaminated with [phosphorus] and other nutrients" (Varnell, & Thawaba, & Solis, 2010, p.1).

Cattails are naturally rigorous growers. Modern agriculture that uses increasing amounts of fertilizers and pesticides leads to an increase in "levels of nitrates, phosphates, and other chemicals in the drainage water" (Varnell, & Thawaba, & Solis, 2010, p.1). This means that cattail growth will "increase dramatically as a result of the infusion of nutrients from agricultural runoff" (Varnell, & Thawaba, & Solis, 2010, p.1). It is recommended that cattails are used in the settling pond. The settling pond will ample growing room and the cattails would serve as a good means for slowing down the confluence of the stream and treating hydrocarbons from Highway 1.

The efficiency for a wetland complex to work as a site for environmental remediation site depends on several factors "including types of soil and slope, vegetation type, and the frequency and duration of flooding" (Varnell, & Thawaba, & Solis, 2010, p.2). The efficiency of environmental remediation can be increased by adding complexity to a wetland. By increasing the size, sinuosity, and length of the wetland, it will consequently increase the amount and surface area of remedial plant and soils. In addition, a low topographic relief or slope will slow down contained water and allow an increased opportunity for remediation. The Somenos Basin provides an excellent slope that will allow the confluence of Bings/Holmes Creek to move relatively slowly through. It is recommended that the wetland complex design incorporates several meandering channels and emergent wetlands that have islands contained within them. This will promote surface area of vegetation and soils.

> The quantity of heavy metals taken up by plants depends on a whole variety of factors (e.g. speed of water flow, size of treatment area, climate, type of plants used) but levels are commonly many times higher in plant stems, leaves and roots than in the wastewater being treated, clearly showing the effectiveness of wetland vegetation as a 'biofilter'.
>
> - Ramsar, A, 2012.

Desired Plants

It is recommended that the plants chosen for planting at the Project Site be native vegetation for their "ability to withstand large amount of water, their low maintenance requirements and their capabilities to adapt to local weather conditions" (McGuire, & Wyper et al, 2010, p.59). Native plants are often cheaper to acquire by salvaging from the development site, or by propagating new growth by live stalking. Vegetation for the purposes of phytoremediation should be chosen based on the priority needs for treatment based on current water sampling. In summary, it is recommended that vegetation should be evaluated on their ability to work in harmony with the wetland ecosystem, be non-invasive, and by their remedial efficiency.

- **Phytoremediation:** Cattail (*Typha*), sedges (*Carex app.*, and *Schoenoplectud spp.*), water lilies (*Nymphaea spp.),* spatterdock (*Nuphar spp*.), Common Water Hyacinth (*Eichhornia crassipes*), knot grass (*polygonum aviculare*), duckweed (*Lemna*), water fern (*Azolla*), and common reed (*Phragmites*) (Rehbein, 2004, p.18-19).

- **Food and Diversity:** Bulrush, sedge, skunk cabbage.
- **Native tree/shrub:** Most woody vegetation that inhabits wetlands should be able to withstand flooding when dormant, and less tolerant to prolonged flooding during the growing season (Rehbein, 2004, p.18). Cascara, pin cherry, Dogwood, mountain ash, red alder, willow, Big-leaf Maple, native cottonwood. "Plants can be seeded or transplanted in the form of roots, rhizomes, tubers, seedlings, or mature plants" (Rehbein, 2004, p.19).

Warning: "Indeed all non-native water plants used for wastewater treatment – particularly those that float – require careful management to prevent them from invading natural wetland ecosystems" (Ramsar, A, 2012). Species like cattails are rapid colonizers that require strategic planting in order to prevent monocultures (Rehbein, 2004, p.19). Additionally, willow and poplar have extensive root systems that may out-compete other vegetation. This problem is not as concerning if the other vegetation is established first. Willow in particular, is suggested as a good shelterbelt around ecosystem, protecting it from aeolian erosion.

2.5.4 Alternatives

Alternatives given supplement the above recommendations. A committee should evaluate how much wetland restoration is desired. If funding is insufficient, or the magnitude of the project is insurmountable, then it can be decided to not pursue all stages. The initial recommendation has been designed so that the first phases can be completed without necessarily having to complete the last stages.

Option 1: If it is decided that the Bings/Holmes Creek should not be intercepted by a wetland complex, then complete only Phases 1-4. Restore a complex of 15-30 wetlands in the Nature Trust of BC's property while leaving the Bings/Holmes Creek undisturbed. Not diverting the stream would greatly decrease the potential for environmental remediation and expansion, and is the cheaper option. Wetland habitat would still be created, and aquatic habitat condition for salmonids would not change.

Option 2: If it is decided that a complex wetland is unwanted, then complete Phases 1-3. This would allow the creation of 5-15 wetlands. Environmental remediation potential would further decrease. Increased water storage is still promising.

Option 3: If multiple wetlands are unwanted, then complete Phases 1-3 and develop a single wetland. A single large wetland (100 m^2 or larger) could be created for increased habitat and biodiversity. This would be the cheapest development. The potential for water treatment is almost non-existent.

Another set of alternatives rests in the balance between how much agriculture land there should be versus wetland. This is a more convoluted decision and should be based off of the merits of wetland ecosystem services, alternative agriculture opportunities, and a cost/benefit ratio between development and non-development.

Option 1: It can be decided to completely abandon commercial farming altogether, and instead instigate a remedial agricultural foundation. This would have the largest all around ecological benefit by increasing the amount of habitat, biodiversity and at the same time reducing anthropogenic pressures. Abandoning agriculture at the Project Site would make the land a “non-use” under the Agriculture Land Reserve as which is contestable under the current global agricultural market.

