Nanaimo River Watershed Baseline Report
2nd Edition

Social, Environmental and Economic Values
of the Nanaimo River Watershed.

NALT
NANAIMO & AREA LAND TRUST

Nanaimo
River
Watershed
Roundtable

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Message from the Nanaimo & Area Land Trust Board

Dean Gaudry and Dale Lovick

NALT Board Co-chairs

While the work that went into developing the chapters of this report and the information that has been assembled is truly impressive (and largely voluntary), it needs to be stated that, as with any document which has not had the benefit of peer review, opinions about the accuracy of the contents may vary from chapter to chapter. Rather than try to homogenize the style and content of the chapters, it was a decision of the Baseline Subcommittee to retain these distinct voices as a reflection of their position as Nanaimo River stakeholders.

NALT would like to personally thank all of the contributors for the time and commitment each gave to this attempt to compile a comprehensive baseline report about the Nanaimo River and its watershed. We also thank the members of the Baseline Subcommittee for the many, many hours they spent designing, developing and guiding the first incarnation of this document.

The Second Edition of the Nanaimo River Baseline Report (2014) is the continuation of a work-in-progress. This edition benefits from the work provided for the first edition of this report. Thanks to Jessica Korrol for providing many of the maps carried forward from 2011 and thanks to Carra Simpson for the layout and design which this edition is built on. Originally, the Baseline Subcommittee identified twelve aspects of the river they felt deserved a chapter in the report; however, for the first edition, only nine chapters were completed for the Symposium. In the second edition, new information includes: a Water Budget Study prepared by Waterline Resources Inc. for the Regional District of Nanaimo; a Fish Habitat Enhancement Update; and Biogeoclimatic and Terrestrial Habitat Reports for specific properties in the watershed.

FOREWORD
FROM THE FIRST EDITION

JOE STANHOPE

REGIONAL DISTRICT OF NANAIMO BOARD CHAIR

The Nanaimo River Baseline Report provides a unique overview of the Nanaimo River watershed and the economic, social and environmental significance of the River. The Nanaimo River watershed contributes to our community - as the source of clean drinking water to over 86,000 residents, habitat for healthy fish and wildlife populations, refuge for species at risk, land base for local food production, location of some of the most productive forest lands in Canada, outdoor recreational jewel, and home to many local residents.

Through the Drinking Water and Watershed Protection Program, the Regional District of Nanaimo is committed to improving our understanding of local water resources and working with land use planners and communities to enhance awareness of our local water resources in order to protect drinking water and watershed health. The RDN commends the Nanaimo and Area Land Trust for developing the Nanaimo River Baseline Report and sharing an understanding of, and promoting a desire to protect, the Nanaimo River watershed.

The Baseline Report is accessible to the community and provides a wealth of information in a form that is interesting, informative, and understandable to both non-technical and technical readers. A unique collection of expert contributions highlights the diverse array of values of the river and surrounding watershed. Never before has such a wide range of information from local experts on the Nanaimo River been brought, into a single, accessible document for the community.

I encourage you to read this Report and consider the many values of the Nanaimo River watershed. We all live in a watershed, and we all have a role to play in protecting watershed health.

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About the Authors

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David has worked with restoration and assessment projects since 1981. He won the National Recreational Fishery Award in 2010 in recognition of his work with stewardship organizations. The Nanaimo River is the first river he swam in as a child.

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Matt Kellow, MA

Matt was born and raised on southern Vancouver Island and currently lives with his wife and three children on Salt Spring Island. He has worked at VIU as an Outdoor Recreation instructor for 13 years where he has the privilege of introducing students to the natural environment through recreation. When not working or mucking around with his kids, Matt can be found outside participating in all kinds of different adventure sports, and he spends a considerable amount of time during the year whitewater kayaking on the Nanaimo River.

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Morgan was born and raised around the Lower Mainland and currently resides in Nanaimo where she is the Manager of Sustainable Timberlands and Community Affairs for Island Timberlands Limited Partnership. She has worked in the planning and reforestation aspects of forestry for almost 13 years, as well as bioproducts and bioenergy in Alberta. Morgan holds a strategic role at Island Timberlands to formulate, plan and communicate multiple resource management opportunities inside and out of the many watersheds we own land and manage forests within. Morgan has a keen interest in the outdoors, particularly hiking and sea kayaking within the region.

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Bernadette relocated to Nanaimo with her family from Calgary. She is a Geological and Water Resources engineer with over 13 years consulting experience on a variety of surface water and groundwater related projects in Canada and abroad. As part of this project, Bernadette has enjoyed the opportunity to explore the Nanaimo River and learn about her family's water supply.

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Joe has been living on, and exploring nature on, Vancouver Island for more than 26 years. He is the principal biologist for an Island-based wildlife consulting firm, providing wildlife inventory and habitat assessments for public and private-sector clients. Joe's personal experience of the Nanaimo River Valley has included hiking up Green Mountain, fishing the higher lakes, swimming in the lower river, and birding in the estuary.

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Brad is a graduate of the Vancouver Island University Fisheries Program in 2007. He has worked as a restoration and assessment biologist on freshwater and marine shore projects on most of Vancouver Island, much of his work has been in developing and implementing restoration plans with stewardship groups.

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Mayta has spent many years living and farming in the Cedar area and is integral to the Cedar Farmer's Institute. A retired schoolteacher, Mayta is actively involved in many community issues, with a special interest in agriculture and water.

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Pam has been a land use planner for more than 28 years and is a Professor in the Geography Program at Vancouver Island University. She is an elected Senator for VIU, a Council Member for the Planning Institute of BC, and her current research focuses on community-based participatory research and adaptive co-management processes. Pam's first text book titled, "*A Field Guide to Communication*" was published in 2008 with Oxford University Press. Her second book "*Boxed In: Searching for the Public Good in Urban Planning*" is under development.

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Matt holds an MSc in Earth and Ocean Sciences from the University of Victoria, an Advanced Diploma in GIS from Vancouver Island University, and has over 10 years of experience in geological sciences with a specialization in information technology. Matt has worked on municipal GIS relevant to Planning, Public Works and Engineering on behalf of the City of Port Alberni, District of Tofino and Regional District of Nanaimo. Since joining Waterline as a Project Geologist in January 2012 Matt has advanced the use of GIS technology in groundwater studies, data management and 3D geological modeling. Matt has designed and implemented spatial databases for managing groundwater, hydrology, geology, and water monitoring related data. These databases provide the framework for science-based decision making in the areas of surface water and groundwater.

Craig Sutherland, MSc, PEng

Craig Sutherland is a professional engineer with a strong technical background in hydraulic modelling of rivers and floodplains, assessment of urban stormwater systems, and hydrological analysis of urban and rural watersheds. He has prepared dam safety reviews, emergency preparedness plans, dam breach inundation studies, as well as designs for hydraulic structures for dams, reservoirs and irrigation works. He also is undertaking several studies for micro-hydro facilities and has a keen interest in climate change assessment and its impact on water resource infrastructure.

Jessica Wolf, BSc

Jessica is a biologist and nature awareness mentor. She was involved in the protection of the Ayum Creek estuary in Sooke BC, and many other environmental initiatives. When not delivering workshops on edible wild plants and mushrooms, Jessica can be found swimming in the Nanaimo River or foraging for food along its banks.

INTRODUCTION

The initial impetus for this report was to serve as a reference document for the 2011 Nanaimo River Symposium organized by the Nanaimo & Area Land Trust. A Baseline Subcommittee was formed to gather the information included in the first edition of this report, released at the Symposium on the Rivers' Day weekend of 2011.

Since the Symposium and release of the report, a number of stakeholders in the Nanaimo River watershed, representing residents, environmental organizations, recreational groups, departments of municipal, provincial and federal government and industry, have formed the Nanaimo River Watershed Roundtable. The mission of the Roundtable is *to advise and develop strategies and initiatives for the long-term promotion, protection, sustainability and stewardship of the watershed*.

It has always been the intention that the Nanaimo River watershed Baseline Report would be a living document, with new information added to future editions of the document. In the second edition, Water Values are considered in two chapters: the information reprised from the first edition is augmented with an additional chapter on a Water Budget for the watershed. As well, Fish Values are addressed in two chapters: the original report of the first edition and an updated report on fish habitat in the Nanaimo River and some significant tributaries. The second edition also includes new information on the biogeoclimatic values and terrestrial habitat values of properties now in transition from forestry use to residential. These properties, the Couverdon properties, are currently being considered by the Nanaimo & Area Land Trust for acquisition to add to parkland in the watershed.

It is important to note the support of two funding agencies that have been instrumental in the production of this edition of the report. The Pacific Salmon Foundation – Community Salmon Program provided funding for the production of the Fish Habitat Update and the Thrifty's Foods Smile Card Program provided the funds to print and distribute the report. It is also important to recognize the Regional District of Nanaimo for distilling a Water Budget Study for the entire region, down to the information pertaining to the Nanaimo River watershed and aquifers for this report. Both Dawn Keim and Julie Pisani were instrumental in adapting the Water Budget Study to fit the scope of this Baseline Report.

This report would be remiss not to recognize that the Nanaimo River and watershed are part of the traditional territory of the Snuneymuxw and Stz'uminus First Nations. It is hoped that future editions will include a chapter or chapters expressing First Nations points of view in relation to watershed values.

SURFACE AND GROUNDWATER

BERNADETTE LYONS, MSC.E., P.ENG

Overview

The diverse array of values generated by the Nanaimo River watershed – ranging from recreation to fisheries to the provision of clean drinking water - all depend to some extent on the flow of water. This chapter explains the flow of water through the watershed, and how consumptive users and other stakeholders benefit from and affect the quantity and quality of water in the Nanaimo River. The chapter also explains how the surface water in the lower reaches of the Nanaimo River and its tributaries is intricately linked to groundwater contained in Cassidy aquifers that exist beneath the river system. These aquifers provide water supply to area residents and industry and contribute to river baseflow[1] that is vital to maintaining the health of the Nanaimo River system.

Surface water

The Nanaimo River originates from Mount Hooper and flows 78 km to its mouth at the Nanaimo River Estuary, which is located at the south end of the Nanaimo Harbour (Figure 1). Over its course the Nanaimo River and its tributaries drain an area of approximately 813 km^2 (1). The major tributaries of the Nanaimo River are North Nanaimo River, South Nanaimo River, and Haslam Creek. The watershed includes two natural lakes (First and Second Nanaimo Lakes) that are both situated on the North Nanaimo River.

Three major manmade structures control flow on the Nanaimo River. These structures are the Jump Creek Dam, the South Fork Dam, and the Fourth Lake Dam. The City of Nanaimo operates the Jump Creek Dam and the South Fork Dam to supply water to the Snuneymuxw First Nation, the City of Nanaimo's residents, and the South West Extension Improvement District (2). These dams are located on Jump Creek and the South Nanaimo River, respectively. The area of the watershed upstream of the dams covers approximately 230 km^2. The storage capacity of the two dams is estimated at 18.6 million m^3 (3).

The Fourth Lake Dam and reservoir is located on Sadie Creek in the upper reaches of the North Nanaimo River catchment, and is operated by Harmac Pacific (Harmac). The reservoir is used to supply water to Harmac's Northern Bleached Softwood Kraft (NBSK) pulp mill located outside the watershed at Duke Point. The storage capacity of this reservoir is estimated at 38 million m^3 (4).

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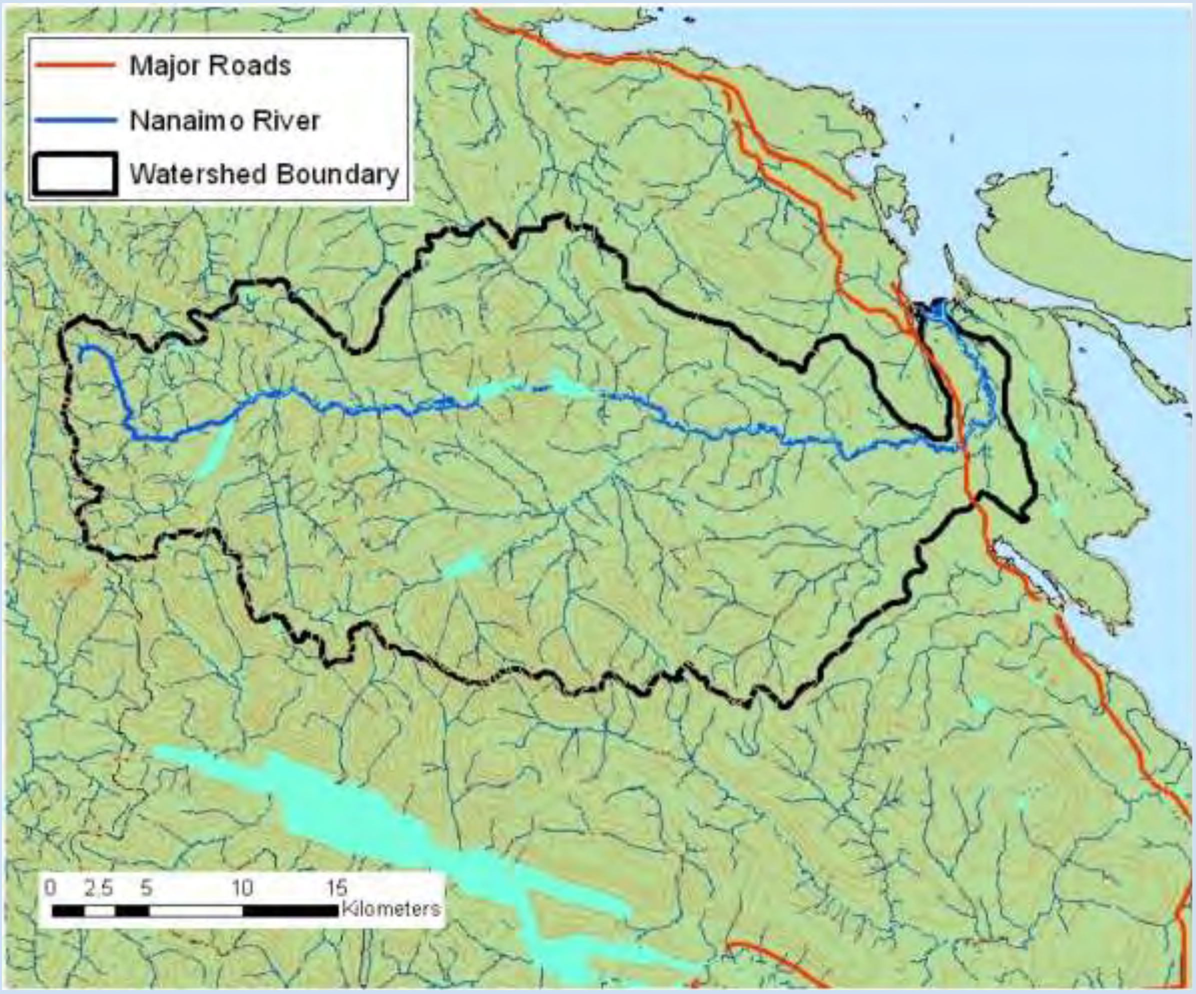
[1] Baseflow is that portion of a river's flow that comes from deep subsurface flow and delayed shallow subsurface flow.

Figure 1: The Nanaimo River watershed.



Water Flow

There are two active Water Survey of Canada (WSC) hydrometric monitoring stations in the watershed. Station 08HB034 is located on the Nanaimo River at Cassidy, and has information available from 1965 to present. This station measures a drainage area of 684 km^2. Station 08HB092, located on the South Nanaimo River upstream of its confluence with the mainstem, has information available from 1997 to present for a drainage area 211 km^2. Both stations are located downstream of the reservoirs and therefore measure regulated (i.e., influenced by storage management) water flows.

Information on water flow is also available from four discontinued WSC hydrometric stations:

- 08HB005 Nanaimo River near Extension, 1913-1927 and 1948-1964, drainage area 645 km^2
- 08HB033 Nanaimo River above Rockyrun Creek, 1963-1964, drainage area 75.6 km^2
- 08HB041 Jump Creek at the Mouth, 1970-1988, drainage area 62.2 km^2
- 08HB003 Haslam Creek near Cassidy, 1914-1915 & 1949-1962, drainage area 95.6 km^2

The data from the Nanaimo River near Extension Station (08HB005) are particularly useful because they provide a record of natural (unregulated) flows in the Nanaimo River. Fourteen years of data are available (1913-1927) prior to the construction of the South Forks Dam, which was built in 1930 (3).

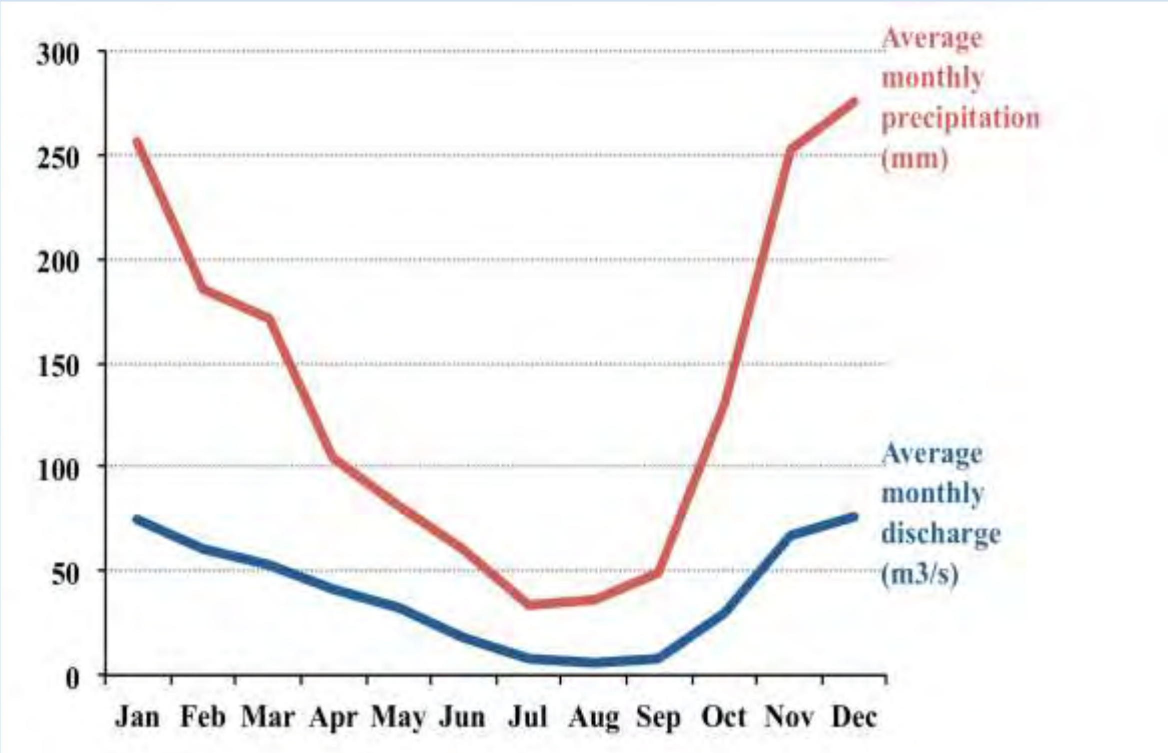
The distribution of flow throughout the year is illustrated in Figure 2, which shows the mean monthly discharge for the period from 1965-2006 at WSC station 08HB034 in the Nanaimo River at Cassidy. High flows generally occur in November, December or January. Low flows most often occur in August but can occur in July or September. The highest mean monthly flow on record was measured at 174 m^3/s in November of 2009 (5). The lowest mean monthly flow on record was measured at 3.01 m^3/s in July of 1992.

Figure 2 also shows the mean monthly total precipitation from the same time period at the Nanaimo Airport. Comparing the two datasets shows that despite the presence of three storage reservoirs in the upper watershed, the annual distribution of flows in the Nanaimo River at Cassidy varies closely with precipitation.

A comparison of regulated flows following dam construction, and natural flows (unregulated) prior to dam construction was completed using data from the discontinued WSC Gauge 08HB005 as part of the Nanaimo Water Management Plan (1). Low flows in the gauged reach were found to be higher after the reservoirs were installed than were measured under natural flow conditions. The augmentation of low flows provides an important benefit to fisheries and recreational users.

Monitoring of surface water quality by the City of Nanaimo in the catchment area of its water supply on the South Nanaimo River shows that water quality is generally very good. Occasional instances of high turbidity occur following heavy rainfall events (2). Two other water quality issues are worth mentioning. First, water quality testing done as part of the 1993 Nanaimo River Watershed Water Management Plan showed that summer bacteria levels had exceeded relevant human health standards downstream of the Island Highway. Second, late summer water temperatures may be approaching levels that are causing stress to fish. During the low flow period in late summer, water temperatures in this section have been recorded as high at 20.4 C (1)[2]. Ideal rearing temperature for fish is 18 C, and temperatures above 23 C are considered lethal.

Figure 2: Mean monthly precipitation and discharge for the Nanaimo River (1995-2006).