Option 2: If agriculture is still desired then it is recommended that there should be a change from reed canary grass to an alternative agriculture that is more suitable for the wetland conditions, produces more tangible uses, and has a higher profit margin. See section 2.2 *Agriculture Alternatives*.

Option 3: Continue farming reed canary grass. Provide good food for waterfowl. If the farming of reed canary grass continues, there is the difficulty of obtaining two optimal crops a year, deceasing crop area, and spread of grass that can lead to the chocking of water channels.

Other marginal alternatives include:

- An alternative to diverting the whole Bings/Holmes Creek confluence is to create a side channel designed to divert 30-80%of the flow through the wetland complex, maintaining water flow in the channel. This option is recommended if the approval to change the Creek is denied. Diverting partial confluence will allow moderate environmental remediation. Having less inflowing water for the wetland complex will require the design to accommodate more ephemeral wetlands, and less emergent wetlands. Less water also poses a problem to salmonids that want to inhabit the wetlands. Less water means a higher chance of connecting channels drying up, trapping fish.
- Join two or three small wetlands together to make one larger wetland.
- It can be decided how much of wetland area should be emergent (year-long) wetlands versus ephemeral (short-term) wetlands.
- If steps for restorative/remedial action are not undertaken, there will be a continuation of environmental degradation.

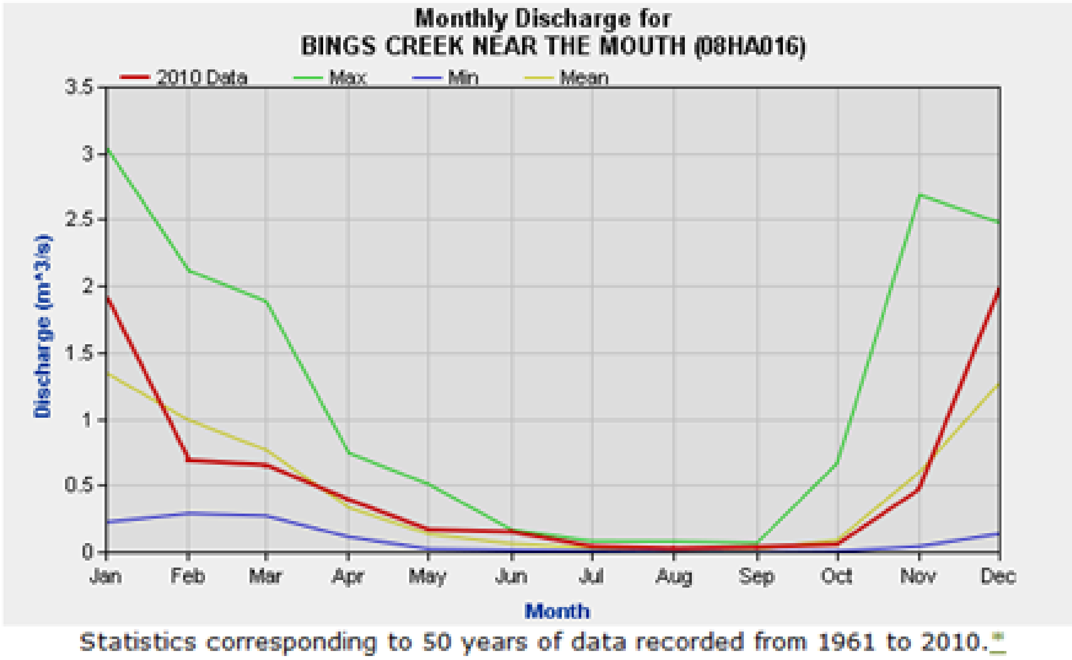
2.5.5 Consideration of Potential Project Issues

The following is a list of issues that the recommendations of the report may be subjected to:

- Zoning conflicts: None of the designations or zoning would affect development.
- Vacancy of Wildlife. Ensure that the new wetland system is viable and useable by wildlife - hire QEP. The potential for this issue is extremely low. Restoring wetlands for wildlife seems to follow the motto “If you build, they will come” (Rehbein, 2004, p.64). Initial colonization by animals and vegetation will be likely if there is adequate: food, standing water, shade cover, and shelter (Rehbein, 2004, p.64).
- Attempt to design wetlands to accommodate beavers. Wetlands should be designed with the knowledge that beavers may, over time, attempt to dam the system. It was generally thought that beaver dams were negative for anadromous fish like salmon, and it was common to remove them until recently. Recent literature has noted the benefits that wetlands provide fish like salmon where “more than 80 North American fishes have been documented in beaver ponds, including 48 species that commonly use these habitats” (Pollock, & Press et al, 2004, p. 749). When a beaver makes a dam, it creates an excellent fish habitat by slowing down the current velocity and providing large edge-to-surface-area ratios, which therefore contain extensive cover and a highly productive environment for both vegetation and aquatic invertebrates (Pollock, & Press et al, 2004, p. 749). Beaver activity can also be discouraged by designing the wetland “with gradual 20:1 slopes [that] will help the wetland appear more natural,

reduce muskrat and beaver problems” (Biebighauser, 2011, p. 97). It is additionally recommended that research should be done in order to find out where the beaver will most likely dam, and plan the design to incorporate a possible dam as a natural feature. If there is current beaver activity at the Project Site, some potential overstory canopy vegetation may require fencing during establishment to prevent beavers from cutting the trees down. Other than dams, beavers can also dig channels that may drain one wetland into another. “If two wetlands are next to each other, and one is on higher ground, a beaver-dug channel can drain the upper wetland into the lower wetland” (Biebighauser, 2011, p. 148). This can be partially prevented during wetland construction by compacting the soils with and excavator on the downward facing slope, and/or adding more clay to the soils on the downward facing slope.

- Muskrats: Muskrats can damage wetlands by digging holes through the dam that retains water in the wetland. This severity of this problem is significantly less when working with ground water wetlands.
- Disturbance of wetlands due to flooding waters: Over time, proper maintenance of wetlands requires “appropriate disturbance management” (Rehbein, 2004, p.100) of which pulse flood events and water level drawdowns are the main management techniques. Wetlands are adapted to relatively harsher conditions. Pulse flood events would actually reinforce a wetland complex.
- Some believe that wetlands significantly add to the mosquito populations (a pesky and potential disease) carrying problem. Tom Biebighauser in his book *Wetland Restoration and Construction A Technical Guide* (2011) mentions this mosquito issue and comments “contrary to public belief, building a wetland can actually lower mosquito numbers” (p.107). Many animals found in wetlands feed on mosquitos and their larvae including “swallows, dragonflies, [fish, salamander larvae,] frogs, and toads prey on adult mosquitoes during the day with bats taking over at night” (Biebighauser, 2011, p.107)
- Design contingency plans in case of any highway accidents that would affect the health of the ecosystem (see additional recommendations #)
- Make sure wetland has water year round: It is important to ensure that the channels have enough water to maintain connection to the shallow water wetlands year round. This is imperative for aquatic species that require connectivity between habitats. It is also out of habitat importance that ephemeral wetlands have an opportunity to dry up. Concerns stem from low water levels during the summer for Bings/Holmes Creek during the summer (see Figure 4). Although discharge of the Bings/Holmes Creek does decrease during the summer, the Bings/Holmes creek does not run dry (Environment Canada, C, 2012 ; Fletcher, 2012). The precipitation pattern shows season variability. Between October and March, there are high amounts of precipitation, and during April to September, there are low amounts of precipitation. As Christina Rehbein says in her report concerning the water balance in the Somenos Basin: “the problem therefore becomes a matter of storing the excess winter water to use during the summer shortages for wetland areas” (2004, p. 115). Properly designed wetlands should be able to retain water year round. Wetlands increase the water carrying capacity of the surrounding land will aiding in baseflow which sustains water levels during low precipitation months. If the wetlands cannot retain an adequate water level, the use of flow control structures can assist in water storage “by holding it back using berms and or stoplogs” (Rehbein, 2004, p.58). Stoplogs are recommended because they are the most resistant against beaver and rodent damage (Rehbein, 2004, p. 119). Ephemeral wetlands will be designed with the help of a QEP to ensure they are built to certain depths and at certain topographic areas to will allow for water level fluctuations.



Information from the Environment Canada. Retrieved from

Environment Canada, C. (2012). 08HA016. Monthly Discharge. Government of Canada. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?yearb=&yeare=&station=08HA016&report=monthly&year=2010.

Figure 4.

- Invasive species problems in the Cowichan are a common occurrence. When establishing wetlands and allowing the colonization of native plants, or disturbance to soils during construction may bring about invasive species. It is recommended that during the first few years, or if feasible in perpetuity, to form invasive weed pulling groups. These groups, often formed out of volunteers form the community, can be an excellent way of encouraging nature enthusiast to learn and experience more wetland ecology
- Design wetlands to accommodate climate change: The design of the wetland complex should incorporate a water table variable designed by a QEP.

2.5.6 Consideration of Potential Adverse Environmental Effects

Potential interaction with wildlife during construction may come in the form of direct disturbance (as in altering or disturbing a tree with nesting birds) or indirect disturbance (such as rainwater flushing excavated sediments downstream). The following is a list of possible adverse environmental interactions:

- Clearing of trees and other vegetation – particularly riparian habitat or flood ecosystem areas
- Introduction of foreign bacteria and other potential pathogens such as the *chytrid* fungus and the *ranavirus* from the soils on dirty heavy equipment
- Temporary storage of soil or backfill material
- Run-off from surface water mixing with excavated sediments causing erosion and sedimentation
- Excavation within wetted channels and adjacent upland areas

- Construction of temporary or permanent watercourse crossings and access roads
- Hazardous materials spills
- Abatement of hazard trees within the flood ecosystem located on or near The Project
- Noise-related disruption to wildlife – in particular nesting raptors (e.g. Heron, Eagles).
- Ground water contamination
- Heritage resource loss
- Mortality, habitat alteration, or degradation for aquatic and terrestrial wildlife

Proposed Preventative/Mitigative Measures

To prevent the above potential adverse environmental interactions, proper due diligence should be in order. The following list provides mechanisms that will limit or control adverse environmental effects.

1. Monitoring- The most important aspect that will act as the project's hinge pin is an environmental monitor known as a Qualified Environmental Professional (QEP). This is the person whom is to be contracted to oversee construction activities to ensure that environmental impacts are minimized through the implementation of appropriate mitigation measures. "Any potential adverse effects can be mitigated to result in no, or negligible impacts."
2. Tiered construction process- Isolating the main construction- the wetlands and associated channels from the preexisting Bings/Holmes Creek, will significantly help in minimizing sediment release and minimize disruption of riparian function.
3. Perform works during favorable weather- This means conforming to "working in the dry". By working in favorable weather conditions such as low precipitation and/or low stream flow means that there will be a smaller probability of indirect disturbances.
4. Abide by biota windows. And finish construction work as soon as possible.
5. Erosion and sedimentation control measures- follow appropriate erosion and sediment control (ESC) measures in place and use of detention BMPs.
6. Salvage and/or reestablish vegetation and aquatic species including amphibians and fish.
7. Promptly revegetate and mulch disturbed areas within and around watercourses to discourage the establishment of invasive species.