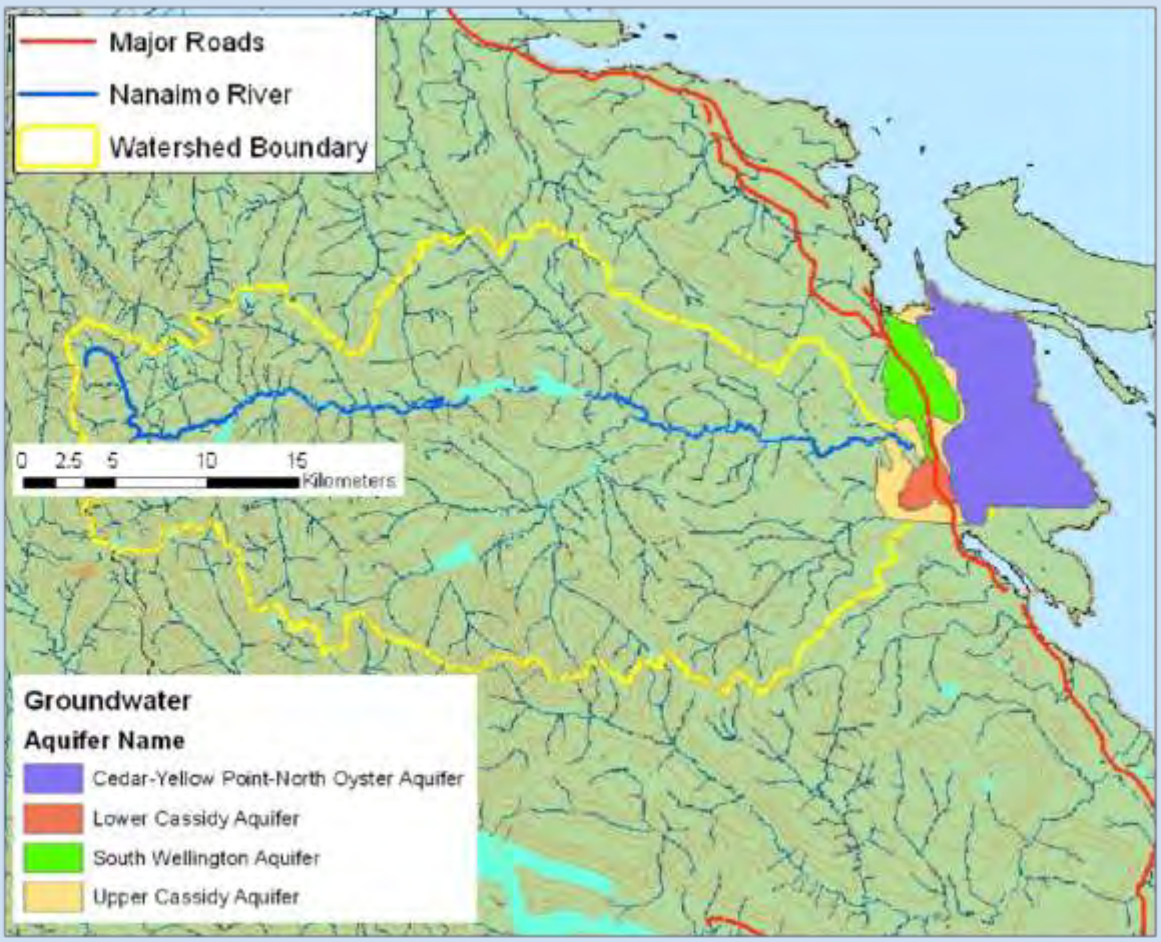
Groundwater

In addition to the surface water resource, the Nanaimo River watershed is host to the highly productive Cassidy groundwater aquifer, which also serves as a regionally significant and valued water supply. The location of the Cassidy aquifer is shown in Figure 3.

[2] This number refers to a record low prior to dam build; subsequent flow augmentation has helped reduce temperatures (C. Metherall, pers. comm.).

The Cassidy aquifer consists of the unconfined[3] Upper Cassidy aquifer and the confined Lower Cassidy aquifer. The Upper Cassidy aquifer is 6 to 26 meters thick and is composed of sand and gravel laid down by glacial and post-glacial rivers (1). The Upper Cassidy Aquifer is underlain by a clay deposit, which ranges in thickness from 6 to 30 m. The Lower Cassidy Aquifer is made up of layers of compacted sand alternating with cemented gravel and clay.

Figure 3: Aquifers of the Lower Nanaimo River.



The Upper Cassidy aquifer is likely in direct hydraulic connection with the Nanaimo River and Haslam Creek (1, 6) while it is unclear whether the Lower Cassidy aquifer is in direct hydraulic communication with the River. The water table in the Upper Cassidy aquifer is very close to surface.

[3] Aquifers are unconfined when water can directly enter from the surface to the saturated zones of the aquifer. Confined aquifers have a "confining layer" between the aquifer and surface that prevents the movement of water.

There are three BC Ministry of the Environment (MOE) monitoring wells in the Cassidy Aquifer, shown on Figure 4:

- OBS Well 228 – Cassidy near Airport, Water level recorded: 1954-present;
- OBS Well 312 – Cassidy at Boat House, Water level recorded: 1991 - present; and
- OBS Well 330 - Cassidy (Harmac), Water level recorded: 1996 – present.

Observation Well 228 is located on the watershed divide between the Nanaimo River watershed and the Ladysmith Harbour catchment and may not be representative of the groundwater conditions in the watershed. Observation Wells 312 and 330 are influenced by the Harmac pumping wells (6). Without specific information on the pumping rates of the Harmac wells, the utility of these observation wells is limited.

Generally in situations where a permeable groundwater aquifer is in hydraulic connection to a river system, the river recharges the aquifer during the period of high river flows, while the aquifer recharges the river during the low flow period in the river. Salmon and other fish may depend on the inflow of cooler cleaner groundwater during critical times in their life cycle (7). Similarly, groundwater inflows from the Cassidy Aquifers may be a significant component of baseflow in the lower reaches of the Nanaimo River during the low flow period in late summer and early fall.

The Regional District of Nanaimo completed a survey of groundwater quality in the Cassidy and South Wellington aquifers in the summer of 2011, and the results will be released publicly later in the year (8).

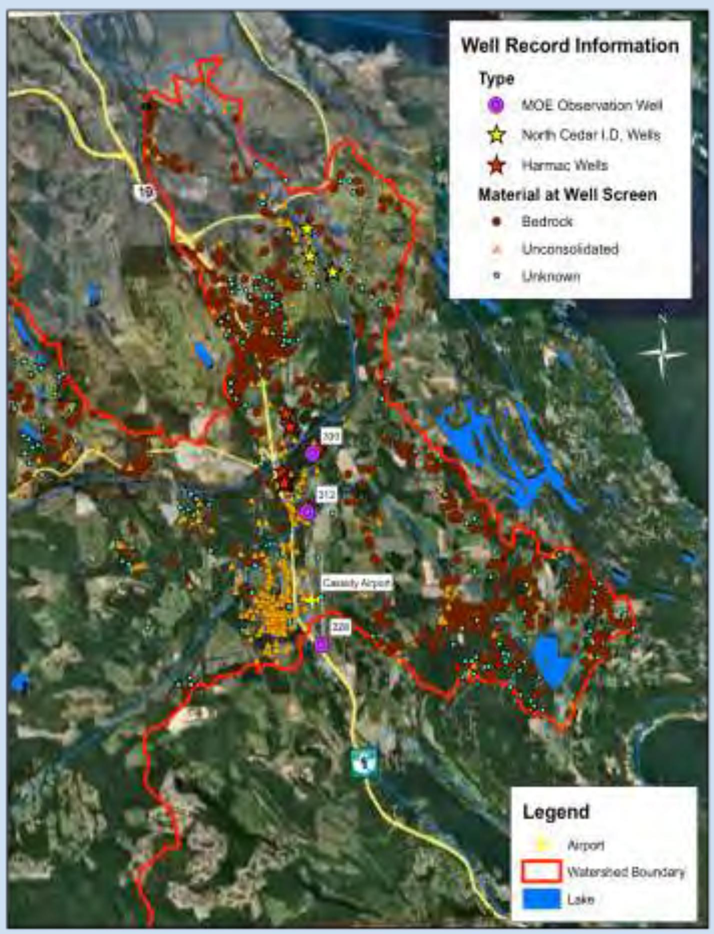


Figure 4: groundwater wells in the Nanaimo River watershed

Portions of the South Wellington and the Cedar/Yellow Point North Oyster bedrock aquifers are also situated within the Nanaimo River watershed. Groundwater divides in these aquifers coincide roughly with the Nanaimo River watershed surface water flow boundary, and groundwater flow direction within the watershed is toward the Nanaimo River and Halsam Creek.

These bedrock aquifers are unconfined and are mostly recharged by precipitation. Aquifer storage is limited and aquifer yields are low (6). Therefore, although locally important for water supply, these bedrock aquifers are not likely to contribute significant baseflow to the Nanaimo River system.

Climate change

Annual watershed yield in the South Nanaimo watershed is expected to decline 13% in the next 50 years, and a similar decrease can be expected for the entire Nanaimo River watershed (9, 10). As well, total watershed low period (June – September) yield is expected to decline up to 60% in the next 50 years.

In other words, the watershed is expected to produce slightly less water on an annual basis, but significantly less water during the dry season. Therefore, precipitation will be concentrated during winter, resulting in more severe storms and runoff events, lower snowpack and its contribution to late spring flows. This is based on the CGCM3-A2 climate model for eastern Vancouver Island, and adjusted to the Nanaimo River watershed, using flow distribution patterns from the Chemainus River gauge (since this is an unregulated river, and would reflect annual naturalized flow patterns).

STAKEHOLDERS

There are four categories of stakeholders with respect to water: consumptive water users, non-consumptive water users, land users and regulatory bodies. Table 1 briefly describes each type of stakeholder and their potential to impact or be impacted by changes in the flow and quality in the Nanaimo River.

The remainder of this section focuses on consumptive water users, as other stakeholder groups are treated elsewhere in this book.

The Nanaimo River flow is fully allocated from July to September (1). This means that no future water withdrawal licenses will be issued except for domestic use, unless additional storage is provided. However, because groundwater withdrawals are as a rule unregulated in British Columbia (7), this restriction does not apply to groundwater withdrawals from the Cassidy aquifer, even though the Cassidy aquifer is likely in direct communication with the Nanaimo River and Halsam Creek (1, 6).

The largest consumptive water user from the Nanaimo River watershed is Harmac Pacific (Harmac). The second largest user is the City of Nanaimo. Together these two users represent over 98% of the total licensed surface water withdrawal in the watershed (1). Both users are located outside the watershed.

Harmac

Harmac Pacific, a division of Nanaimo Forest Products Ltd., withdraws water from both the Nanaimo River and the Cassidy Aquifer to supply water to its Northern Bleached Softwood Kraft pulp mill located outside the watershed in the Duke Point area. Harmac stores water in its Fourth Lake Reservoir during the winter and spring and releases it to the Nanaimo River during periods of low flow, generally from early July to early October (11). The Fourth Lake Reservoir is located in the upper reaches of the North Nanaimo River (Figure 1). Harmac withdraws water from a surface water intake and a series of groundwater wells just south of the Island Highway (Figure 4). From there, the water is pumped through an above ground pipeline to the pulp mill.

In 2010, Harmac's average annual withdrawals were 61,000 m^3/day (0.71 m^3/s) of surface water and 48,000 m^3/day (0.56 m^3/s) of groundwater from wells in the Cassidy Aquifer. Total average withdrawal was 109,000 m^3/day (1.26 m^3/s) (11).

Table 1: Nanaimo River Watershed (NRW) water stakeholders

Type of Stakeholder	Description	Relationship to water issues
Consumptive Water Users	The largest water user in the watershed is industrial (pulp and paper) followed by the City of Nanaimo. Other users include light industry, agriculture and residential.	Consumptive water users impact the water resources in the NRW by removing water from the system, as well as by storing water during the winter and releasing it to the river in summer. Consumptive water users are impacted by changes in water quality and quantity. Consumptive water users have the potential to both negatively and positively impact the interests of non-consumptive water users, depending on how they affect flow during critical periods. In the case of Nanaimo River, where total annual flow is not limiting, consumptive water users provide an important benefit to fish by increasing summer base flows.
Non-Consumptive Water Users	The main non-consumptive water users in the watershed are fisheries, wildlife and recreation.	Non- consumptive water users can be impacted by changes in water quantity and quantity. Wildlife and recreational users can negatively impact water quality by introducing bacteria.
Land users	The primary land use in the watershed is forestry. Other land uses include agriculture, industry, and residential.	Land use in the watershed has the potential to impact water quality. Changes in land use can affect the water demand of the consumptive water users. Water availability and quality can limit future development and land use changes.
Regulatory Bodies	The majority of the NRB is within the Regional District of Nanaimo. A portion of the estuary is within the Snuneymuxw First Nation reserve lands, and a portion of the upper watershed is in the Cowichan Valley Regional District. In general, the regulation of water in the basin (and BC) is primarily under the jurisdiction of the provincial government, but is also influenced by various municipal and federal government agencies.	Regulatory bodies have the ability to impact water use and water stewardship through the development of regulations to protect water quality and quantity.

Harmac is a rare exception to the rule that groundwater diversions in the province of BC are unregulated. Harmac's groundwater wells are licensed under the *Water Act* along with its surface water intake (11). Harmac is currently withdrawing water from the Nanaimo River well below its licensed withdrawal rate of 330,288 m^3/day (3.82 m^3/s).

The City of Nanaimo

The City of Nanaimo (City) supplies drinking water to City residents, the Snuneymuxw First Nation, and the South West Extension Improvement District from its Jump Creek and South Fork Dam reservoirs. Water released from the Jump Creek Reservoir flows down the South Nanaimo River to the South Fork Dam reservoir. The water level in the South Fork Dam is maintained at full capacity, and water is released to the South Nanaimo River either over the crest of the dam or through a low-level fisheries release point (9). The City's 2010 surface water withdrawal rate was c. 43,000 m^3/day, serving a population of roughly 86,000 (2).

The City collects meteorological information and monitors water quantity and quality within the South Nanaimo River watershed. The City works with forest owners in their water supply watershed to develop monitoring programs and to implement best management forest practices to help protect the City's water supply (3).

Minimum Flow Requirements and Pulse Flows

Through an agreement with the Department of Fisheries and Oceans (DFO) the BC Ministry of the Environment (MOE), Harmac and the City release water from their reservoirs to maintain a minimum flow of 3.9 m^3/s at the WSC Station 08HB034 Nanaimo River at Cassidy (1). Typically the City releases 1 m^3/s and Harmac releases 2.9 m^3/s (11).

In years when there is insufficient storage in the dams to maintain the desired flow, the City is required to maintain a minimum flow of 0.28 m^3/s below its South Fork Dam (9). Harmac is required to maintain a minimum flow of 1.4 m^3/s below its surface water intake, just downstream of the Island Highway (11)[4].

Harmac, the City of Nanaimo, DFO, MOE, The Nanaimo River Hatchery and the Snuneymuxw First Nation also work together to produce a fall pulse flow of 14 m^3/s over several days to encourage Chinook salmon to migrate up the River (1, 10, 11).

[4] The last time Harmac had difficulty meeting its minimum flow requirement was in the early 1990's (Bramley, pers.comm.).

Other Consumptive Users

Even when considered together, the domestic, industrial (other than Harmac) and agricultural surface water extractive demands are not significantly large to appreciably affect the flows in the Nanaimo River. However, if water is extracted from one of the smaller tributaries in the watershed, water demand may negatively affect the flow and in turn the fish habitat in that specific tributary (1). This is the case with agricultural water use in the Haslam Creek sub-watershed where irrigation water taken from small tributary streams competes with the in stream fish flow requirements.

The MOE groundwater well database shows 1270 wells in the Nanaimo River watershed. The location of the wells is shown on Figure 5. Table 2 summarizes the well use.

Table 2: groundwater wells in the Ministry of Environment database.

Well Use	Count
No Label	51
Abandoned	1
Commercial	28
Domestic	717
Water Service	21
Irrigation	12
Observation	3
Other	3
Unknown	434
Total	**1270**

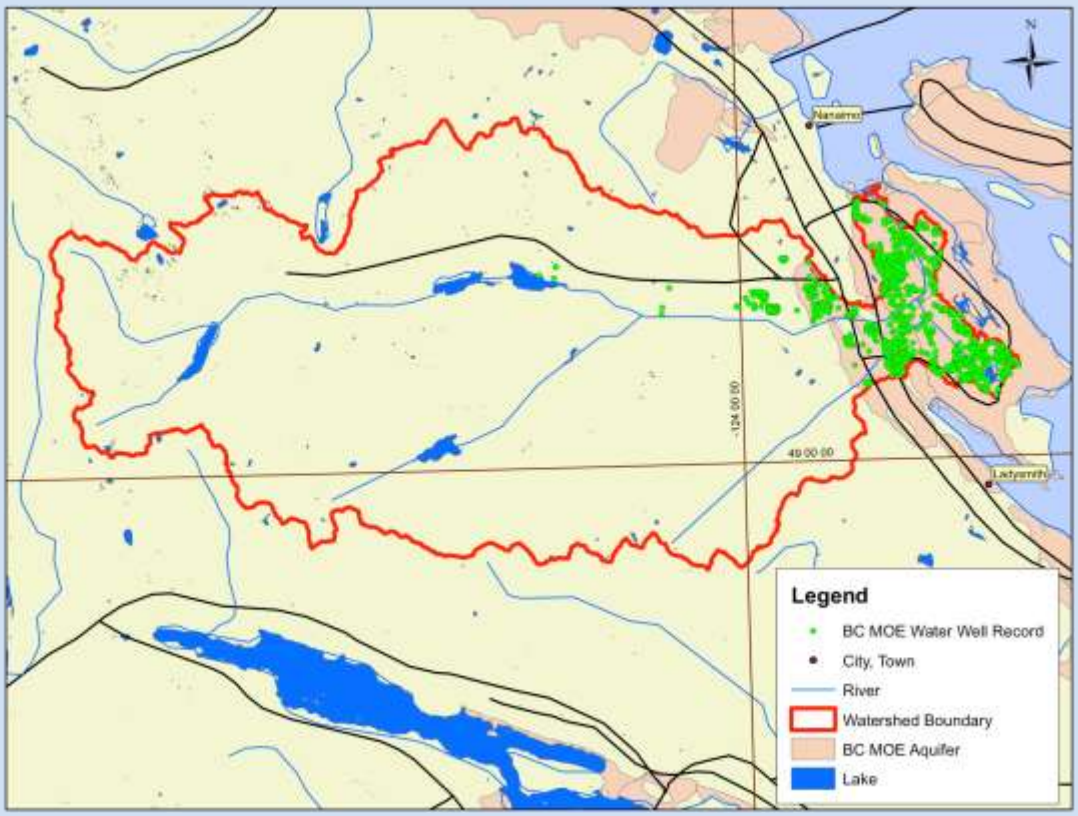
TRENDS

Increasing human populations, further development, and changes to regulations will influence future water use in the Nanaimo River watershed. Some of the main factors affecting water use trends in the watershed are:

- Water flow in the Nanaimo River watershed is fully allocated during the period from July to September - no future water withdrawal licenses will be issued except for domestic use, unless additional storage is provided (1).
- The Province is proposing a modernization of the Water Act that will include groundwater licensing of large water users (> 500 m^3/day) (7).
- Nanaimo Forest Products is seeking other business opportunities on the Harmac property, some of which will increase its water requirements (11).

- The City of Nanaimo is planning to build a third dam and reservoir upstream of the South Fork Dam in order to meet future water needs (12).
- The continuing development and population increase of the Cassidy and Cedar area will increase the demands on the groundwater aquifers in the area (6).

Figure 5: Location of groundwater wells in the Nanaimo River watershed (Source: Ministry of Environment Groundwater Database).



Risks and Impacts

The main concerns related to the quantity and quality of water in the Nanaimo River watershed are:

- Low flows in the Nanaimo River during the summer and early fall;
- High water temperatures in surface water during the low flow period;
- Increased turbidity in the Nanaimo River and its tributaries following high precipitation events;
- Bacteria in the lower reaches of the Nanaimo River; and,
- Development pressures and potential for contamination of the Cassidy aquifer.

Low flows in the Nanaimo River during summer and early fall

There is an abundant supply of water available in the Nanaimo River watershed during the winter and spring. However, surface water flows from June to early October are low. At this time, the naturally low flows in the watershed combined with water use may negatively affect fish (1). To mitigate this problem, DFO has come to an agreement with the two main water users in the watershed, Harmac and the City of Nanaimo, to maintain a minimum required flow in the Nanaimo River.

During dry years when insufficient storage is available in the Fourth Lake reservoir to meet the 3.9 m^3/s target flow at the WSC Station, Harmac must maintain a minimum flow in the Nanaimo River of at least 1.4 m^3/s downstream of its surface water intake. This minimum required flow is calculated by subtracting the Harmac surface water diversion from the measured flow at the WSC Station (11).

This minimum required flow calculation does not take into account Harmac's groundwater diversion, which is downstream of the WSC Station and Harmac's surface water intake. The Upper Cassidy Aquifer is expected to be in direct communication with the River at the locations of the Harmac extraction wells (1). Water balance calculations, done for the 1993 Baseline Report, concluded that a significant portion of the groundwater being pumped by Harmac is coming from the River through induced infiltration and may have a significant influence on low flow conditions in the River. The Harmac wells are likely also intercepting groundwater that would have reported to the Nanaimo River as baseflow. To give an indication of magnitude, Harmac's average groundwater withdrawal rate in 2010 was 48 000 m^3/day (0.56 m^3/s) or 40% of the 1.4 m^3/s minimum required base flow (11).