2.5.7 Best Management Practices

The standards and Best Management Practices (BMP) set out by the British Columbia Government are designed to "when followed, will allow you to undertake instream works in a way that will avoid, limit or mitigate impacts to aquatic and riparian habitats, water quality and quantity, fish and wildlife species, and public safety and property"(MWLP, 2004, p. 33). BMP's exist to help developers unsure their work is in compliance with applicable legislation and in carried out in a manner that will not cause harm to the environment.

To view the Best Management Practices and view more information on regulations for instream works reference:

MWLP. (2004). Standards and Best Practices for Instream Works. Ministry of Water, Land and Air Protection Ecosystem Standards and Planning Biodiversity Branch. Government of British Columbia.

2.5.8 Permit/Authorization

Developing a wetland complex on the Nature Trust of BC property in the Somenos Basin requires permission from the land owner and the lease: the Nature Trust of BC, and the Ministry of Environment. Development should seek First Nations authorizations. A series of authorizations and permits should be obtained including:

- Local Government Act (DNC, B, 2011, p.2).
  → Development Permit Area 3 *(Natural Environments)*. Approval may be required
  → Section *5 (Farmland Protection)*. Approval may be required.
- Water Act-
  → Section 5-7: Water licenses and whom may acquire them and when.
  → Section 9: "*Changes in and about a stream"* requires written approval.
- Fish Protection Act-
  → 40.1: Prohibition against introducing debris (including: clay, silt, sand, rock, or similar material, or any material natural or otherwise from construction or demolition) into a steam without authorization. It is important to note that "there are no direct fines and penalties under the Fish Protection Act. However, by not complying with the Act and its associated regulations, you risk committing an offence under the Waste Management Act, the Water Act, the Wildlife Act, or other legislation" (MWLP, 2004, p. 16).
- Wildlife Act, Wildlife Permit Regulation-
  → Section 9: A person commits an offense if they harm or destroy a muskrat or beaver habitat unless authorized (MWLP, 2004, p. 17).
  → Section 34: A person commits an offence if they harm or destroy a bird, nest or egg.
- Fisheries Act
  → Section 36: no one shall "throw overboard ballast, coal ashes, stones or other prejudicial or deleterious substances in a river… where fishing is carried on"
- Species at risk Act (2002):
  → This act aims to protect wildlife at risk from becoming extinct or lost from the wild. Seek to help wildlife numbers to recover. Species at risk Act prohibits the killing, harming, harassing, capturing, or taking of species officially listed as threatened, endangered or extirpated, and the destruction of their residences or critical habitats. It applies to plants and animals.
- *Migratory Birds Convention Act*
- Provincial archeology office-
  → Section 14 approval
- Fisheries Act (Fisheries and Oceans Canada) –
  → Section 35: It is against federal law to carry on work that results in the harmful alteration, disruption, or destruction of fish habitat.

2.5.9 Developing Partnerships

Building a strong partner base helps facilitate development in multiple ways. Having more partners increases the amount of leverage for the proposed project. Partners strengthen a project by increasing: funding sources, in-kind contributions, support through the community, and importantly, a strong partner base shows development and authorization agencies like Fisheries and Oceans Canada the pertinent degree of the project and its internal strength.

- The Nature Trust of BC
- The Ministry of the Environment
- Cowichan Tribes
- Cowichan Stewardship Roundtable
- Somenos Management Committee
- Somenos Basin Technical Committee
- Oceans and Fisheries Canada
- Ducks Unlimited Canada
- The District of North Cowichan
- Cowichan Watershed Board
- BC Lake Stewardship Society
- Cowichan Valley Naturalist in respects of invasive/native vegetation

2.5.10 Additional Recommendations

- Acquire land around the Richards Creek and add it to the Somenos Management Area. This land is of high ecological importance and the current Management Area fragments this area. Typical financial incentives for acquiring land include: tax incentives for donating land as conservation easements, land covenants, and stewardship programs. Richards Creek, although outside of the Management Area, is the most substantial tributary of the Somenos Basin, and is connected with the most amount of farmland. It is the most extensively used stream by Coho salmon (Williams & Radcliffe, 2001, p. 24), at this period of time.
- Develop a commission to encourage the implementation of integrated water management approach to propel the implementation of rainwater, LID and green infrastructure, working top down, not bottom up across the watershed. Work with the Province's *Water Sustainability Action Plan, Ling Water Smart: BC's Water Plan,* and *Stormwater Planning Guidebook*. The Province has also provides two websites to assist those implementing LID techniques**-** *www.waterbucket.ca*, and *www.waterbalance.ca.*
- Develop bioretention techniques like sediment and oil traps along highway to help remove heavy metals and petrochemicals from highway pollution. A report by the EPA on the effectiveness of LID techniques noted: "In general bioretention areas were found to be effective in reducing runoff volume and in treating the first flush (first ½ inch) of stormwater. Results from three different studies indicate that removal efficiencies were quite good for both metals and nutrients. Removal rates for metals were more consistent than for nutrients. Removal rates for metals ranged from 70–97% for lead, 43–97% for copper and 64–98% for zinc. Nutrient removal was more variable and ranged from 0–87% for phosphorus, 37–80% for Total Kjeldahl Nitrogen, <0–92% for ammonium and for nitrate <0–26%" (B, 2000).