The Harmac wells are licensed as a surface water withdrawal. Therefore, the Harmac wells should be considered as surface water intakes and the measuring point should be moved downstream of the Harmac wells. The flow calculation should include some portion if not all the groundwater diversion.

It is expected that climate change will cause wetter winters and drier summers in the Nanaimo River watershed (9). This will likely result in a further decrease in summer low flows on the River, increasing the challenge of managing water storage on the River and the groundwater resources.

High water temperatures during low flow period

Water temperatures as high as 20.4 C have been recorded in the river downstream from where the Nanaimo River crosses the highway (1). Temperatures above 20 C can be stressful for trout and salmon and increase the prevalence of disease such as white spot disease. Ideal rearing temperature is 18 C, and temperatures above 23 C are lethal.

The heating of water in the lakes and reservoirs during the spring and summer likely causes high temperatures. Water is released from both the City and Harmac from a low level outlet, which is cooler than the surface temperatures, thus countering the effects of solar warming.

Groundwater temperatures in the Nanaimo River watershed are generally between 6 C and 10 C (13). Increasing the proportion of flow supplied by groundwater during the low flow season could help mitigate the water temperature concerns.

Increased turbidity in the Nanaimo River and its tributaries following high precipitation events

The City of Nanaimo monitors surface water quality in the catchment area of its water supply on the South Nanaimo River. Water quality is generally very good, although turbidity occasionally exceeds standards after heavy rainfall events (2). High turbidity after heavy rainfall likely occurs through the watershed, and can lead to increases in pathogenic microorganisms, such as giardia and cryptosporidium, which may infect consumptive and recreational water users (9).

Bacteria in the lower reaches of the Nanaimo River

Water quality testing done as part of the 1993 Nanaimo River watershed Water Management Plan showed that the microbiology criteria for primary[5] recreational contact had been exceeded on a few occasions in the summer downstream of the Island Highway. Swimming in water with microbiological contamination can cause gastrointestinal and minor skin, eye, ear, nose and throat infections (14). Bacteria levels are therefore a potential concern at popular swimming locations on the River downstream of the highway.

[5] Primary contact means full submersion with the chance of ingestion and intimate contact with eyes and nose.

Development pressures and potential for contamination of the Cassidy aquifer

The Cassidy aquifer is highly vulnerable to contamination as it is unconfined, highly permeable, and the water table occurs near the ground surface. Accidental spills of toxic materials over the aquifer could contaminate a large area of the aquifer and potentially affect surface water quality in the Nanaimo River and Haslam creek. Further land development in the region, including development plans for the Nanaimo airport, will increase the demand for groundwater from the Cassidy Aquifer as well as the potential for contamination. Increased demand could potentially further reduce discharge from the aquifer to the river during the low flow period.

OPPORTUNITIES

There are many opportunities for improved stewardship of water in the Nanaimo River watershed. A few of the most important opportunities include:

- The management of surface water and ground water should recognize that the two are integrally linked. The public should advocate for inclusion of all groundwater withdrawals in the Water Act. BC is the only jurisdiction in Canada, and one of the only jurisdictions in North America, that does not regulate groundwater use. The Province is proposing a modernization of the Water Act that will include groundwater licensing of large water users (> 500 m^3/day).
- Encourage the regulatory stakeholders to consider and manage the watershed as a whole rather than based on political/electoral boundaries or ministerial jurisdictions.
- Work with the City of Nanaimo and the Regional District of Nanaimo to help implement and expand upon their water conservation strategies[6], especially during the low flow period. The Regional District of Nanaimo's *Action for Water*[7] plan may help to advance some of these opportunities.
- Work with the Regional District of Nanaimo to protect the groundwater quality in the Cassidy aquifer.
- Work with the forestry companies to understand what water quality information is being collected and how forests are managed in the City Nanaimo water supply watershed. This information could improve the understanding and stewardship of the water resources in the watershed as a whole.

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[6] For example, see: RDN's teamwatersmart.ca, and City of Nanaimo's 2008 Water Conservation Strategy.

[7] http://www.rdn.bc.ca/cms.asp?wpID=1718#9

INFORMATION GAPS

The key information gap in order to enhance the understanding and management of water quality and quantity in the Nanaimo River watershed is to better understand the relationship between the Upper and Lower Cassidy aquifers and the Nanaimo River. The 1993 Nanaimo River Water Management Plan recognized this as a priority (1), as have other studies (e.g., reference 6) but no further study appears to have been undertaken.

Specific information gaps include:

- A quantitative understanding of the contribution of groundwater from the Cassidy Aquifer to surface water flow in the Nanaimo River during low flow periods.
- A quantitative understanding of the effects of groundwater extraction from the Cassidy Aquifer on low flow in the Nanaimo River, preferably obtained by monitoring river flows downstream of the major groundwater users.
- An understanding of the effects of groundwater extraction from the Cassidy Aquifer on the water quality in the Nanaimo River, specifically its effect on the water temperature in the River during low flow.
- An understanding of the potential for contamination of the Cassidy aquifer to reach the Nanaimo River and its tributaries.
- Improved information on the level of suspended solids and their impact on fish habitat, and monitoring of bacteria levels at popular swimming locations would also be beneficial.

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REFERENCES

Literature Cited

1. Ministry of Environment, Lands and Parks (MOELP). 1993. Nanaimo River Water Management Plan.

2. City of Nanaimo 2011. 2010 Annual Water Quality Report.

3. City of Nanaimo and the Greater Nanaimo Water District (City and GNWD). Water, Nanaimo's Most Precious Resource (undated PDF document from City of Nanaimo website)

4. Harmac Archives, Fourth Lake Reservoir Storage Survey

5. Water Survey of Canada, 2011. http://www.wsc.ec.gc.ca/applications/H2O/report-eng.cfm?yearb=&yeare=&station=08HB034&report=monthly&year=2010 . Viewed on 08/Jun/2011

6. GW Solutions Inc. and Vancouver Island University. 2010. RDN Electoral Area A – Groundwater Assessment and Vulnerability Study. Prepared for the Regional District of Nanaimo.

7. Government of British Columbia. Living Water Smart. http://livingwatersmart.ca/water-act/groundwater.htm. Viewed 29/June/2011

8. Metherall, Christina. Regional District of Nanaimo. Personal communication. 2011.

9. Associated Engineering. 2007. City of Nanaimo Water Resources, Water Supply Strategic Plan.

10. Sims, Bill. City of Nanaimo, Personal communication. 2011.

11. Bramley, David. Technical Services Superintendent. Harmac Pacific Pulp Operations, Personal communication. 2011.

12. City of Nanaimo. 2011 http://www.nanaimo.ca/EN/main/departments/Engineering-Public-Works/13038/FutureProjects.html. Viewed on 08/Jun/2011

13. Ministry of the Environment (MoE) 2011. Groundwater Temperature Data for Observation Well 228 and 312.

14. Human Heath and the Great Lakes. http://www.great-lakes.net/humanhealth/rec/swim.html. Viewed 29/June/2011

WATER BUDGET PROJECT
RDN PHASE ONE (VANCOUVER ISLAND)

Excerpts pertaining to the Nanaimo River Water Region

Submitted To:

REGIONAL DISTRICT OF NANAIMO

6300 Hammond Bay Road
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Submitted By:

Waterline Resources Inc.
Nanaimo, BC
June 17, 2013

Project No.: 1924-11-001

Waterline Resources Inc.

EXECUTIVE SUMMARY

The RDN Water Budget Project is a series of two studies commissioned by the Regional District of Nanaimo (RDN) to examine the relationship between surface and groundwater, current water demands, and the long-term impacts of climate change.

Water Budget reporting was produced for each of the 6 RDN Water Regions within our regional district on Vancouver Island, with a separate Water Budget Report produced for Water Region 7, Gabriola, Decourcy and Mudge Islands. These Phase 1 Water Budget assessments provide an initial indication of the level of stress on RDN water regions' aquifers and surface water resources. Continued updating of actual water availability and water use will be required to further improve our understanding of this important resource.

For the Nanaimo River (Water Region 6), it should be emphasized that the stress assessment provided in the report is based on *licensed* withdrawals, not on actual withdrawals. Accurate figures of withdrawals from licensed sources are still required in order to provide a ranking that reflects the actual hydrological function of the river. This report provides a preliminary baseline of supply, demand, and relative stress with the information available at the time of the study, to help prioritize areas for future study and identify existing data gaps.

For the purposes of this publication, sections of the Vancouver Island Water Budget Study have been extracted and collated here within to highlight the main findings of the Nanaimo River Water Region (WR6). A copy of the complete Vancouver Island report can be obtained from the RDN Water Budget Website www.rdnwaterbudget.ca.

Mike Donnelly,

Manager of Water Services
Regional District of Nanaimo

REGIONAL DISTRICT OF NANAIMO

INTRODUCTION

The RDN is a rapidly growing area where the land base is primarily rural, with several expanding urban areas. Projections indicate that the population in the RDN will increase 49% by the year 2031 (HB Lanarc, 2010). During this time, climate change is predicted to cause irregular weather patterns that include longer, hotter and drier summers. Present data indicates that water levels may already be dropping in some water supply aquifers, causing reduced flows in rivers and associated ecosystem impacts (HB Lanarc, 2010).

A water budget assessment is an attempt to consider all the inputs and outputs from the surface water and groundwater systems to assess if water is being used sustainably, or being overused. As all water inputs to both surface and groundwater systems within the RDN comes from precipitation, either as rain or from the mountain snowpack, climate data is very important to complete accurate water budget estimates. The interaction between different systems, i.e. exchanges between aquifers and rivers, and both natural and anthropogenic discharges from the system must be understood to facilitate a preliminary water budget.

STUDY OBJECTIVES AND GOALS

The primary objective of the RDN Phase 1 Water Budget Project was to develop a better understanding of the interactions between rivers/creeks, lakes, and groundwater aquifers across the RDN. In order to meet the objective of the study, compilation of available hydrology and hydrogeology information into a comprehensive electronic geodatabase was completed by Waterline. The electronic information was then used to develop an up-to-date conceptual model of each region to assess water movement and exchange between various watershed elements including rivers and creeks, lakes, and aquifers. An important aspect of the study was to assess environmental controls on surface water and groundwater availability such as climate, topography, soil/geology, land cover, aquifer geometry, etc. and how they affect the water balance in each region.

As part of the water budget assessment, the determination of the availability of water needed to maintain natural ecosystems and community water supplies was also required. The study aimed to develop an understanding of the current water demands, the stresses placed on rivers/creeks and aquifers by human activities, as well as long-term effects of changing climate conditions. The ultimate goal of the project was to determine the sustainability of current and possibly future water use practices in each water region and to identify uncertainties and data gaps in the analysis. Recommendations are also included to improve input parameters for water budget estimates and to develop surface water and groundwater monitoring strategies that will help ensure sustainability of water resources for future generations.

It must be cautioned that the RDN Water Budget project is a regional study intended as a high level water budget assessment for many of the watersheds and aquifers within the six water regions on Vancouver Island. As a result, calculations presented herein are conceptual in nature and only serve to provide an assessment of the linkages between various water resource elements. Local issues may not be fully addressed at the current scale of assessment.

Although water budget and stress calculations presented herein may appear quantitative, they should only be considered as qualitative. The water budget estimates provide a relative comparison from region to region or aquifer to aquifer, rather than actual values of water availability or water use which are needed for quantitative land use planning and design.

The RDN Water Budget project is expected to greatly benefit the people who live and/or work within the RDN as it forms the foundation for understanding the present and future availability and demand for fresh water. The project outcome allows the RDN to plan for future development in a way that contributes to protection and management of groundwater and surface water resources not previously available.

METHODOLGY AND APPROACH TO WATER BUDGET SURVEY

DATA COMPILATION

A considerable amount of data was compiled to produce the maps needed to complete water budget calculations. It should be noted that any data received and compiled by Waterline as part of the present study were assumed to be correct and have not otherwise been verified for quality or accuracy other than what could be assessed as part of the development of conceptual models for each region. There may be a need for further verification of the data used to develop the conceptual models if interpretations and analysis conflict with other information, or interpretations not considered as part of the study. In addition, as new data becomes available and a more comprehensive understanding of surface water and groundwater flow systems is developed, the enclosed conceptual models will need to be updated accordingly.

CONCEPTUAL WATER BUDGET MODEL DEVELOPMENT

Surface Water

Using existing information, the Waterline team developed conceptual models to help describe the overall water flow system dynamics for each water region in the RDN. Using available stream flow and climate data, estimates of monthly and annual runoff from each of the major watersheds was completed to assess the seasonality of water availability. Stream flow estimates were developed using a regional hydrology approach in which naturalized stream flow records were adjusted to account for water withdrawals and/or storage in the watersheds. Estimates of stream flows in un-gauged watersheds were developed based on physical watershed characteristics. The summer stream flow estimates were verified wherever possible using available base flow measurements in creeks and rivers. This approach is similar to the approach used to develop the BC MOE Water Allocations Plans (Boom and Bryden, 1994; Braybrook et. al., 1995; Bryden et. al., 1994; Pirani and Bryden, 1996; Bryden et. al., 1994; and MoELP, 1993) and provides an assessment of surface water availability in the major watersheds and allows for completing watershed stress assessment.

Groundwater Aquifers

An aquifer is described as a geologic unit that can transmit useable quantities of groundwater to a well. A fractured bedrock aquifer is formed when a series of interconnected fractures exists that can store and transmit water. Unconsolidated, sand and gravel aquifers store water between the sediment grains and coarse sand and gravel deposits can form high water yield aquifers as is observed across the RDN. The unsaturated zone occurs above the water table and aquifers that are in direct contact with the atmosphere are known as unconfined aquifers. If a layer of silt or clay covers the saturated sand and gravel or fractured bedrock aquifer then the aquifer is considered to be confined (or semi-confined) from the atmosphere and referred to as a confined aquifer.

A significant amount of groundwater and surface water information exists within the six defined water regions that make up the RDN study area. The RDN has made considerable progress in assembling this information into an ARC-GIS system which is now available on-line in the RDN Water Map. Wherever possible, Waterline attempted to integrate concurrent activities being conducted by the RDN, the Geological Survey of Canada, Englishman River Water Service, and BC Ministry of Agriculture and Lands with the Water Budget Project. Developing a conceptual hydrogeological model of subsurface aquifers is a complex exercise that involves integrating numerous key datasets including, but not limited to, the following existing information:

• Topography/digital elevation maps,
• Climate data,
• Land cover information,
• Surficial and bedrock geology maps,
• Borehole geology and water level information,
• Aquifer mapping and vulnerability data,
• Aquifer properties including permeability and storage parameters,

• Long-term water level monitoring data, and
• Groundwater use (pumping) data where available.

All of these datasets were processed electronically so they could be entered into Waterline's Geodatabase. These data were then used to develop other maps and to profile the subsurface geology to facilitate an understanding of how the surface features interact with the subsurface geology. Using these and other datasets, it was then possible to develop three dimensional views of the subsurface, which form the conceptual aquifer models for each region.

Regional Geology

Most of the landscape and landforms observed across the RDN resulted from glacial and interglacial processes operating during the last 50,000 years. The latest and largest glaciation was the Fraser Glaciation which started approximately 29,000 year before present (BP) due to a deteriorating (colder) climate. In southwestern BC, mountain glaciers formed between 19,000 and 30,000 BP before they advanced, coalesced, and thickened to create the maximum extent of the ice sheet that covered Georgia Strait nearly 15,000 BP. At this time, the ice surface was at about 2300 mASL and towered over 1000 m above the present-day peak of the Coast Mountain Range. After about 14,500 BP, the regional climate began to warm causing ice to melt and glaciers to retreat over the next 5,000 years (Clague, 1994).

During the advancement phase, glaciers from Vancouver Island flowed towards and coalesced with ice flowing south along the Salish Sea (present day Strait of Georgia), producing a large glacier lobe that extended down into the Puget Lowlands in Washington, USA. Quaternary sediments up to 300 m thick underlay the lowlands bordering the Strait of Georgia. Throughout this region, sediments were deposited during the glacial advance and retreat and in some areas during older glacial and intervening interglacial cycles. Loading and unloading of the ice sheet caused significant land rebound and sea level fluctuations. Along the Strait of Georgia, sea level rose up to almost 200 m above present-day sea level, leaving various marine deposits observed across the Nanaimo Lowlands and the Sunshine Coast at elevations up to 180 mASL (McCammon, 1975).

A description of the regional geology based on Fyles (1963) defines the overburden geology. All geology data has been compiled electronically in Waterline's geodatabase and was considered in the construction of the conceptual hydrogeological model.

The main unconsolidated deposits with the RDN include the following:

1. **Salish:** Recent shore, deltaic, and fluvial deposits laid down by rivers and creeks and by wave action along coastal areas. The deposits contain gravel, sand, silt, clay and form local aquifers along river/creek and lake.
2. **Capilano:** Deltaic, and marine veneer deposits laid down during glacial retreat and ocean ingress over the Nanaimo Lowlands and coastal areas. The extent of marine ingress can be seen across the RDN and generally is below 200 m ASL. The deposits contain sand, gravel, clay; and stoney clay, clay and silt and the coarser fractions form local unconfined aquifers, whereas the finer clays and silts form aquitards.
3. **Vashon:** Glacial fluvial material deposited during glaciation by surface and/or subsurface rivers and creeks formed with the retreat of ice sheets. The deposits contain sand, gravel, clay; and dense clay till. The coarser fractions form local unconfined aquifers, whereas the finer clays and silts form aquitards.
4. **Quadra:** Pro-glacial fluvial outwash materials deposited during glacial advance at the leading edge of the ice sheet. The Quadra sand deposits form regionally significant aquifers in the Nanaimo Lowland are very important from a water supply perspective within the RDN.

Most of Vancouver Island is made up of what is referred to as the Wrangellia Terrane which collided with the west coast of North America around 100 million years ago (m.y.a.) (Earle, 2012). The Nanaimo Group rocks were deposited on top of the Wrangellia rocks from about 85 to 65 m.y. ago.

The Vancouver Island mountain range occurs in the western portion of the water region. The structural geology in this area is complex and comprises northwest striking faults that subdivide the different bedrock types into narrow structural and geology units. Within these narrow units, the rocks may be folded, and block or thrust faulted. The primary bedrock types within RDN include the following:

1.**Nanaimo Group:** The Nanaimo Group sedimentary rocks were deposited into the basin between Wrangellia and North the American plate. Most of the Nanaimo Group sediments were deposited under marine conditions, largely as submarine fans offshore from coastal shelf deposits. Comprises clastic sedimentary conglomerates, sandstones, and mudstones. The Nanaimo Group rocks are situated along the coastal areas and typically are overlain by Quadra or Quadra equivalent sediments.

2. **Vancouver Group - Karmutsen Formation:** The Karmutsen Formations is part of the Vancouver Group and comprises volcanic basalt flows and pillow basalt deposited on the sea-floor. The Karmutsen is the most common rock type exposed on Vancouver Island and within the RDN.

3. **Sicker Group - Nitnat Formation:** These are the oldest rocks of Vancouver Island and are Devonian in age (ca. 370 m.y.). They are composed of calc-alkaline volcanic rocks and include sea-floor and terrestrial volcanic rocks.

4. **Buttle Lake Group; Mount Mark Formation:** Comprises limestone formed as part of an ancient reef deposit.

5. **Buttle Lake Group - Fourth Lake Formation:** Sedimentary bedrock composed of chert, siliceous argillite, silici-clastic rocks.

6. **Island Plutonic Suite:** Igneous intrusive rocks dominantly quartz diorite to granodiorite but with considerable lithological variation observed across the RDN.

7. **Mount Hall Gabbro:** Igneous intrusive rocks composed of gabbroic to dioritic.

SURFACE WATER ASSESMENT AND WATER BUDGETS

Regional Hydrological Model

A regional hydrological model has been developed for the RDN to assess surface water balance and estimate contributions to groundwater. It is a GIS-based distributed conceptual model which uses physical parameters of the watersheds to calculate runoff for each one square kilometre grid cell.

The physical parameters considered in the water balance for each square kilometre include:

1. Average ground elevation
2. Surficial Soil Types
3. Ground Cover; and
4. Leaf Area Index

Once calculated at a grid-scale, the surface runoff is then routed to watercourses using a flow accumulation routine to estimate surface water discharges for entire watershed. Through the surface water balance process the model also estimates groundwater recharge on a 1 sq. km grid across the region. The inputs to the model include gridded average monthly precipitation and temperature data from the ClimateBC and Climate NWA models (Wang et. al., 2006 and Wang et. al. 2012) and the model calculates average monthly stream flow.

The Climate BC Model down scales climate variables (temperature, precipitation, etc.) from larger scale data sources (with grid cells larger than 1 sq. km), such as; historical climate data from the PRISM data set as well as forecast future climate from Global Circulation Models (GCMs) or Regional Climate Models (RCMs). Climate BC model uses temperature and precipitation lapse rates (rate of change of climate with elevation) to adjust the larger scale data to take account of topography not captured in the larger grid sizes of the larger scale datasets.

Runoff for each grid-cell is calculated using a water budget which accounts for snowpack accumulation and melt, potential and actual evapotranspiration, soil moisture, transfer to ground water storage and runoff from the surface and ground water. The runoff model is based on the Monthly Water Balance Model developed by the US Geological Service

(McCabe and Markstrom, 2007), with some changes to reflect local conditions. These changes include:
Adjustments to Potential Evapotranspiration based on land cover data and leaf area index; Spatially variable soil infiltration parameters based on surficial soils data; and adjustment to snow accumulation and melt routine using a temperature range (2oC to -2oC) to represent partial rain/snow mix throughout the month.

The model generates monthly runoff for each grid square, which is then used to develop a set of gridded runoff data for the entire region. These monthly runoff surfaces are then used to generate stream flows using a GIS stream-flow accumulation routine. The result is an estimate of average monthly stream flows along the length of the water courses in the region. Using precipitation and temperature from the Climate BC model for future climate change conditions, an estimate of future stream flows have also been made.

Surface Water Budgets and Stress Analysis

Surface Water Budgets for each of the major watersheds has been completed as part of the assessment. A water budget is used to assess the relative stress of each of the watersheds by comparing water availability with water demand. The water budget considers all inflows and discharges from the surface water component of the water cycle including rainfall and snowmelt as inflow; evaporation/evapotranspiration, canopy storage and human consumption as losses; transfer to and from soil moisture storage, surface storage in lakes and reservoirs; and ground water recharge and exfiltration. It should be noted that some amount of water extracted for human consumption returns can return to the surface water or ground water components of the water cycle either through treated waste-water effluent, septic fields or irrigation runoff. However, the larger municipal and industrial users on Vancouver Island discharge treated effluent directly to the ocean and is therefore lost to the surface and ground water budgets. For this study, we have considered all consumptive water demands as a permanent loss to the surface and ground water budgets which is considered to be a conservative assumption.

Each parameter is described as follows:

1. Inflow to the surface water budget comes from either precipitation in the form of rainfall or from snowmelt from snow pack

2. Losses from the surface water budget include evapotranspiration from vegetated areas and evaporation from lake and other open water surface which is calculated using average monthly temperatures and the Hamon (1961) equation;

3. Surface water extraction amount have been assumed to be equal to the volumes allocated under water license unless recorded values are available. The licenses have been classified based on water use including municipal water supply which is assumed to follow an annual cycle with lower winter indoor water use base demands, and higher summer demands which includes irrigation and outdoor water use, agricultural demands which are assumed to only occur during the summer months for irrigation, except for stock watering which occurs year-round, and other demands such as industrial or institutional demands which are considered to be constant year round;

4. Surface water storage is considered to be lakes and managed reservoirs which capture winter and spring runoff to release during the summer and the early fall low flow period. Surface water storage within a watershed is assumed to be the total of the licensed storage volume for managed reservoirs and 0.5 m of storage on natural lakes and wetlands (the assumed average natural water level variation). To simplify the water balance, water release from surface water storage is assumed to only occur between July to September, unless specific operating rules are provided for the reservoir which provide different criteria;

5. Soil and ground water storage are accounted for within the water balance using the USGS water balance model which is based on the Thorntwaite (1948) method and linear reservoir for ground water storage;

6. Finally, surface water runoff is assumed to be the remaining component of the water balance not accounted for in the components outlined above which is calculated based on mass balance equation such that inflow minus outflow is equal to the change in storage over the time period.

During most of the year, the availability of surface water far exceeds demands. However, during the summer dry period water demand increases and water availability decreases to a point where water stress may occur. Therefore, the stress analysis has been carried out for the summer months which typically extend from July to September each year.

The surface water stress is calculated using the following formula:

$$\text{Surface Water Stress (\%)} = \frac{\text{Consumptive Demand} + \text{Minimum Conservation Flow}}{\text{Natural Water Supply} + \text{Storage}} \text{ x } 100$$

Consumptive Demand is the total allocated or licensed demand for all consumptive water uses including industrial, municipal waterworks, domestic, agricultural, etc. Where appropriate, the annual average licenced amounts have been adjusted to account for seasonal variation in demand such as agricultural, domestic and municipal waterworks demands. Where records of surface water demands are available, they have been used to estimate actual demands to prepare a recorded Water Stress Analysis. This provides a current snapshot of water stress for certain watersheds.

The Minimum Conservation Flow is assumed to be 10% of Mean Annual Discharge (MAD). This is the current FLNRO Policy for water licencing on the east coast of Vancouver Island as outlined in the BC MOE Water Allocation Plans (Boom and Bryden, 1994; Braybrook et. al., 1995; Bryden et. al., 1994; Pirani and Bryden, 1996; Bryden et. al., 1994; and MoELP, 1993). Any new water licence which results in residual flows in the river being less than 10% MAD on a monthly basis, requires storage to support the demand.

The natural water supply is either the recorded flows where available or the results of the regional hydrological model in ungauged watersheds. It is considered to be the unregulated natural flow available in the river. Finally, storage includes all licenced storage in the watershed including conservation storage and land improvement storage.
The results of the Surface Water Stress Analysis have been assigned a relative stress scale and aquifer color code as follows:

• 0-25% = Low Stress Blue
• 25-50% = Low to Moderate Stress Green
• 50-75% = Moderate Stress Yellow
• 75-100% = Moderate to High Stress
• 100-150% = High Stress Red
• >150 % = Very High Stress Red

It should be noted that the water stress analysis is based on average monthly water availability and demands and does not take into account inter-annual variations in stream flow or demand, in particular drought periods. It assumes that water licences reflect actual water demands and that all storage in the watershed is available to support the consumptive demands and minimum conservation flow requirements for the 90 day period through July to September. The water stress has been assessed on a watershed scale and does not consider relative stress within sub-watersheds or river reaches.

GROUND WATER ASSESEMENT AND AQUIFER WATER BUDGETS

The following describes the overall rationale for Waterline's approach to aquifer water budget calculations.

Approach Used For Water Budget Calculations

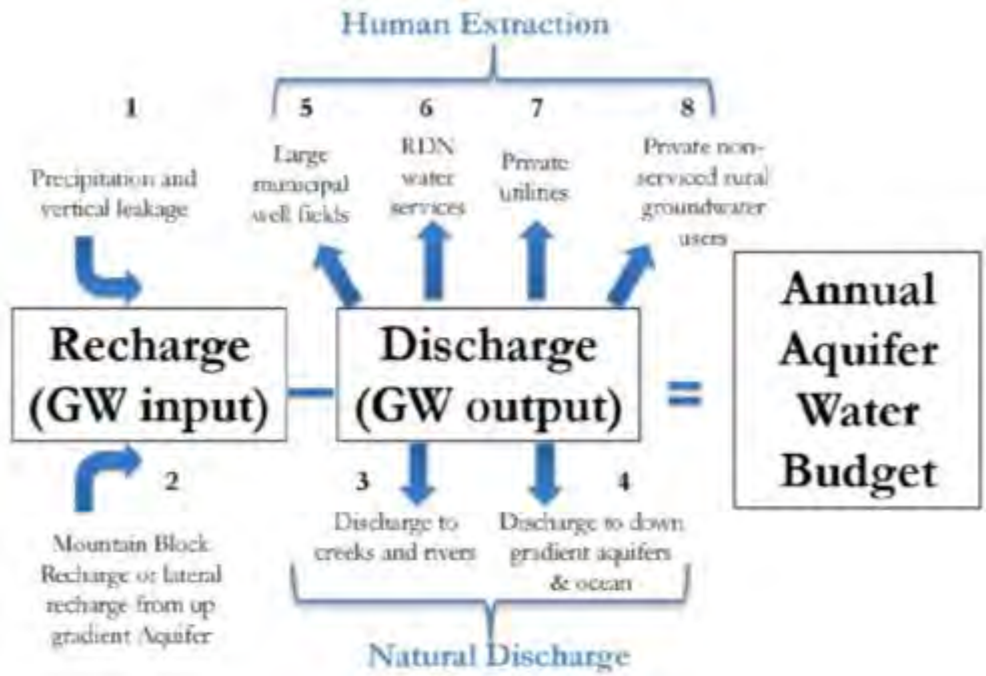
Waterline used aquifer mapping layers available from the BC Water Resources Atlas at the time of data compilation in February of 2012 (BCGOV ENV Water Protection and Sustainability Branch 2012). As previously indicated, aquifer mapping updates were made available from the MOE in late 2012.

All fresh water resources in rivers/creek/lakes and water supply aquifers originate as rain or snow melt. A portion of precipitation returns to the atmosphere by direct evaporation from the ocean and lakes and streams, or is taken up by trees and vegetation (evapotranspiration). Some portion will runoff the land as a function of land cover, soil texture (fine clay, silt, or coarse sand and gravel, or fractured bedrock) and slope, and a small portion (about 10%) will percolate into the subsurface and recharge the aquifers.

The RDN is bounded to the west by mountains and to the east by Georgia Strait. Surface water and groundwater drain from high to low elevations, thus the steep coastal profile creates a natural gravity-driven system with relatively high hydraulic gradients to the ocean. Fresh water resources that do not evaporate or transpire will eventually flow to the ocean, unless intercepted by wells or surface intakes for water supply use. The groundwater flow paths in aquifers across the RDN tend to mimic the topography of the land.

Surface water and groundwater systems are dynamic systems and constantly in a state of flux in accordance to the changing seasons and longer term climate variability on the Pacific Coast of North America. Both surface and groundwater systems in the RDN are expected to have short residence times resulting in relatively young groundwater (10's to 100's of years old) from the point of recharge at higher elevations to discharge points in local creeks, or near the coast. Rivers and creeks exchange water with shallow aquifers through the watershed. Over time, rivers and creeks erode away surficial materials and cut down into underlying aquifers causing direct exchange between the surface water and groundwater systems. As groundwater flows from areas of high topographic elevation to areas of lower elevation, aquifers can also receive lateral recharge from adjacent, up gradient aquifers, or from bedrock fractures in contact at higher elevations on the coastal mountains, also termed 'mountain block recharge'.

Aquifer recharge characteristics and groundwater extraction practices in a region will significantly affect groundwater levels in and availability in RDN aquifers. Therefore, it is important that properly located observation wells are monitored over the long term in order to gauge the aquifer performance and response to pumping. Monitoring therefore provides an early-warning system which allows private and public users to maintain a balance between aquifer recharge and groundwater use. These data are critical to help determine if groundwater extraction activities are negatively impacting aquifers and whether such practices can be sustained into the future. At present, the level of groundwater monitoring being conducted in many aquifers across the RDN is insufficient to allow for proper aquifer and watershed management. The following generalized equation was used to assess aquifer water budgets and the groundwater demand (stress) on each mapped aquifer:



Each parameter is described as follows:

1. Precipitation and vertical leakage is rainwater or snowmelt that recharges the subsurface or water that moves from an overlying aquifer to an underlying aquifer through vertical leakage,

2. Lateral through-flow and mountain block recharge is an important source of aquifer recharge. Aquifers that have been mapped at the higher elevations tend to receive recharge directly from the upgradient mountain block and will also then feed aquifers at lower elevation located near the coast and is referred as lateral recharge from upgradient;

3. Some of the creeks are in direct hydraulic communication with the various creeks and rivers within each water region. There is a certain amount of groundwater that discharges to these creeks and it is important that this is maintained in an effort to preserve a healthy ecosystem. This volume of groundwater was estimated for aquifers that were considered to be connected to a local creek or river and factored into the aquifer water budget analysis;

4. All aquifers mapped in each water region will discharge to an adjacent down gradient aquifer which maintains the health and water balance in the system. The volume of groundwater moving out of one aquifer (discharge) and into a down gradient aquifer (recharge) was also considered in the aquifer water budget assessment;

5. Human extraction of groundwater by pumping was also considered wherever data was available. Annual extraction from large municipal wells that service communities such as Parksville and Qualicum Beach were consider in the Aquifer Water budget assessment;

6. Similarly, RDN has a number of water service wells located in various aquifers and locales across the RDN. Annual water abstraction data for each system was used to assess aquifer water budgets in each respective area;

7. In areas not serviced by a community system, the water use was estimated by assigning water use parcels based on zoning and land use. For instance, agricultural parcels were assign a groundwater use based on the BC Ministry of Agriculture and Lands water demand model previously developed for the RDN. Other land use parcels such as residential, commercial, and industrial were assigned water use values in accordance to estimates provided by the RDN for water service areas where the water use was metered. The estimates were applied to non-service areas where groundwater was thought to be in use based on the existence of water wells in those respective areas.

8. The final aquifer water budget (surplus or deficit) was determined by adding the summing the recharge components (inputs) and subtracting the sum of all discharge components (outputs). A negative number would indicate that there is less water recharging the aquifer than is discharging from the aquifer in which case one would expect declining water levels in the aquifer. Where available, the long-term water levels trends were considered in the final aquifer stress assessment.

Aquifer Stress Assessment – Relative Ranking

A stress assessment for an aquifer is a function of the amount of water available versus that which is needed to maintain lateral recharge to down-gradient aquifers, to maintain baseflow to creeks/rivers, and to service the existing demand for groundwater supply. Although aquifer stress analysis may only consider the anthropogenic stress on an aquifer, for the purpose of the RDN Phase One project the final stress ranking factors in both natural stressors on water availability (reduced precipitation and recharge, the need to maintain groundwater discharges to creeks and rivers, etc.) and anthropogenic stressors (groundwater abstraction, land development and its effects on aquifer recharge, etc..).

The following simplified equation was used to assign a relative stress ranking to each aquifer mapped within the RDN:

$$\text{Aquifer Stress (\%)} = \frac{\text{GWout}}{\text{GWin}} \text{ x } 100$$

Where:

- GWout is the calculated discharge to down-gradient aquifers plus discharge to any creek/rivers based on the geological model and measured or estimated groundwater pumping for water supply purposes.
- GWin is the estimated recharge to aquifers either directly from precipitation in the case of unconfined aquifers, or from vertical leakage in the case of confined aquifers plus any lateral recharge from adjacent upgradient aquifers, or mountain block recharge.

The final calculations were then assigned a relative stress scale and aquifer color code as follows:

- 0-25% = Low Stress Blue
- 25-50% = Low to Moderate Stress Green
- 50-75% = Moderate Stress Yellow
- 75-100% = Moderate to High Stress
- 100-150% = High Stress Red
- >150 % = Very High Stress Red

The analytical method used provides a crude approximation of stress to a particular aquifer. It should be noted that by using this method of assessment it is possible for an aquifer to be classified as being under some level of stress even though there is no significant anthropogenic use (i.e.: groundwater pumping). In this case the aquifer stress is natural and it may mean that the aquifer is vulnerable to pumping and development resulting from generally reduced recharge due to assessed ground/soil conditions or perhaps due to natural climate variability causing declining precipitation and recharge. More detailed aquifer data and complex computer simulations (numerical modelling) would be required to fully couple surface and groundwater systems, which would allow for a more accurate and quantitative assessment. As indicated previously, the stress assessment provided herein should be used for comparison purposes only and should not be considered as a quantitative assessment for design or detailed watershed management purposes.

WATER REGION #6 – NANAIMO RIVER

8.0 WATER REGION # 6 - NANAIMO RIVER (PAGES 160 – 190 of the report)

8.1 Regional Overview

The Nanaimo River water region (WR6-NR) is defined as the area extending from the coast at the Nanaimo River Estuary and Cedar, west to the top of the Nanaimo River catchment (Figure 79). It should be noted that the actual water region boundary in the southernmost part of WR6 (NR) was extended beyond the RDN boundary to coincide with the drainage basin. Although the RDN has no jurisdiction over this area, the water budget assessment needed to be completed at the basin scale and water resource management of this area will need to be a joint effort with the Cowichan Valley Regional District.

WR6 (NR) is largest water region within the RDN covering an area of approximately 939 km2 (Table 51). The region is densely populated as it encompasses the communities of Cedar, South Wellington, Extension, and Cassidy. There are a total of 10 watersheds and subwatersheds in WR6 (NR), the largest of which is associated with the Nanaimo River (Figure 79). Five hydrometric stations, four climate stations, and approximately 359 surface water diversion licenses exist within the region (Figure 79, and Table 51). The two largest water users in this area include the City of Nanaimo and Harmac Forest Products. It should be noted that the City of Nanaimo also pumps water outside of the Nanaimo River watershed for use in WR5 (SW-N).

Table 51: WR6 (NR) - Watersheds, Wells and Surface Water Licenses

Total Water Region Area	*939 km^2
Major Watersheds	**Drainage Area[1] (km^2)**
Nanaimo River (including all tributaries)	829.5
Haslam Creek (tributary to Nanaimo River)	128.7
Hokken Creek (tributary to Haslam Creek)	14.6
South Nanaimo River (tributary to Nanaimo River)	213.3
Jump Creek (tributary to South Nanaimo River)	61.7
Sadie Creek (tributary to Nanaimo River)	29.3
Beck Creek	13.9
Berkley Creek (tributary to Nanaimo River)	9.2
Boulder Creek (tributary to Nanaimo River	12.1
Stark Creek (Tributary to Nanaimo River)	13.7
Wells and Surface Water Diversion Points	**No.**
# Water Wells listed in MOE DB	2686
Surface water diversion licenses	359

Note: Drainage Areas are based on 1:50,000 BC Watershed Atlas. *Total water region area includes areas which drain directly to the ocean and do not lie within a major watershed. The Nanaimo River drainage area includes all tributaries.

According to the MOE Wells Database (BCGOV ENV Water Protection and Sustainability Branch, 2012) WR6 (NR) has the highest number of water wells (2686 wells) of the six water regions in the RDN. The MOE database likely only represents a fraction of the actual wells currently in use. Many well records may not have been entered into the database and some wells may simply not be in use or have been abandoned. As there is no mandatory requirement for submitting well logs or well abandonment records, it is not possible to determine the groundwater demand from private wells with any degree of certainty, nor is it possible to assess the vulnerability that may exist with improperly abandoned or standing water wells.

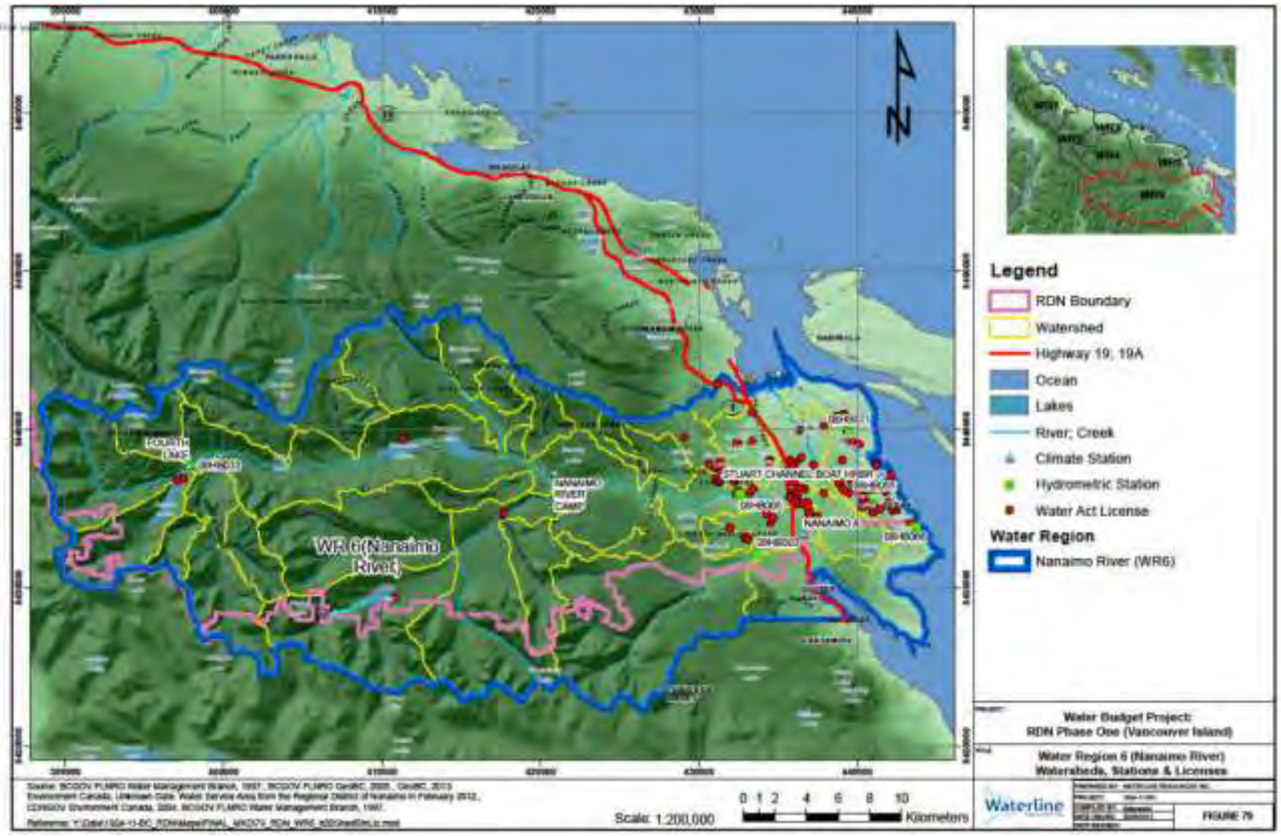


Figure 79: WR6 (NR) – Watershed, Stations & Licenses

8.2 Surface Water Assessment

8.2.1 Terrain and Topography

The Nanaimo River Water Region (WR6) includes the Nanaimo River Watershed and its major tributaries as well as that part of southern NRD (Cedar and North Oyster) which drain directly to the ocean. The southern edge of the watershed crosses into the Cowichan Valley Regional District including a large part of Haslam Creek. The majority of the upper watershed is private forest lands managed by Timberwest. The lower part of the watershed consists primarily of rural development with agriculture land, low density residential development and some light industrial development.