- Get First Nations involved as soon as possible.
- Enforce the Federal Fisheries Act.
- Section 909 concerning biocides regulation (DNC, 2011).
- Environmental Development Permit Areas.
- Implement a ban on the sale of invasive species.
- Catalogue and map spatial features in the Somenos Basin, and upload this data to an online community mapping initiative such as the Community Mapping Network: http://www.cmnbc.ca/ to add to the strength of a comprehensive provincial database.
- Use of EcoTraction instead of road salts. EcoTraction is a "100 percent green product" (EcoTraction, 2012) that can be used as an alternative to road salts used for winter road traction. Salts used on roadways during the winter eventually dissolve and often end up in adjacent habitats, including groundwater. EcoTraction's website even asserts that their product "improves soil aeration as well as water and nutrient retention, reducing water and fertilizer requirements" (EcoTraction, 2012).
- **Nature center -** Often overlooked, maintaining a healthy ecosystem requires an appreciation of the importance that the natural environment and biological diversity has for people. It is a recommendation of this report that a nature center should be built in the Somenos Basin to help facilitate the reconnection between humans and the environment; and to bring more tourists to North Cowichan. Through a Nature Center, people could learn about history, local biodiversity, and resource management. A Nature Center could provide nature enthusiasts with: binoculars, umbrellas, maps, souvenirs, nature guides, and warm beverages. A portion of the money earned through the Nature Center should go towards environmental stewardship.

2.6 Successful Examples

- This project would like to emulate the works Ducks Unlimited Canada did with the property adjacent to the BC Forest Discovery Center and Averill Creek. Ducks Unlimited dug deep ponds and diked off an area of flats to create a shallow water wetland system. This created wetland has increased the number of winter and summer birds (Edwards & Greig, 1988, p.6).
- In 2012, Cowichan Land Trust and their partners constructed seven wetlands in the Quamichan Basin, adjacent to the Somenos Basin. The wetlands were created to increase wildlife habitat, and help treat water quality. After one month, animal and vegetation species are expected to colonize. There were four large wetlands (approx. 100m in diameter) and three smaller wetlands (approx. 50m). The planting of vegetation was done by seed (grass only), transplanting, and live staking. The planting was done in the fall to allow the plants sufficient time to establish as they lay dormant through the fall and then begin to grow around February (Reitzel, 2012).
- "Using the purification capacity of wetlands, the Indian city of Kolkata (Calcutta) has pioneered a system of sewage disposal that is both efficient and environmentally friendly. Built to house one million people, Kolkata is now home to over 10 million, many living in slums. But the 8,000-hectare East Kolkata Wetlands Ramsar Site, a patchwork of tree-fringed canals, vegetable plots, rice paddies and fish ponds – and the 20,000 people that work in them – daily transform one-third of the city's sewage and most of its domestic refuse into a rich harvest of fish and fresh vegetables" (Ramsar, A, 2012).
- "The economic value of the purification function of wetlands can be huge. In 1997, New York City found that it could avoid spending US$3–8 billion on new wastewater treatment plants (with US$700

million in annual operating costs) by investing just US$1.5 billion in land purchase and conservation management measures to protect wetlands in the watershed – wetlands that would do the job of purifying the public water supply for free" (Ramsar, A, 2012).

- "In Florida, the Everglades Nutrient Removal Project involved a 1,544-hectare constructed (artificial) wetland designed to reduce the amount of phosphorus entering the Everglades – a Ramsar Site – from agricultural runoff. Since flow-through operations began in the mid-1990s, observations indicate that the outflow of total phosphorus concentrations, on average, have been about five times lower than inflow concentrations" (Ramsar, A, 2012).
- "Toronto is installing tanks and tunnels to capture and hold Combined Sewer Overflows and stormwater-and subject them to ultraviolet light to kill bacteria before the water is slowly released into the lake. In addition, the city will utilize a technique known as flow balancing to capture runoff and treat it thought the use of ponds and wetlands. The City's Wet Weather Flow Master Plan calls for the creation of 180 ponds/wetlands" (McGuire, & Wyper, et al, 2010, p.97).
- "Calgary is planning to systematically retrofit infrastructure in older neighbourhoods. The City has identified 37 potential sites for the construction of Storm Water Quality Retrofit projects. The projects consist of retention ponds to capture stormwater before it enters a waterway and man-made wetlands to naturally filter out sediment and other impurities" (McGuire, & Wyper, et al, 2010, p.97). Recent wetland project in Calgary include: "East Village treatment facility- a series of constructed wetlands that will take rainwater from city streets and sewers, remove sediments and other contaminants, and treat water before discharging it into the Bow River" (McGuire, & Wyper, et al, 2010, p.97); and, "Shepard Stormwater Diversion Project, which will intercept stormwater from a large area of the City and pass it through a 560-acre constructed wetland that will filter the water before release into the River" (McGuire, & Wyper, et al, 2010, p.97).
- "London, Ontario has constructed two engineered wetlands and 60 wet ponds to manage and clean stormwater. Construction of approximately 80 wet pond facilities is planned for the next 10-20 years" (McGuire, & Wyper, et al, 2010, p.97).
- "The Deepwater Horizon spill oiled coastal wetland ecosystems along the northern Gulf of Mexico. We present data on probable impacts and recovery of these impacted wetlands. Based on numerous greenhouse and field studies conducted primarily in coastal Louisiana, we suggest that marsh vegetation will recover naturally without need for intensive remediation" (DeLaune, & Wright, 2011, p.i).