The region rises from sea level at the Nanaimo River estuary and Stuart Channel up to Mount El Capitan (1,537 m) near Jump Lake. There are four main lakes within the watershed including Fourth Lake, Second and First Nanaimo Lakes and Jump Lake. Dams located at Fourth Lake and Jump Lake are used as surface water storage for the Harmac Pulpmill and City of Nanaimo Municipal Water Supply, respectively. Some of the major tributaries to the Nanaimo River which have surface water licenses include Haslam Creek, South Nanaimo River, Jump Creek and Sadie Creek. The major watersheds in the WR6 (NR) are shown in Figure 79.

8.2.2 Climate

The climate for the Nanaimo River Water Region is similar to the rest of the RDN with cool wet winters and mild dry summers. A single Environment Canada weather station is located at the Nanaimo Airport at lower elevation in the water region. The average total annual precipitation for the 1971 to 2000 period is 1,162.7 mm. Figure 80 shows the monthly distribution of temperature and precipitation recorded at the Nanaimo Airport. Climate station locations are shown on Figure 79.

Significant snowpack accumulations are generally found in the higher elevation sections of the watershed through the winter and spring. The Jump Creek Snow Pillow (03B23P), operated by the BC River Forecast Centre, is located above Jump Lake at Elevation 1,134 m near the watershed divide with Cowichan River to the south. The station has been operational since 1995 and indicates a normal April 1st snowpack SWE of about 1,300 mm and has a maximum recorded SWE of 3,000 mm on April 1st 1999 (see Figure 81). A snow course was also operated in the watershed at Green Mountain (Elevation 1,400 m) from 1954 to 1985 with an average April 1st snowpack SWE of 1,480 mm.

Maps showing the distribution of annual total precipitation and average annual temperature over the water region are shown in Figure 82 and Figure 83, respectively. These maps show the influence of the Vancouver Island Mountains on precipitation and temperature with annual precipitation estimated to be greater than 5,000 mm at the head waters of Sadie Creek.

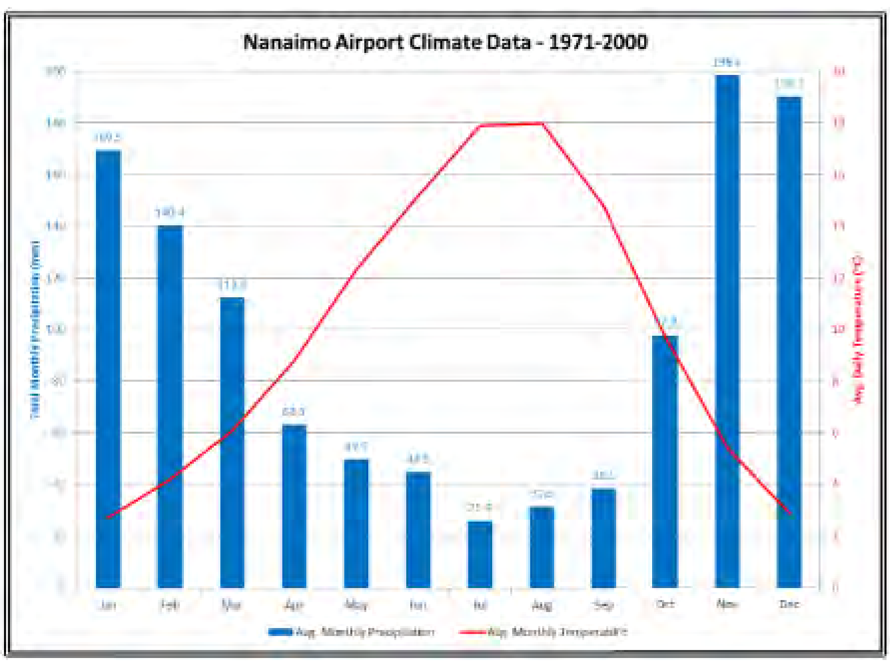
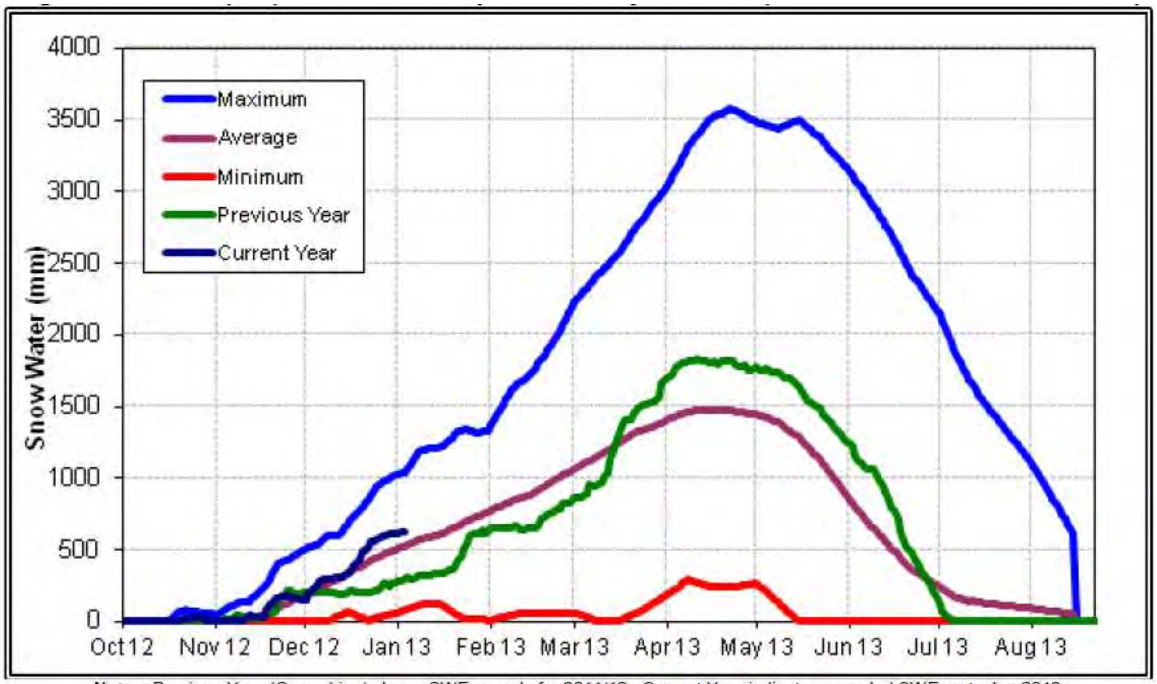


Figure 80: WR6 (NR) – Nanaimo Airport Monthly Climate (1971 to 2000 Normal Period)



Notes: Previous Year (Green Line) shows SWE records for 2011/12. Current Year indicates recorded SWE up to Jan 2013

Figure 81: WR6 (NR) – Jump Creek Snow Pillow

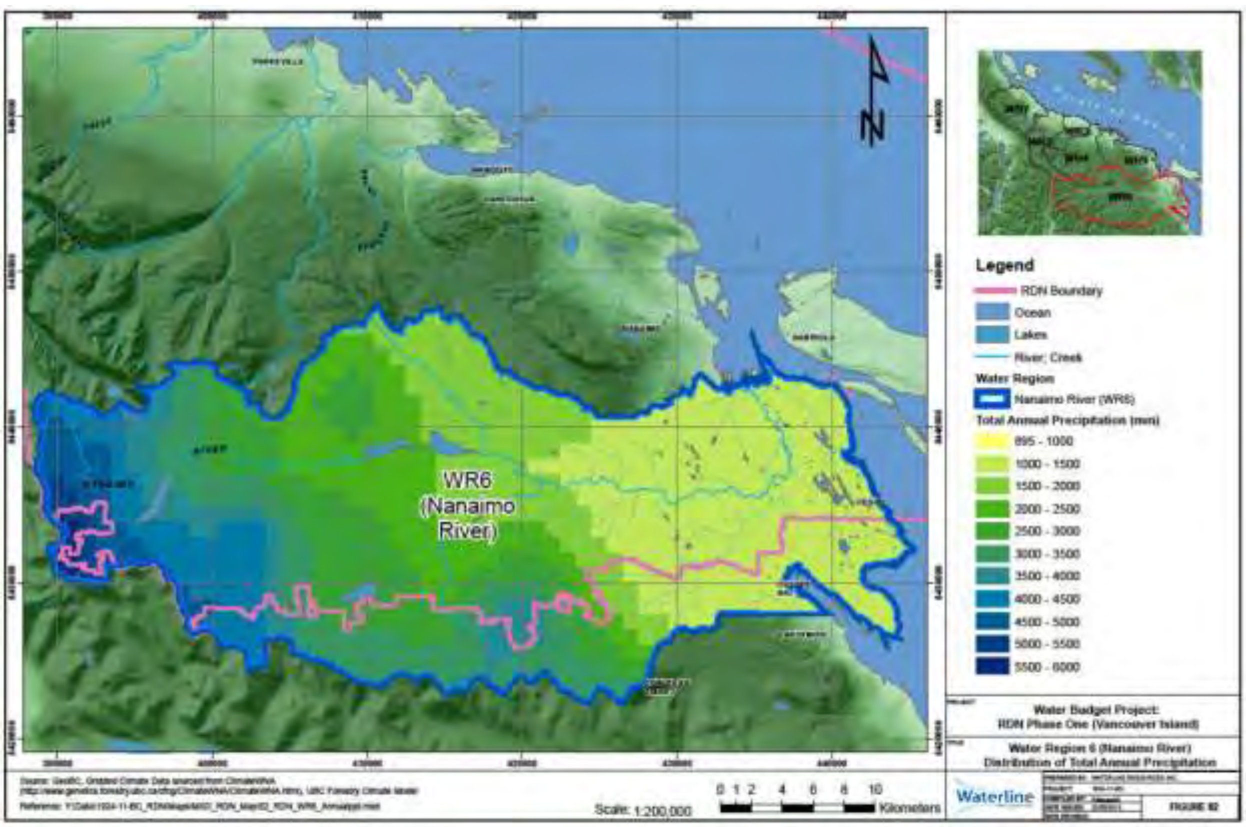


Figure 82: WR6 (NR) – Distribution of Total Annual Precipitation

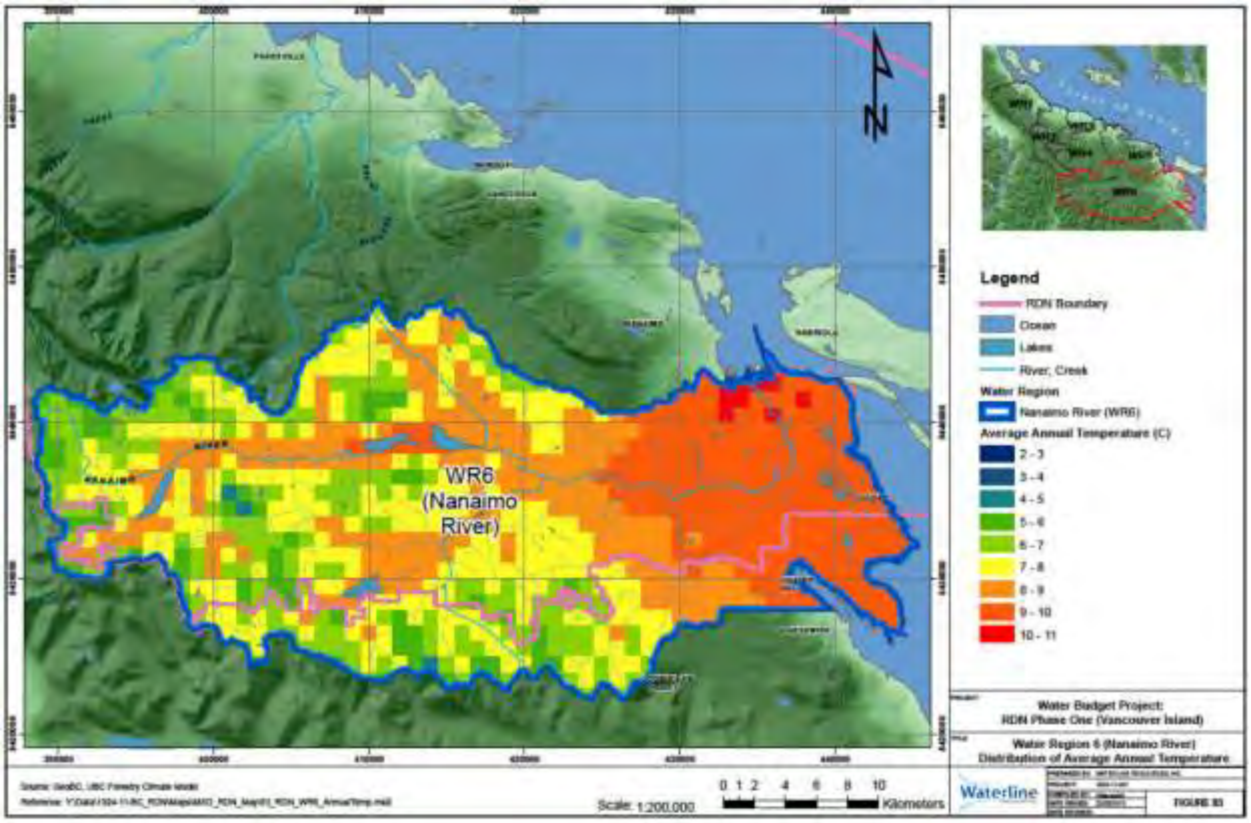


Figure 83: WR6 (NR) – Distribution of Average Annual Temperature

8.2.3 Stream Gauging and Monitoring

Three active and three discontinued water survey of Canada hydrometric stations are located within the Nanaimo River Watershed. The details for each of the stations are included in Table 52.

Table 52: WR6 (NR) – Water Survey of Canada Records

Station	Period	Natural or Regulated	Drainage Area to Gauge (km^2)	Mean Annual Discharge (m^3/s) and Volume (million m^3)	Mean Summer Discharge (m^3/s) and Volume (million m^3)
Nanaimo River near Cassidy (08HB034)	1965 to Present	Regulated since 1963	676	39.8 m^3/s 1,255 million m^3	7.51 m^3/s 59.7 million m^3
Nanaimo River near Extension (08HB005)	1913 to 1927 1948 to	Natural	645	40.5 m^3/s 1,277 million m^3	7.74 m^3/s 61.5 million m^3
Haslam Creek near Cassidy (08HB003)	1914 to1915 1948 to 1962 1992 to	Natural	95.6	4.38 m^3/s 138 million m^3	0.307 m^3/s 2.44 million m^3
South Nanaimo River near Junction	1997 to Present	Regulated	211	14.1 m^3/s 444.7 million m^3	1.98 m^3/s 15.8 million m^3
Jump Creek at the Mouth	1970 to Present	Regulated since 1974	62.2	4.82 m^3/s 0.416 million m^3	1.75 m^3/s 13.9 million m^3
Nanaimo River above Rockyrun Creek (08HB033)	1963 to 1964	Regulated	75.6	N/A	N/A

Monthly average hydrographs for Nanaimo River near Extension and Nanaimo River near Cassidy are shown in Figure 84. The figure provides an indication of the impact that regulation in the system has had on river flows.

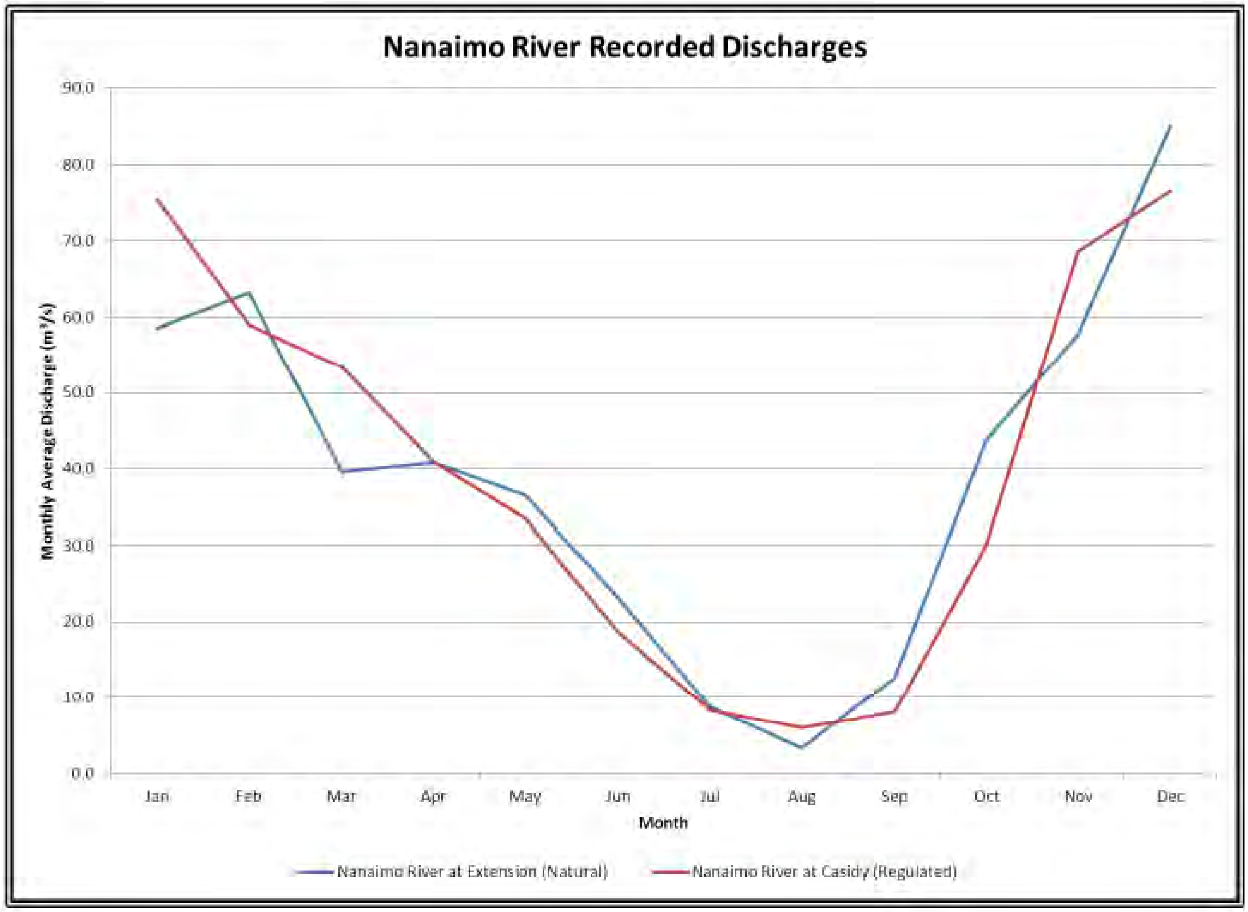


Figure 84: Nanaimo River Recorded Discharges

8.2.4 Hydrology and Surface Water Resources

The Regional Hydrological Model has been used to estimate mean annual discharge and volume as well as summer average discharge and volume for the Nanaimo River and the major tributaries. The results are shown in Table 53.

Table 53: WR6 (NR) – Natural (Unregulated) Surface Water Resources (1971 to 2000)

Watershed	Drainage Area (km^2)	Mean Annual Discharge (m^3/s) and Volume (million m^3)	Mean Summer Discharge (m^3/s) and Volume (million m^3)
Nanaimo River to the mouth (including all tributaries)	830	58.3 m^3/s 1,839 million m^3	7.83 m^3/s 62.2 million m^3
Haslam Creek to the Mouth	129	6.26 m^3/s 197 million m^3	0.378 m3/s 3.0 million m^3
South Nanaimo River	213	16.8 m^3/s 530 million m^3	1.2 m^3/s 9.54 million m^3
Jump Creek	61.7	5.25 m^3/s 165 million m^3	0.36 m^3/s 2.86 million m^3
Sadie Creek	29.3	4.09 m^3/s 128 million m^3	0.506 m^3/s 4.02 million m^3

Flows in the Nanaimo River are regulated at Fourth Lake Dam and Jump Creek Reservoir to support demands at the Harmac Pulpmill and the City of Nanaimo, respectively. Through an agreement with the Department of Fisheries and Oceans and BC Ministry of Forests, Lands and Natural Resource Operations a summer flow of 3.9 m^3/s at the Nanaimo River at Cassidy gauge should be maintained, with roughly 1.0 m^3/s from the Jump Creek dam and 2.9 m^3/s from the Forth Lake dam. During extreme low flow years, a minimum flow of 1.4 m^3/s is required to be maintained below the water intakes for the mill and 0.28 m^3/s in Jump Creek. Currently, the City of Nanaimo is in the planning and design process for construction of a new surface water reservoir on the South Nanaimo River. However, the details of the dam are preliminary and have not been included in the assessment.

8.2.5 Surface Water Demand

Table 54 summarizes the surface water licenses in WR6 from the BC Surface Water License Database. Table 55 outlines the licensed surface water storage. The locations of the surface water licenses for WR6 are shown on Figure 79.