2.7 Conclusion

In summary, the project goal for this report is: *To enhance the function and utility of the Somenos Basin using restorative wetland techniques*. The project's scope limits the study with two stipulations: development must be within the boundary of the Somenos Management Area, and the development must intercept a tributary creek. Through further refinement, an objective of this research aims to produce an ecological design solution that meets the project goal through a triple bottom line principal that benefits the People, the Planet, and Profit. This report recommends restoring a complex of wetlands in the south Somenos Basin located in The Nature Trust of BC's property. This area has been selected because it is included in the Somenos Management Area, as well because of its topography, and proximity to a major creek. This project is a blend between stream restoration and wetland/riparian habitat restoration.

It is the recommendation of this report to meet the project goal through the implementation of the Principal Recommendation. The Principal Recommendation of this report calls for a phased wetland complex restoration with a special emphasis on environmental remediation in order to enhance the function and utility of the Somenos Basin. A phased sequence design promotes efficient ecological enhancement, mitigation of potential environmental impacts, use of financial resources, and time to design and implement a master plan.

Traditional agriculture in the southern Somenos Basin is becoming increasingly uneconomic as the farmer fights against the loss of agricultural product and land through annual flooding and willow scrub secession. It is also logical that North Cowichan's proposed diking system will increase the amount of water the Basin has traditionally held during flood months, potentially exacerbating a hindering problem for agriculture. There exists a structural hydrologic conflict between traditional agriculture and traditional waterfowl habitat, and it comes by way in which water is viewed. Traditional agriculture seeks to increase the confluence of water, attempting to remove excessive water as fast as possible. Wetlands, on the other hand, seek to retain water by slowing it down. In order to efficiently facilitate both wetland and agriculture, the structural and planning paradigm needs to adapt to work synergistically with each other's needs. It is the recommendation of this project that alternate agriculture crops should be explored. Agriculture in the Basin should be dynamic, and working with the natural seasonally flooded land. Blueberries and honey appear to be very attractive choices.

The District of North Cowichan is built on a low-lying floodplain, and as such, experiences periodic flooding. Wetlands are known for their ability to act as flood/drought ameliorators. Developing wetlands into urban or residential area removes this ecologic buffer and can exacerbate urban flooding. A wetland restoration project in the Somenos Basin offers a distinctive opportunity to alleviate pressures of flood waters.

As global climate change alters precipitation patterns (Ramsar, A, 2012) the situation for wetlands become even more precarious. The significance of the Somenos Basin wetlands "can only increase as wetlands become increasingly rare everywhere" (Radcliffe, 1990, p. 4).

One of the most imperative objectives that needs to be sought is further scientific study and exploration of pertinent variables within the Somenos Basin. Doing so can allow the creation of an efficient tailor-made restoration project, of which effects can be gauged. Only when there is a concrete understanding of natural fluctuations and patterns can a truly effective wetland restoration project commence.

Human civilization has unfortunately, over time, put considerable amount of pressure on the potential ecological capacity of these wetlands. “The decline of biodiversity in the area has been identified as a management issue due to the increase in human impacts on natural habitat” (Rehbein, 2004, p. 122). Worldwide, wetlands are disappearing at an alarming rate (Ramsar, A, 2012). Historically, in North Cowichan, the loss of wetlands are primarily due to the draining and ditching of wetlands to create agriculture land, and urban encroachment that fills in wetland/riparian area in order to create suitable land to develop on. Further degradation of the environment comes from polluted stormwater that introduces into local streams an abundance of nutrients from farms, heavy metals, petrochemicals and much more. Diminished lake water quality and eutrophication that occurs during the summer leads to a wall of limiting factors for aquatic species. It is in the tributaries like Bings Creek that act like an imperative cool water refuge for fish and spawning (Williams & Radcliffe, 2001, p. 24).

The Municipality of North Cowichan openly recognizes “that the ecosystems and watersheds we occupy are under considerable strain” (OCP, A, 2011, p. 25). The Municipality has shown that the gradual impetus to conserve and protect wetland environments comes into direct contestation with classic urban design models of the past. While the world is facing turmoil such as population growth, climate change, new urban planning ideas like Site Adaptive Design, New Urbanism, Smart Growth, Low-impact Development, and Green Infrastructure promise a new outlook. The Municipality of Cowichan is in a transitory period where documents like the Cowichan Basin Management Plan express the desire to change the current paradigm, Cowichan’s Flood Upgrade of 2012 project, although sensible, further cements the old way of treating water. This recommended project allows for the chance to not only restore a wetland habitat, but to also increase knowledge and awareness of resource management issues, and an increased profit from alternative agriculture crops and/or the implementation of a nature center to attract tourists.

Perhaps one of the most beneficial outcomes of the many recommendations made in this report is a strengthening of the harmony between natural systems and the humans that inhabit their landscapes. If implemented, a wetland complex would be enjoyed and appreciated by local wildlife, the Municipality of North Cowichan, and all nature enthusiasts.

Restoring wetlands will improve the Somenos Basin through wetlands’ natural amenities such as water purification, biodiversity, flood control, recharge aquifers retain/remove sediments and nutrients, climate change mitigator, and an opportunity to act as great wildlife viewing area. Wetlands are pivotal ecosystems that are intrinsically connected to the hydrological cycle and provide a diverse habitat where a strong biodiversity of plants and animals can flourish. A healthy wetland ecosystem provides valuable environmental services for both wildlife and humans alike.

3.0 APPENDIX

- **Water Balance**
  Below are water balance formulas that can be used to do a preliminary balance of the test site using known data, and formulas for wetland sizing:

1) Change in volume of water storage per unity time:
   $\Delta V/\Delta t = (P - ET) + (S_i - S_o) + (G_i - G_o)$

   $\Delta V/\Delta t$ = Change in volume of water storage per unity time
   P= precipitation
   ET= evapotranspiration
   S_i= surface inflows
   S_o= surface outflows
   G_i= groundwater inflows
   G_o= ground water outflows (Mitsch & Gosselink, 2000, p.119).