Table 54: WR6 (NR) - Surface Water Demand

Type of Demand	Monthly (m^3/month)	Annual (million m^3)	Summer (Jul-Sept) (million m^3)
Consumptive Demand			
Agriculture	28,300	0.340	0.254
Domestic	2,400	0.0288	0.095
Industrial	9,910,000	118	29.7
Institutional	68	0.0008	0.00027
Water Works	5,390,000	64.7	21.4
Total Consumptive	15,330,000	184	51.3
Non- Consumptive Demand			
Power	699,840	8,398,080	
Conservation	-	-	
Total Non-Consumptive	699,840	8,398,080	

Table 55: WR6 (NR) - Licensed Surface Water Storage

Type of Demand	Total Storage (Million m^3)
Storage	64.3
Conservation Storage	0
Other Storage	0.87
Total Storage	65.1

The two largest water users in the Nanaimo River Water Region are the Harmac Pulpmill and the City of Nanaimo for Municipal Water Supply. The mill has a license to withdraw up to 3.82 m^3/s (118 million m^3) while the City of Nanaimo has a license to withdraw up to 64.7 million m^3 annually. However, both use less than their allocated amount. Actual recorded withdrawals for 2010 are included in Table 56.

Table 56: WR6 (NR) - Recorded Surface Water Withdrawal in 2010

Water User	Total Annual Volume (Million m^3)	Total Summer Volume (Million m^3)
City of Nanaimo	15.7	5.30
Harmac Pulp Mill	39.8	9.95
Total Recorded Withdrawal	55.5	15.5

Notes: Recorded withdrawal values were from Nanaimo River Baseline Report (Nanaimo Area Land Trust, 2011)

8.2.6 Surface Water Stress Analysis

As outlined in the introduction, a surface water stress analysis for each of the major watersheds has been completed. Water budget analysis for other smaller ungauged subwatersheds within WR6 (NR) should be completed when data is available and as part of a more detailed Tier 1 or Tier 2 water budget assessment (OMNR 2011). The results of the allocation and actual demand stress analysis for the watersheds in WR6 (NR) are shown in Table 57. A map showing the relative stress for each watershed is shown in Figure 85.

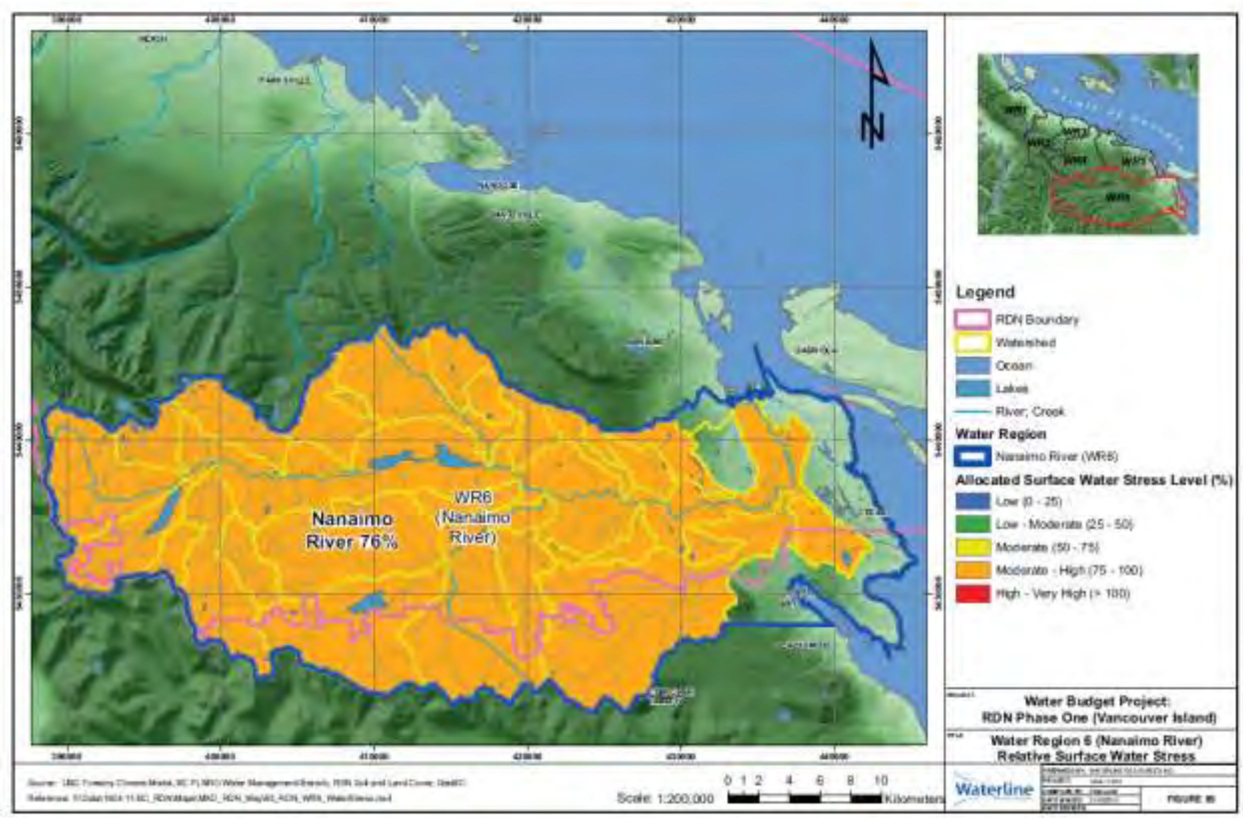


Figure 85: WR6 (NR) – Relative Surface Water Stress

Table 57: WR6 (NR) – Surface Water Stress Analysis

Watershed	Average Natural River Flow Supply (million m^3)	Storage (million m^3)	Conservation Flow (10% of MAD) (million m^3)	Licensed Demand (million m^3)	Allocation Stress	Stress Level	Actual Demand (million m^3)	Actual Stress
Nanaimo River	62.2	64.2	45.8	51.5	**76%**	Moderate to High	15.5	**48%**

Notes: Volumes indicated in the table are average volumes for summer period (Jul to Sep). Average natural river flow is the estimated or recorded unregulated flow in the watershed. Total storage is based on licensed storage volume and assumes all storage is available to support conservation flow and licenced demand for the Jul to Sep period. The 10% of Mean Annual Discharge (MAD) conservation flow is based on current Ministry of Forest, Lands and Natural Resource Operations (MELP, 1996) minimum conservation flow policies for the east coast of Vancouver Island. Licenced demand is the total licenced volume for summer based on consumptive water licences. Allocation stress = (Average Natural supply + storage) / (Conservation Flow + Licenced Demand). Actual Stress = (Average Natural supply + storage) / (Conservation Flow + Average Recorded Surface Water Demand). Surface water stress color codes: blue=low, green =low to moderate, yellow =moderate, brown =moderate to high, red=high to very high. Values reflect average flow conditions and do not consider drought years.

8.3 Groundwater Assessment

8.3.1 Existing Groundwater Studies and Data – WR6 (NR)

Given the regional scale of the Phase One Water Budget Assessment, the most important data compiled and geo-referenced by Waterline was the water well information, elevation data, soil and geology maps, land cover, aggregate resource map, mapped aquifers, and water service areas.

Although only some of the data in certain reports may have been incorporated into Waterline's Geodatabase, the primary studies in the region were used in Waterline's water budget assessment to provide the local hydrogeological are provided in Table 58.

Table 58: WR6 (NR) – Hydrogeology Reference Reports

Author	Year	Study Title
Associated Engineering	2007	South Nanaimo River-Watershed Yield Assessment (2007)
Associated Engineering	2009	Nanaimo River Fourth Lake Yield Assessment
GW Solutions, Vancouver Island University	2010	Area A Groundwater Assessment and Water Budget
Levelton	2011	RDN Observation Well Holden Corso and Lofthouse Roads, Cedar
Pacific Hydrology Consultants	1990	OCI Boat Harbour Development - Water Supply Completion Report
Piteau Associates	1992	Water Well Testing for Pylades Development
Piteau Associates	1995	Pylades Well – Pumping Test – 2380 Bissel Road Cedar
Piteau Associates	2001	North Cedar Improvement District Hydrogeologic Assessment to Identify New Well Source
SRK Consulting	2007	TEL_17-123-432f_rpt_Cassidy Aquifer - Completion Report
Thurber Engineering Ltd.	2006	Water 2006S Nanaimo Lakes Groundwater Study

8.3.2 Description of Aquifers and Water Wells

A total of three unconsolidated aquifers and three bedrock aquifers have been mapped within WR6 (NR) (Table 59). The Capilano aquifer 161 (Cassidy Aquifer) was mapped as having high productivity, is highly developed, and is also high vulnerable due to its unconfined nature. The underlying Vashon sand and gravel aquifer (#160, Lower Cassidy Aquifer) exhibits moderate productivity, low vulnerability, and is not well developed. Bedrock aquifers in Extension (164) and South Wellington (165) exhibit low yield, moderate demand, and moderate vulnerability. The Cedar/Yellow Point aquifer (Aquifer 162) exhibits low productivity/yield, high demand, and high vulnerability. It should be noted that aquifers 963 and 964 are newly mapped aquifers in this region and water budgets were not included in the current water budget assessment.

Table 59: WR6 (NR) – Summary of Mapped Aquifers

Aquifer Tag No.	Aquifer Lithology	Location Within Water Region	Potential Groundwater-Surface water or Aquifer to Aquifer Interaction	Developed Aquifer surface Area	Confined, Semi, or unconfined, Aquifer Vulnerability Code	Yield
				(m2)		(L/M/H)
160	Vashon	Lr. Cassidy	NR	6.0E+06	Semi-Confined, IIC	M
161	Capilano	Cassidy	NR	3.0E+07	Unconfined, IIA	H
162	NG	Cedar, Yellowpoint	NR, Ocean	7.9E+07	Unconfined, IA	L
163	Quadra	North Holden Lk., Cedar	Ocean	1.6E+06	Unconfined, IIB	M
164	NG	Extension	NR	6.2E+06	Confined, IIB	L
165	NG	South Wellington	NR	1.7E+07	Confined, IIB	L

Notes: A/B/C is high/moderate/low vulnerability, I/II/III is heavy/moderate/light use, H/M/L means high/medium/low productivity/yield. All aquifer classification parameters, codes and yield are defined at the following MOE web address http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/Aq_Classification/Aq_Class.html#class. NG means Nanaimo Group.

Figure 86 shows the three sand and gravel aquifers mapped in WR6 (NR) with associated supply wells listed in the MOE Wells Database. Figure 87 shows the three bedrock aquifers with associated supply wells listed in the MOE Wells Database. There are a total of 2686 overburden and bedrock wells listed in the MOE data base in WR6 (NR) (Table 51). As there are no regulatory requirements in BC to submit wells logs to MOE for capture in the Wells Database, the water wells shown on Figure 86 and Figure 87 likely represents only a fraction of wells actually drilled.

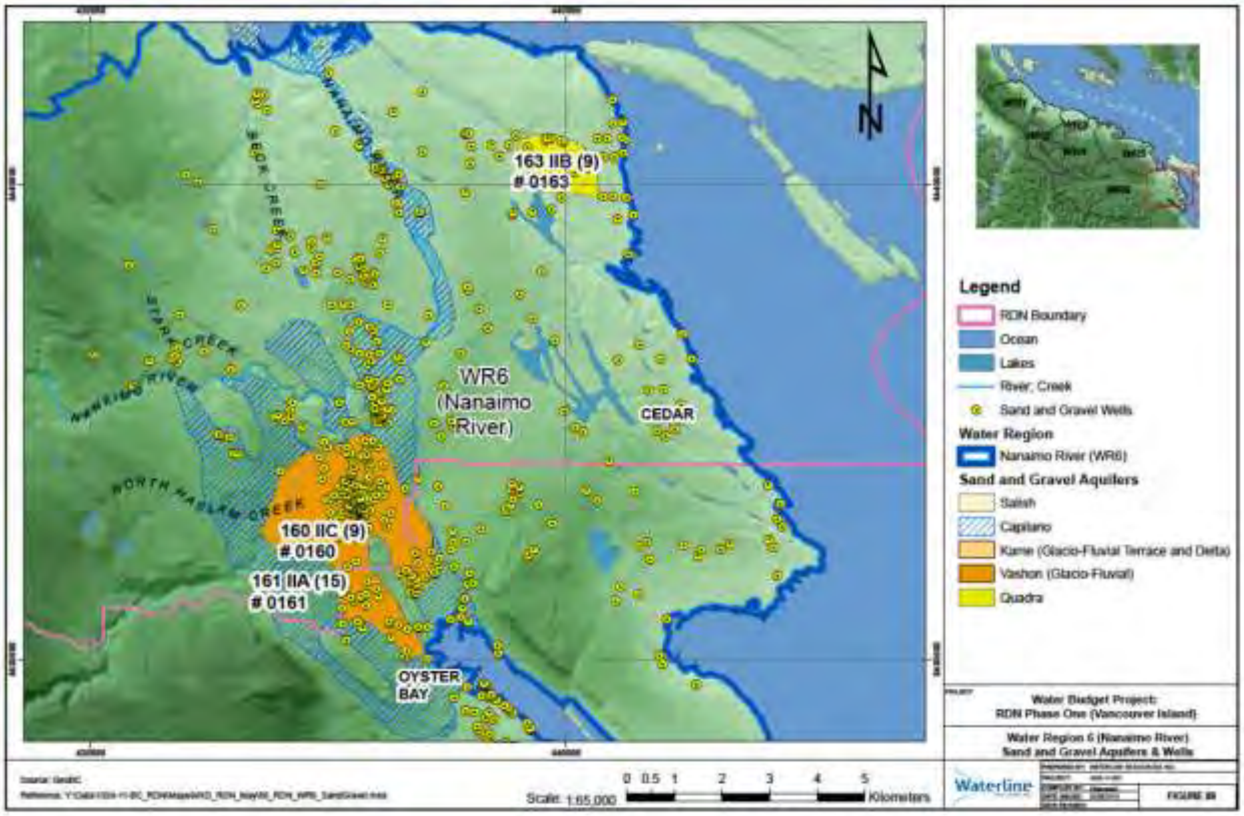


Figure 86: WR6 (NR) – Mapped Sand and Gravel Aquifers & Wells

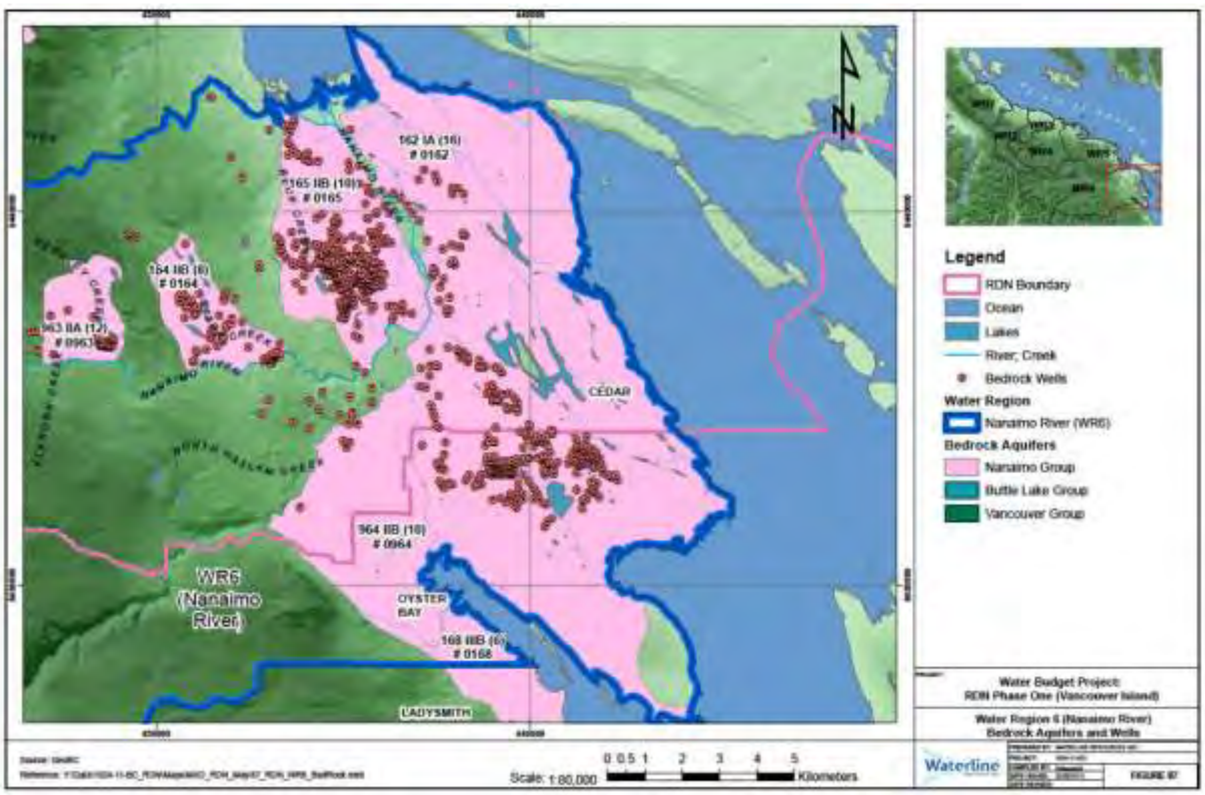


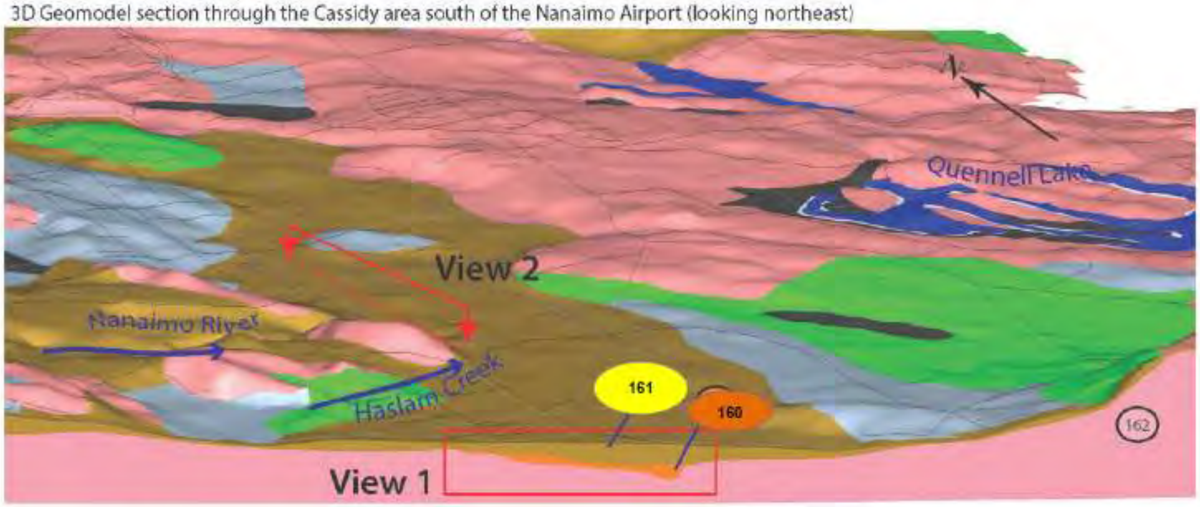
Figure 87: WR6 (NR) – Mapped Bedrock Aquifers & Wells

8.3.3 Groundwater-Surface Water Interaction - Conceptual Hydrogeological Model

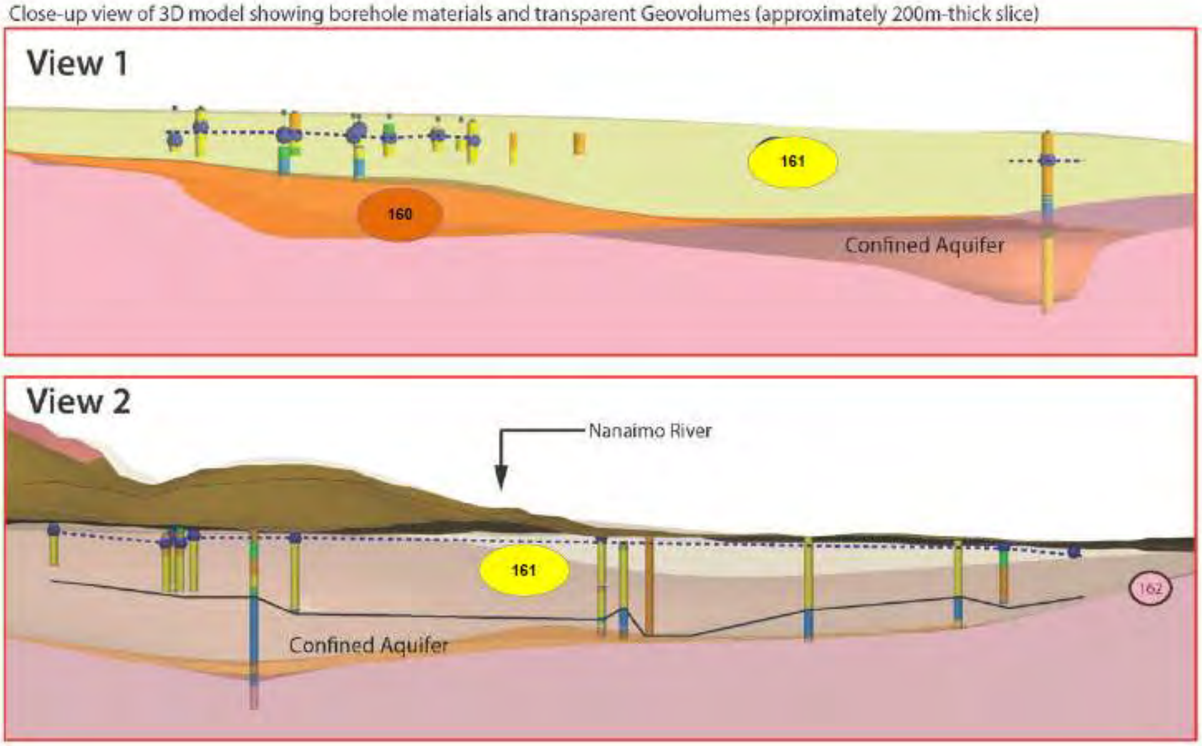
A conceptual hydrogeological model of each aquifer with WR6 (NR) was developed in order to understand the key elements and linkages between surface water and groundwater systems required to complete the aquifer water budget assessment. Although conceptual hydrogeological model developed by Waterline includes numerous cross-sectional views developed within the Waterline Geodatabase, only one 3D view into the subsurface will be presented here.

Figure 88 shows a 3D block diagram illustrating the relationship between surface and subsurface geology in the Cassidy area of WR6 (NR) where two major water supply aquifers have been mapped. The schematic shows how the Capilano Aquifer (161) is exposed in Haslam Creek and the Nanaimo River and likely contributes important base flow to the creek during the summer and fall season. View 1 shows the upper Cassidy aquifer (161) with a high water table. The lower Cassidy aquifer (160) is considerably less developed but water levels appear to be high suggesting that it may be connected to overlying upper Cassidy aquifer (161).

3D Geomodel section through the Cassidy area south of the Nanaimo Airport (looking northeast)



Close-up view of 3D model showing borehole materials and transparent Geovolumes (approximately 200m-thick slice)



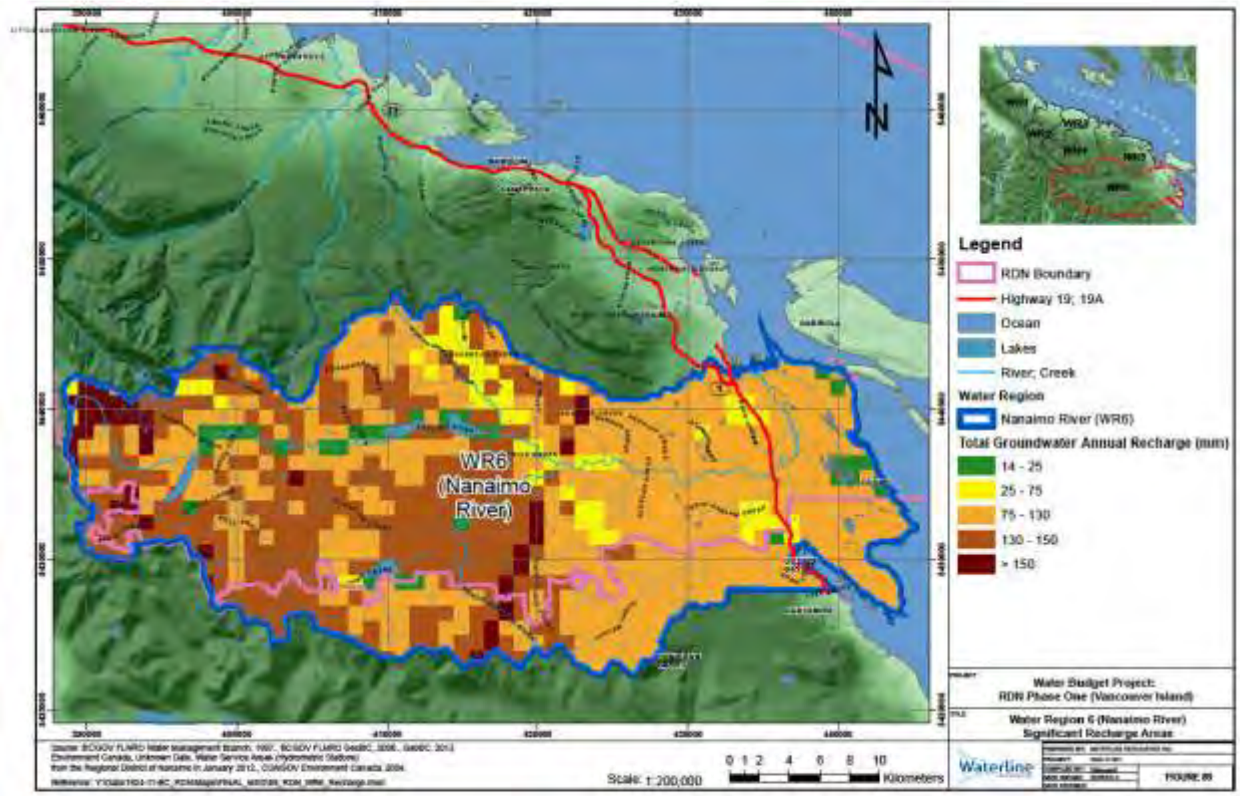


Figure 89: WR6 (NR) – Significant Recharge Areas

8.3.5 Groundwater Level Monitoring – BC MOE Observation Well Network

Long-term water level monitoring data provides an indication of an aquifer's response to global, regional, and local environmental changes in climate, groundwater pumping, and the impacts (if any) of other activities related land development. Long-term records also allow for establishing hydraulic linkages between the groundwater and surface water systems.

Figure 90 shows the locations of MOE observation wells and long-term water level monitoring records in relation to community water supply wells identified from the MOE Wells Database (E.g.: Large municipal users, the RDN, private utilities wells). Although numerous community wells are listed in the database, Waterline understands that not all of the wells shown on Figure 90 are currently active.

One of the problems encountered by Waterline during the water budget project was that community well owners generally do not cross reference active production wells to respective well logs in the MOE database. Often wells are referred to by local names (E.g.: RDN well # 1, #2, etc…). As water budget calculations require that production wells be assigned to specific aquifers, it is important that cross-referencing with the MOE well logs be completed. Well owners are encouraged to report the MOE well plate number so that accurate water level and groundwater extraction volumes can be allocated to the corresponding MOE well log and mapped aquifer.

Water level monitoring records are available for five MOE observation wells in WR6 (NR) (Figure 91 to Figure 96, inclusive). Two MOE wells (330 & 312) are completed in the

Cassidy (upper) Aquifer 161 (Figure 91 and Figure 92), MOE well 228 in the Vashon (Lower Cassidy) Aquifer 160 (Figure 93), and three MOE wells in Nanaimo Group Bedrock (Cedar and Yellow Point) Aquifer 162 (Well # 337, 315, and 331 (Figure 94 to Figure 96). Water levels in MOE Wells were plotted along with the Nanaimo Airport precipitation record and the Jump Creek River Stage (level) in the case of MOE well 330 located at the confluence of Jump Creek and the Nanaimo River.

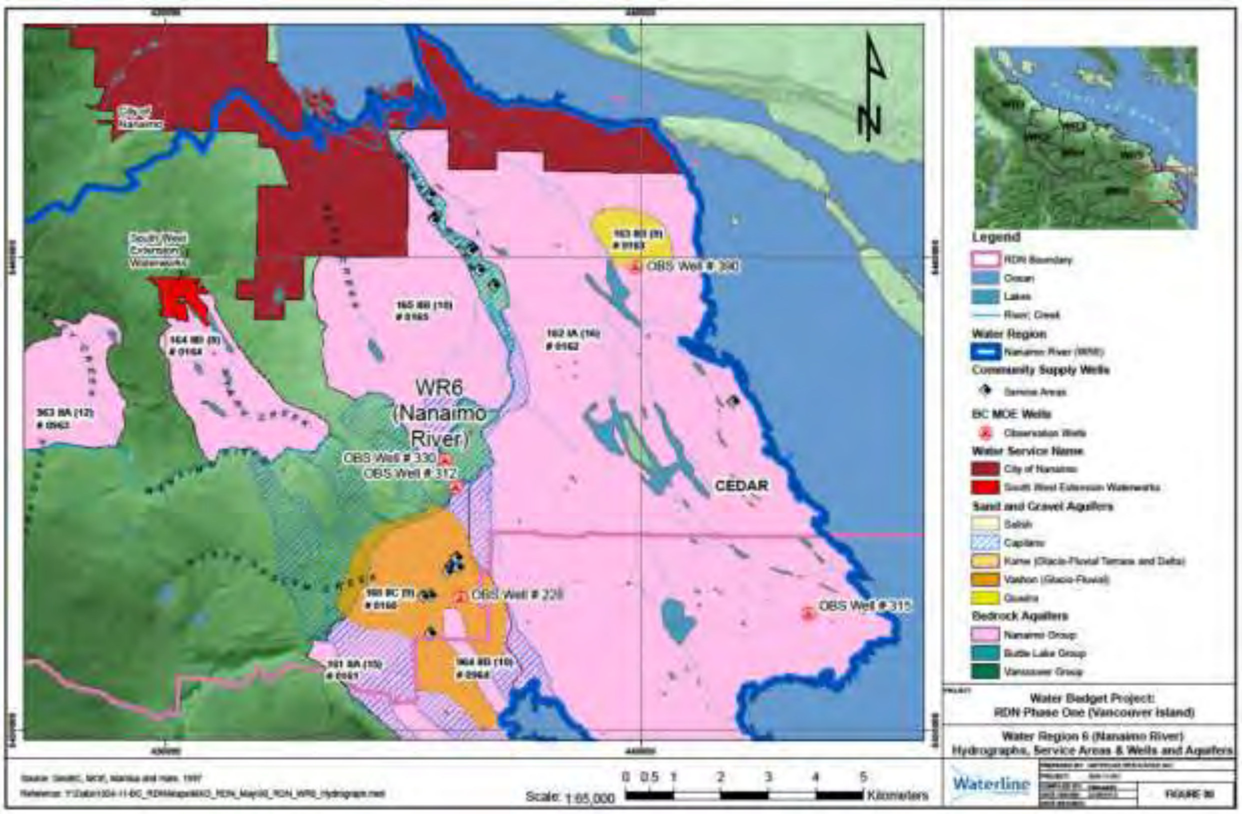


Figure 90: WR6 (NR) – MOE Well Hydrographs, Service Areas & Wells, and Aquifers.

MOE observation wells 330 and 312 completed in Capilano aquifer 161 (Upper Cassidy Aquifer) shows a 2-6 m water level decline since monitoring began until the year 2000. This was followed by a level trend to present day. Both wells also follow the Jump Creek level, Nanaimo Airport precipitation data, and PDO trend suggesting a direct connection to the surface. The data suggests that groundwater pumping significantly affects water levels in the Capilano Aquifer 161 (Upper Cassidy Aquifer). High volume wells located near the Nanaimo River, and/or the fact that the flow in the Nanaimo River is regulated, could account for the water level drop in the aquifer observed between 1996 and 2000 (MOE Well 330) and 2003 (MOE Well 312). More information is needed to verify the cause and effect relationship.

Water level data collected in the underlying Lower Cassidy Aquifer (Well 228, Figure 93) shows a much more stable trend as only a few water supply wells extract groundwater from this aquifer. The water level record exhibits close correlation to the local precipitation data and the PDO trend suggesting a direct connection to the surface. This also means that the

Lower Cassidy aquifer may be semi-confined and hydraulically connected to the overlying Cassidy aquifer.

The water level hydrograph for MOE well 337, completed in bedrock Aquifer 162 near Henry Roethel Road shows seasonal variations and an overall water level decline of 15m between 2002 and 2010. This decline can likely be attributed to a number of factors including local overpumping of the aquifer and its location at the top of the watershed where there is a limited catchment area for aquifer recharge. MOE well 315 is also completed in bedrock Aquifer 162 near the coast but shows a relatively stable long-term water level, although Waterline understands that the logger in this well may not be functioning properly. Both MOE wells completed in Aquifer 162 show a one to two month offset from the precipitation record suggesting a semi-confined system. The record for MOE Well 390 is too short to assess the long-term trend.

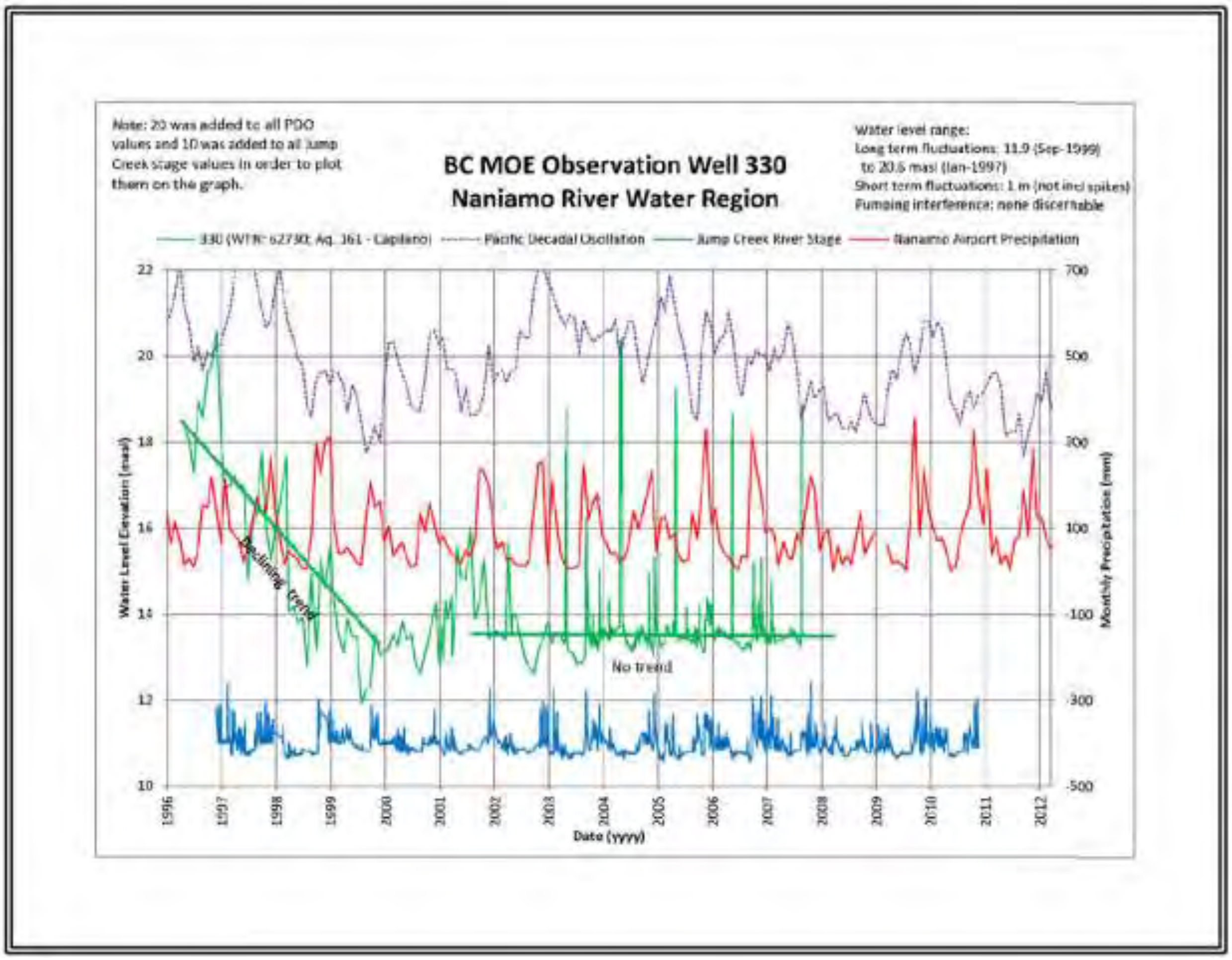


Figure 91: WR6 (NR) – Water Level Hydrograph BCMOE 330.

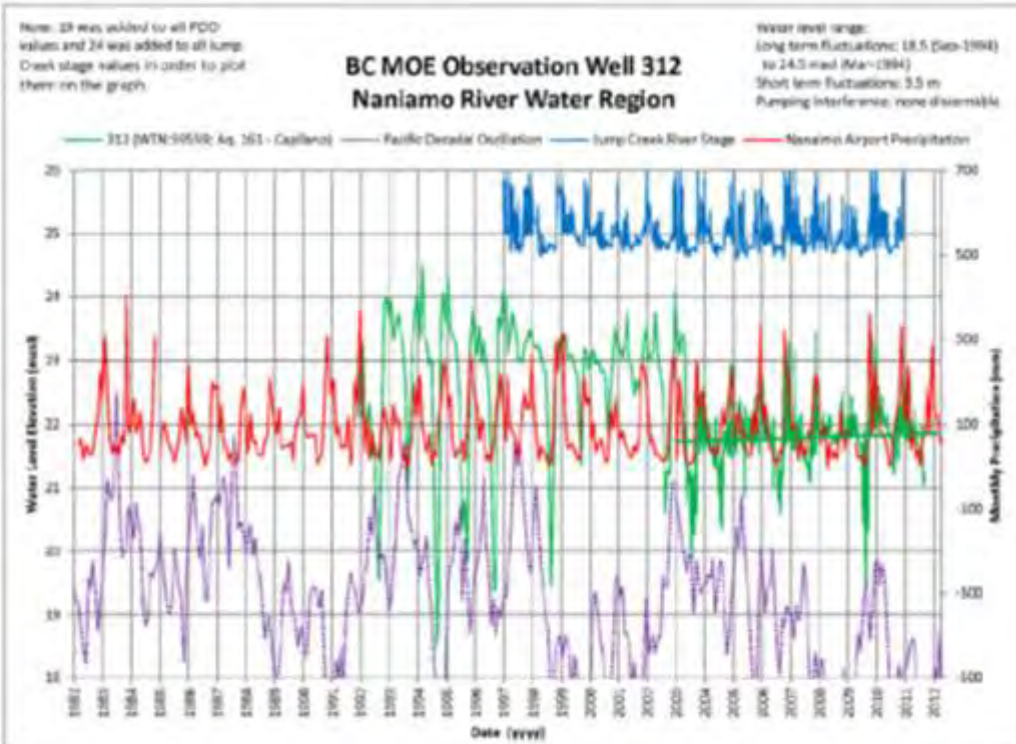


Figure 92: WR6 (NR) – Water Level Hydrograph BCMOE 312.

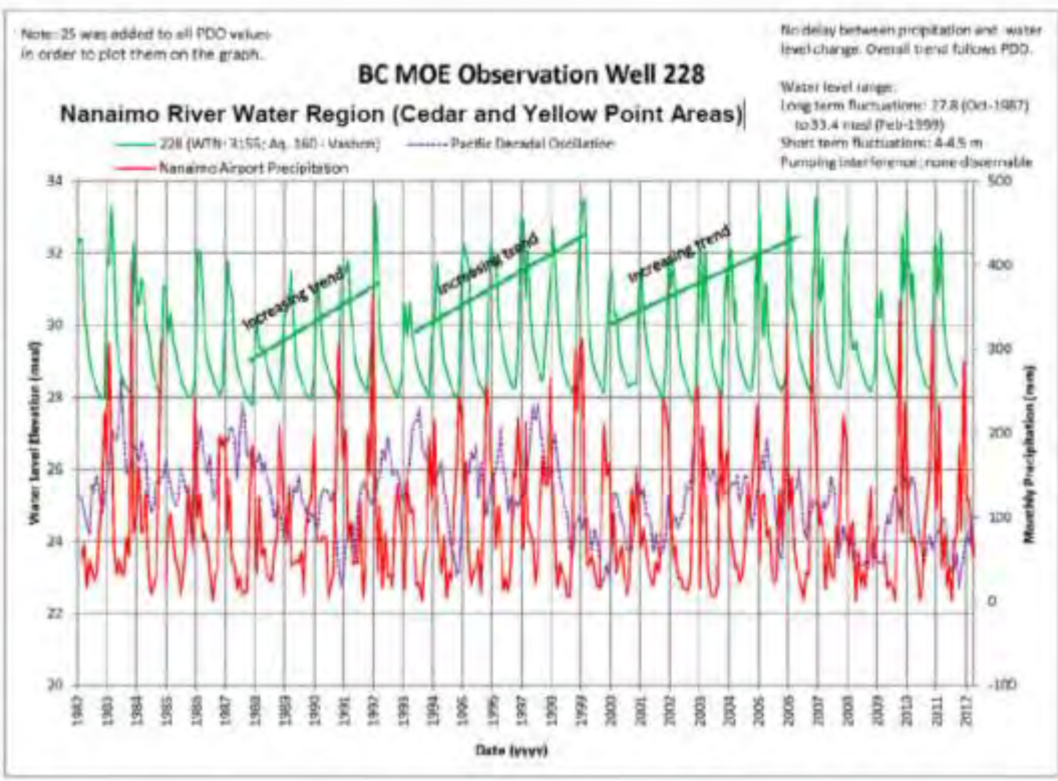


Figure 93: WR6 (NR) – Water Level Hydrograph BCMOE 228.