2) Surface runoff into a wetland:
   $S_i(\text{runoff}) = P \times R_c \times A_w$

   S_i(runoff)= surface runoff into wetland (m^3)
   P= average precipitation in watershed (m)
   R_c= hydrologic response coefficient (proportion of precipitation that becomes direct surface runoff. Typical flat pasture is 30%, therefore the R_c would equal 0.3 Rehbein, 2004, p. 116).
   A_w= area of contributing watershed (Mitsch & Gosselink, 2000, p.128).

3) Peak Streamflow
   $Q = I \times R_c \times A_w$

   Q= peak streamflow at the outlet of the catchment (m^3/s)
   I= rainfall intensity (m/s)
   R_c= hydrologic response coefficient
   A_w= area of contributing watershed (Marsh, 1998, p.151).

4) Surface area of a marsh cell
   $SA = (\pi \times W/2 \times L) / 2$

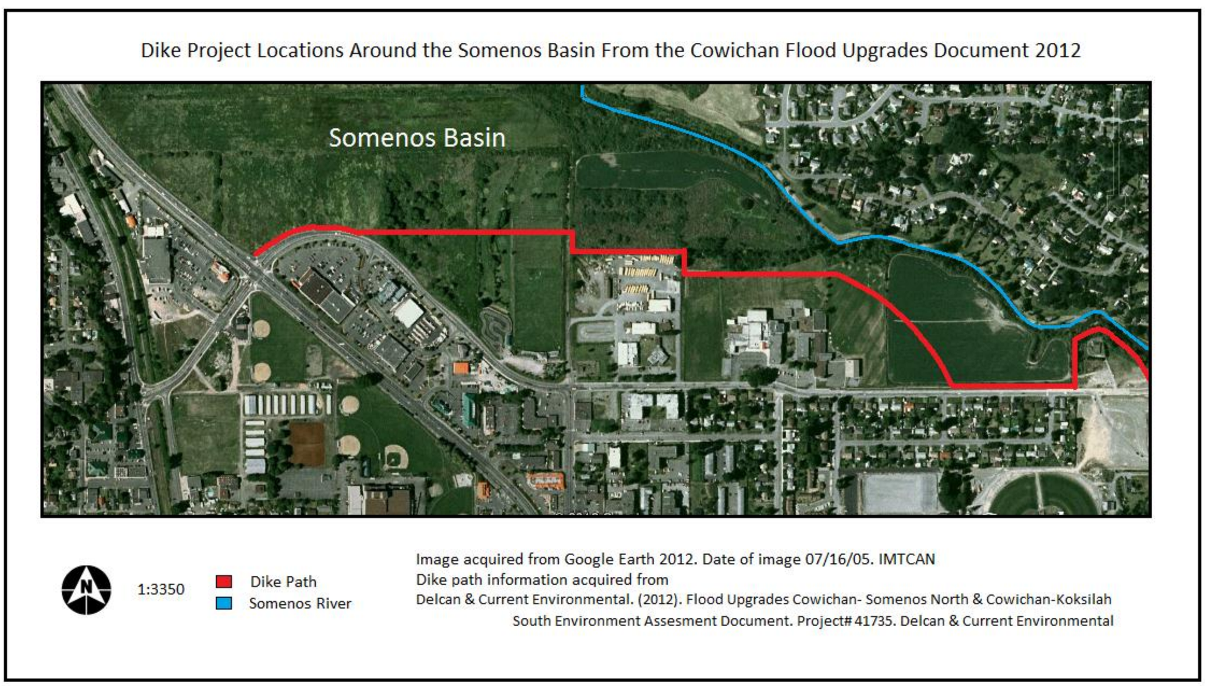
   SA= surface area of marsh cell (approximately ½ an ellipse)
   W= width of the marsh cell
   L= length of marsh cell (Rehbein, 2004, p. 113).

- **Dike Specifications**

Dike specifications around the Somenos Basin								
	Proposed Feature			Anticipated Footprint		Alterations		
	Max length (m)	Max Width	Area (m^2)	Riparian (m)	Watercourse (m)	Permanent (m^2)	Temporary (m^2)	Compens-ation (m^2)
Beverly Road Dike	1,847	18	34,078	2,854	151	151	2854	301
York Road Dike	21	20	420	214	71	71	0	143

Table 4 Data from: Delcan & Current Environmental, 2012, p.24.

- **Dike Project Locations Map**



Map 4

- **Subterranean Cistern**

  If agriculture is still desired in the Somenos Basin, and if soil nutrients remain a problem, then this report recommends the instillation of a subterranean cistern that collects high nutrient water. Water can be collected by via overflow spout that collects water when flood waters arise, or through underground receptacles that have filtration capabilities. Having a subterranean cistern expands the water carrying potential of the basin, and can be used to irrigate nutrient poor soils with nutrient high water.

- **Regulatory Environmental Bylaws**
  There exists a number of ways to protect/conserve environmental amenities through the use of legislation. The following is a list of governmental regulation tools that can be used to facilitate habitat restoration in the Somenos Basin:

Municipal- Local Government Act
DNC, A. (2011). Official Community Plan Bylaw. Bylaw 3450. District of North Cowichan. North Cowichan, BC.

→ Section 540 - A board may, by bylaw, regulate and prohibit design and installation of drainage and sewers works. This section would allow source pollution control regulations.
→ Section 542 - A board may establish requirements for the construction of dikes, works to maintain the proper flow if the stream/ditch/drain/sewer, or works to reclaim or protect part of the land mass of the regional district from erosion.
→ Section 548 - This section deals with interjurisdictional watercourses. A board can make agreements with adjacent municipalities, regional districts, or a owner of land on a watercourse in order to: construct, enlarge, or maintain a culvert, ditch, flume or other work.
→ Section 796.2 - Gives local government the right to regulate services including: over time/area, different persons, licenses, permits, bylaw, and circumstances.
→ Section 849(2) - Purpose of a Regional Growth Strategy should include protecting the quality and quantity of ground and surface water.
→ Section 907 - This section gives local governments the authority to establish runoff control requirements. Local government may require a land owner who carries out construction of a paved area, or roof area, manage and provide the ongoing disposal of surface runoff and stormwater.
→ Section 909 - Gives local governments the jurisdiction to require standards for landscaping in order to preserve, protect, restore, and enhance the natural environment. This is an excellent way to implement low-impact development/green infrastructure.
→ Section 919.1 - Site specific development requirements that shape the construction of new developments that can protect natural environments, its ecosystems, and biological diversity.
→ Section 920 - Allows protected areas the sanction to be preserved, restored, or enhanced. Ability to require dedication to natural watercourses. Specify protection measures including planting or retaining vegetation or trees in order to conserve, protect, restore or enhance fish habitat or riparian areas.
→ Section 933.1 - Development for which charges may be waived or reduces for eligible developments that result in a low environmental impact.

Provincial- Environmental Management Act
Province of British Columbia, B. (2003). Environmental Management Act. Victoria, BC.

→ Section 24(1) - Gives local governments the jurisdiction to implement a Waste Management Plan to gain authority over municipal liquid waste.

Provincial- Community Charter
Province of British Columbia, A. (2003). Community Charter. Victoria, BC.

→ Section 70 - Allows a provincial council to consider the drainage of service water from inside/outside a municipality to prevented, diverted, or improved.

Provincial- Water Act
Province of British Columbia, C (2003). *Water Act*. Victoria, BC.

→ Section 2 - This section delineates stream water in BC to be property of the Provincial Government, except private rights and licenses.
→ Section 5-7 - Water licensees and who may acquire them.
→ Section 9 - "Changes in and about a stream"- require written approval from the comptroller, regional water manager or minister of the Crown.

Federal- Fisheries Act
The Government of Canada, B. (1985). *Fisheries Act*. Ottawa, Ont.

→ Section 35 - Prohibits any work or undertaking that results in harmful alteration, disruption or destruction of fish habitat
→ Section 36 - Prohibits the dumping of deleterious materials in a river used by fisheries.

- **Funding Sources**
  The following are potential environment related grants that could be obtained to help fund development.
  - EcoAction: www.ec.gc.ca/ecoaction
  - EnviroPod: www.centreforsustainability.ca/programs/EnviroPOD.html
  - Columbia Basin Trust- The Environmental Initiates Program:
  - http://www.cbt.org/newsroom/?view&vars=1&content=Program&WebDynID=88
  - Vancouver Foundation- Green City Generation Green Grants: http://www.vancouverfoundation.ca/greenestcityfund/generationgreengrants/
  - Mountain Equipment Coop: http://www.mec.ca/Main/content_text.jsp?FOLDER%3C%3Efolder_id=1408474396038943&FOLDER%3C%3EbrowsePath=1408474396038943&bmUID=1203699307979&utm_source=July+-+August+2012&utm_campaign=SOSCP+Feb+newsletter&utm_medium=email
  - Habitat Conservation Trust Fund: www.hctf.ca
  - Habitat Stewardship Program: www.cws-scf.ec.gc.ca/hsp-pih/
  - TD Friends of the Environment: www.fef.td.com/funding.jsp

- The Ivey Foundation: www.ivey.org/programs/ccforests.html
- Shell Environment Fund: www.shell.ca/sef
- Evergreen: www.evergreen.ca
- BC Agriculture Environment and Wildlife Fund: www.ardcorp.ca
- Brainerd Foundation: www.brainerd.org
- Real Estate Foundation of BC: www.realestatefoundation.com
- Endswell Foundation: www.renewalpartners.com
- RBC Blue Water Project: http://www.rbc.com/community-sustainability/apply-for-funding/guidelines-and-eligibility/blue-water-pre.html
- Turner Foundation: www.turnerfoundation.org
- Weyerhauser Company Foundation: www.weyerhauser.com
- Weeden Foundation: www.weedenfdn.org
- BC Hydro Community Investment Fund: www.bchydro.com
- Public Conservation Assistance Fund: www.hctf.ca
- Vancity Grants: www.vancity.com
- Columbia Valley Local Conservation Fund: www.ekcp.ca
- Conservation Maven: www.conservationmaven.com
- Pollinators Resource Center: www.xerces.org/pollinators-pacific-northwest-region

- **Additional Resources:**
  - Peeling Back the Pavement a Blueprint for Reinventing Rainwater Management in Canada's Communities. Susanne Porter-Bopp, Oliver M.Brandes et al. 2011
  - The Soft Path for Water in a Nutshell
  - Thinking Beyond Pipes and Pumps
  - Worth Every Penny: A primer on Conservation-orientated Water Pricing
  - www.gvrd.bc.ca/park
  - www.naturalhistory.bc.ca
  - www.wetlandscanada.org
  - www.bcwf.ca
  - www.rainfrog.ca
  - www.bcwetlands.ca
  - www.pskf.ca
  - www.lagoonsociety.com
  - www.Ramsar.org
  - www.ducks.ca

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