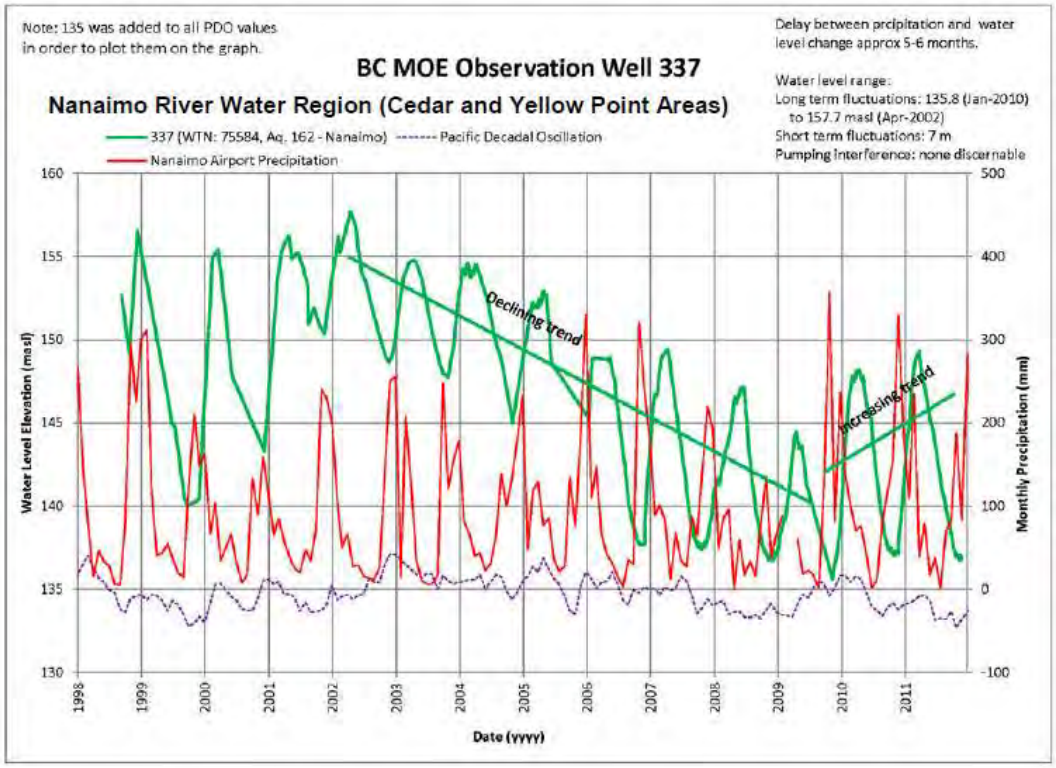


Figure 94: WR6 (NR) – Water Level Hydrograph BCMOE 337.

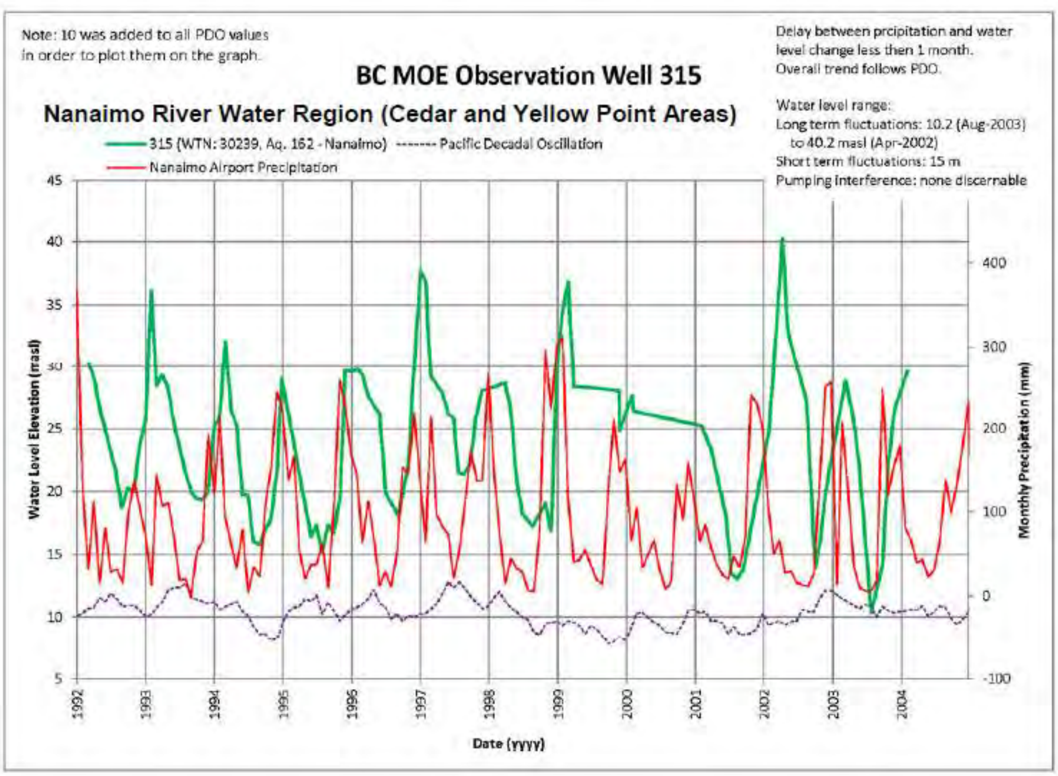


Figure 95: WR6 (NR) – Water Level Hydrograph BCMOE 315.

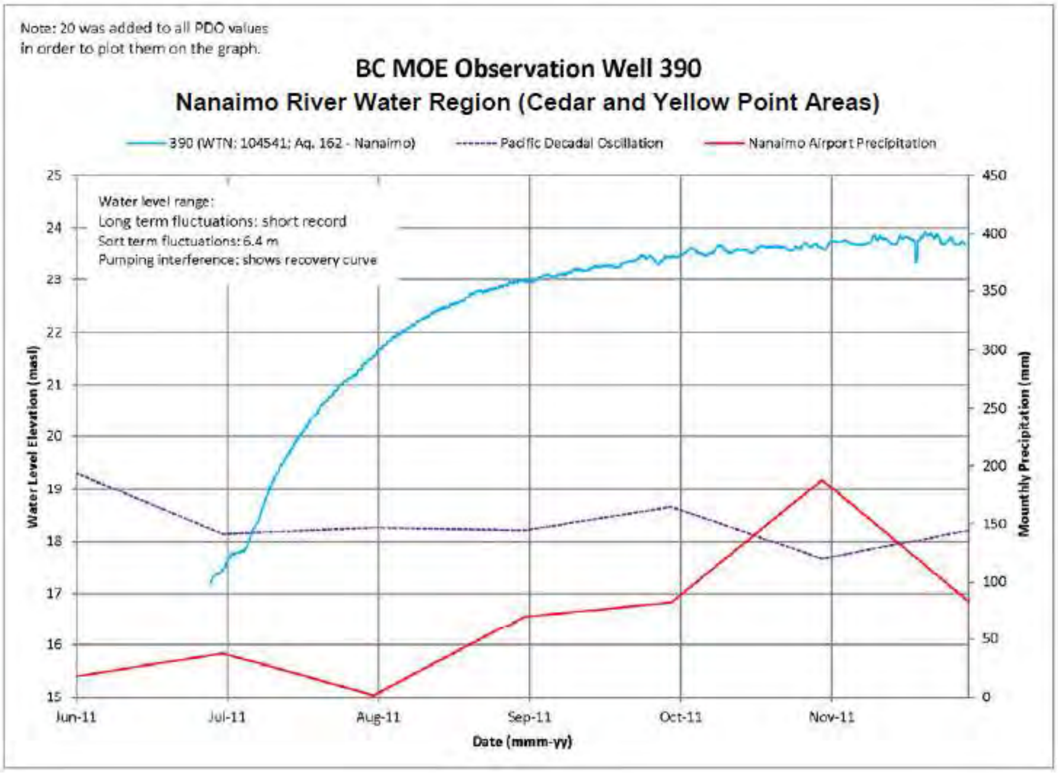


Figure 96: WR6 (NR) – Water Level Hydrograph BC MOE 390.

8.3.6 Anthropogenic Groundwater Demand

Table 60 summarizes the available groundwater demand data available for WR6 (NR).

Table 60: WR6 (NR) – Summary of Anthropogenic Groundwater Demand Analysis

Aquifer Tag No.	North Cedar Water Works	RDN DeCourcy	RDN Pylades	Snuneymuxw First Nation	Nanaimo Airport	Harmac	Other Private Wells (From RDN Water Use Est. based on Zoning compiled on GIS)	Total Ground Water Use Estimate (ANTHout)
	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)
160	NA	NA	NA	NA	2.7E+03	NA	0.0E+00	2.7E+03
161	4.5E+05	NA	NA	?	2.7E+03	3.0E+07	2.0E+06	3.2E+07
162	NA	1.0E+03		NA	NA	NA	1.1E+07	1.1E+07
163	NA	NA	NA	NA	NA	NA	3.1E+05	3.1E+05
164	NA	NA	NA	NA	NA	NA	8.5E+05	8.5E+05
165	NA	NA	NA	NA	NA	NA	1.8E+06	1.8E+06

Notes: NA means not applicable, ? Means not known or unavailable, ANTHout means anthropogenic water extraction from aquifer.

The annual water use for serviced areas within the RDN (large municipal users, RDN wells, and private utilities) is typically measured and was provided by the RDN or taken from annual reports for 2010. The groundwater demand estimate for non-service areas was calculated from water use data provided by the RDN for serviced areas, and then applied to non-serviced areas based on civic addresses and zoning classification. Harmac appears to be the largest single user of groundwater in the region. The method of assessment is further described in Appendix C (Map C21) and Appendix D.

There may also be groundwater discharging from aquifers that is required for conservation of flow in creeks and rivers based on the physical model developed by Waterline. The total groundwater demand for each aquifer, including conservation flow requirements, was compared against the estimated aquifer recharge to assess the stress on each aquifer. The results are presented in the following section.

8.3.7 Aquifer Water Budgets and Stress Analysis

Table 61 provides a summary of the final water budget calculations for each aquifer mapped within WR6 (NR). Detailed water budget calculations are provided in Appendix D (Tables D7 and D8). Water budgets for aquifers that extend from one water region to an adjacent water region (E.g.: Aquifer 161 and 162, Figure 90) were completed as a single aquifer, respectively, regardless of the RDN boundary. The rationale for this was that despite the jurisdictional issues, the RDN will need to consider the water demand and balance for the entire aquifer, not just that portion that lies within its boundary.

Based on the water budget estimates for mapped aquifers within WR6 (NR), moderately high to highly stressed aquifers appear to dominate this region. Only aquifer 165 located in South Wellington exhibits a moderate stress level. The most stressed aquifers include the Upper Cassidy Aquifer (161), the Cedar Yellow Point aquifer (162), and the small Quadra Aquifer 163 mapped near the Holden Cross Road and Haro Road. Many of the aquifers have moderate to higher density wells that likely contribute to well to well interference, particularly in the lower productivity bedrock aquifers with limited recharge.

As indicated above, there are a total of 2686 overburden and bedrock wells listed in the MOE data base in WR6 (NR) which represents the largest number of wells in all of the 6 water regions across the RDN on Vancouver Island. It is also recognized that this number may only represent as little as 50% of water wells actually in operation in this region. This clearly shows that the demand for groundwater in WR6 (NR) is very high and that there is an urgent need to better manage groundwater extraction in this region.

Aquifer stress in this region is primarily due to anthropogenic water use and the lack of monitoring which would otherwise allow proper management of aquifer levels. The main reason for the high indicated stress on Aquifer 163 is due to the small areal extent of the mapped aquifer which limits recharge, and the agricultural water demand values assigned base on the method described in Appendix C (Map C21).

More accurate water budget and aquifer stress estimates could only be accomplished using a computer modelling approach, but again the lack of aquifer data would likely render this exercise inconclusive as well. Rigorous testing requirements and complete aquifer test analysis by groundwater practitioners to determine aquifer transmissivity and storativity properties, in addition to long-term groundwater monitoring data in each aquifer would be required to fully assess the actual stress on each aquifer in this region.

Table 61: Summary of Aquifer Stress Analysis – WR6 (NR)

Aquifer Tag No.	Aquifer Lithology	Potential Groundwater-Surface water or Aquifer to Aquifer Interaction	MOE Obs Well	Seas. Fluc.	Long Term Fluc.	WL Trend (up or down)	Total Est. AQ. Rec. (TRin) (Rp/l + Rmb)	Est. Ann. Disch to Cr. & Down Grad Aquifer (Tc out)	Ground Water Use Estimate (ANTHout)	Total Out [TcOut + ANTH_out]	Stress Anal. % GW Use of the avail. AQ. Rec.	Relative Stress Assess.
			ID	(m)	(m)	U/D	(m^3/yr)		(m3/yr)	(m^3/yr)	(%)	Lo, Mod, Hi
160	Vashon	NR	228	4, 4.5	0	L	1.26E+07	7.84E+06	2.7E+03	7.8E+06	62	Mod-Hi
161	Capilano	NR	330, 312	0, 3.5	5, 6	Aban. D/L	1.26E+08	1.05E+08	2.0E+07	1.2E+08	99	Mod-Hi
[illegible]	[illegible]	NR, Ocean	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
164	NG	NR	?	?	?	?	1.11E+06	5.05E+03	8.5E+05	8.6E+05	77	Mod-Hi
165	NG	NR	?	?	?	?	3.20E+06	4.13E+05	1.8E+06	2.2E+06	68	Mod

Notes: NR means Nanaimo River, NA means not applicable, AQ means aquifer, Seas. Fluc. means seasonal fluctuation, PDO means Pacific Decadal Oscillation, WL means water level, Est means estimated, Disch. means discharge, Rec. means recharge ,Cr. Means creek, TRin means total recharge into aquifer, Rp/l means total recharge from precipitation and/or leakage from overlying aquifer, Rmb means total lateral recharge from upgradient aquifer or mountain block, Tc out means total aquifer groundwater discharge to creek, assess. means assessment , Total out means total discharge from aquifer (not including discharge to ocean), ANTH out mean total groundwater Anthropogenic groundwater extraction from aquifer, aquifer stress color codes: blue=low, green =low to moderate, yellow =moderate, brown=moderate to high, red=high to very high

8.4 Water Management Planning Within WR6 (NR)

General guidance on water management planning for all water regions is provide in later sections of this document. Specific to WR6 (NR), the following recommendations are presented for consideration by RDN to improve the state of knowledge in the water region:

- At least one observation well should be installed in each mapped aquifer. Mapped aquifers that currently do not have MOE observation wells include Aquifer 164 and 165;
- Well owners should identify the MOE well plate and tag numbers for each of their active
  water wells. In this manner, water use and monitoring data can be easily cross-referenced with the BC MOE well records. These included North Cedar Water Works wells, RDN DeCourcy well(s), Nanaimo Airport wells, and Harmac supply wells;
- The significant recharge area map needs to be further updated by further processing of the NRCAN remote sensing data and by field verification;
- Further mapping of the groundwater surface water interactions is also required in Haslam Creek and the Nanaimo River to confirm the interactions between mapped aquifers 161 and 160. Waterline recommends specialized analysis (E.g.: isotopes[29], noble gases) of groundwater samples in this region to assist in determining groundwater age and origin. Thermal imaging of the river during high and low flows may help to quickly pinpoint areas where more detailed studies may be required;
- Reactivation of WSC surface water gauging station for Haslam Creek (08HB003) is recommended;
- Summer base flows (June to Sept) in Hokkenen Creek and Holden Creek should be collected as part of the Community Watershed Monitoring Network to gain a better understanding of summer base flows in smaller watersheds in the region; and
- Reservoir level and discharge data for Jump Creek and Forth Lake should be collected from the City of Nanaimo and Harmac at regular intervals and uploaded to the regional water database.

KNOWLEDGE AND DATA GAPS

Early Warning Monitoring and Cumulative Effects Analysis

Although an abundance of water-related information is being collected each year within the RDN, insufficient regulatory guidance and the inability of MOE/RDN to electronically track this information creates large data/knowledge gaps. This severely impedes the RDN's ability to properly manage watersheds and aquifers in a sustainable manner. In the absence of regulatory guidance, water users and groundwater practitioners are left to develop studies that may not be consistent with other studies or may not sufficiently advance the state of knowledge in a watershed or water region. Studies are often focused on local scale issues, whereas a more regional approach may be necessary to understand the project impact and cumulative effects of numerous water users in a water region. There is a need for developing a consistent approach and consistent data requirements for all water-related studies.

CLOSURE

Surface and groundwater are renewable resources but a balance must be struck between water needed to maintain healthy ecosystems and the demand for water by humans. Although the Phase One Water Budget project sets the framework for assessing water availability versus water demand, considerable gaps exist in the data which need to be filled to provide a more accurate picture of current and future water conditions. The objective in water management is to achieve "sustainability" of water resources. This is simply not possible in the absence of proper monitoring data.

The BC Water Act Modernization process appears to be focused on public consultation and attempting to address the issue of water rights which has caused considerable delay in developing legislation. No matter who owns the rights to the water, sustainable management practices need to be implemented as water supply wells continue to be drilled and aquifers exploited as the demand for water continually rises.

Approaches to water management are relatively well understood and not unique to the province British Columbia. Developing guidelines that lead to improved knowledge of surface water and groundwater systems within each water region has been done by other jurisdiction across Canada and is simply good practice. The absence of Provincial guidelines which include standards of practice for all water practitioners and mandatory monitoring and data submission requirements (i.e.: well logs are only one example), risks the continuance of non-sustainable water management practices.

On-going land development and increasing water demand, combined with the potential effects of climate change will undoubtedly continue to place stress on surface water and groundwater resources in ways that we cannot predict or understand with current datasets. The RDN has taken a proactive step with the initiation of the phase one water budget project. The cooperation of residents, water purveyors, drillers, water practitioners, corporations, municipal/provincial/federal regulatory officials is needed in order to move forward to a sustainable future.

Respectfully submitted,

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To view the RDN Water Budget Study, including graphs and figures, it its entirety, please see www.rdnwaterbudget.ca

REFERENCES

Literature Cited

Boom, A. and G. Bryden 1994: Englishman River Water Allocation Plan. British Columbia Ministry of Environment, Lands and Parks, Vancouver Island Region. Downloaded from http://www.env.gov.bc.ca/wsd/water_rights/wap/ in June 2012.

Braybrook, C., G. Bryden and A. Dambergs 1995: Nile Creek to Trent River Water Allocation Plan. British Columbia Ministry of Environment, Lands and Parks, Vancouver Island Region. Downloaded from http://www.env.gov.bc.ca/wsd/water_rights/wap/ in June 2012.

Bryden. G., T.J. Welyk and S. Gannon, 1994: French Creek Water Allocation Plan. British Columbia Ministry of Environment, Lands and Parks, Vancouver Island Region. Downloaded from http://www.env.gov.bc.ca/wsd/water_rights/wap/ in June 2012.

Pirani, Z. and G. Bryden, 1996: Qualicum River Water Allocation Plan. British Columbia Ministry of Environment, Lands and Parks, Vancouver Island Region. Downloaded from http://www.env.gov.bc.ca/wsd/water_rights/wap/ in June 2012.

MoELP, 1993. Nanaimo River Water Management Plan. Ministry of Environment, Lands, and Parks. July 1993.

Earle, S. PhD. (2007) Geology and Geological History of Vancouver Island. Vancouver Island University, Department of Geology.

Fyles, J. G., 1963, Surficial geology of the Horne Lake and Parksville map-areas, Vancouver Island, British Columbia. Geological Survey of Canada, Mem. 318, 142p.

Hamon, W.R., 1961. Estimating potential evapotranspiration. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, v. 87, p. 107-120.

HB Lanarc, (2010). Drinking Water & Watershed Protection. Watershed Snapshot Report 2010.

McCabe, G. J. and S.L. Markstrom, 2007. A Monthly Water-Balance Model Driven by a Graphical User Interface. US Geological Survey Open-File Report 2007-1088.

McCammon, J.W., 1977. Surficial Geology and Sand and Gravel Deposits of Sunshine Coast, Powell River, and Campbell River Areas. British Columbia Ministry of Mines and Petroleum Resources. Bulletin 65, 36 p.

Thorntwaite, C.W., 1948. An approach towards a rational classification of climate: Geographical Review, v. 38. p. 55-94.

Wang, T., Hamann, A., & Spittlehouse, D. (2012). ClimateBC (Version 4.70) [Software]. Downloaded from http://www.genetics.forestry.ubc.ca/cfcg/ClimateBC/ClimateBC.html in June 2012

Wang, T., Hamann, A., Spittlehouse, D., and Aitken, S. N. 2006. Development of scale-free climate data for western Canada for use in resource management. International Journal of Climatology, 26(3):383-397.

The Estuary

Nanaimo River Estuary Committee

A Place of Connection…..

The Nanaimo River Estuary is a place of connection: where land meets the sea, where freshwater meets saltwater, and where human impacts converge with a fragile ecosystem. Less than 3% of British Columbia's 27,000 km coastline is considered estuarine, yet these fragile ecosystems are among the most productive areas on earth.

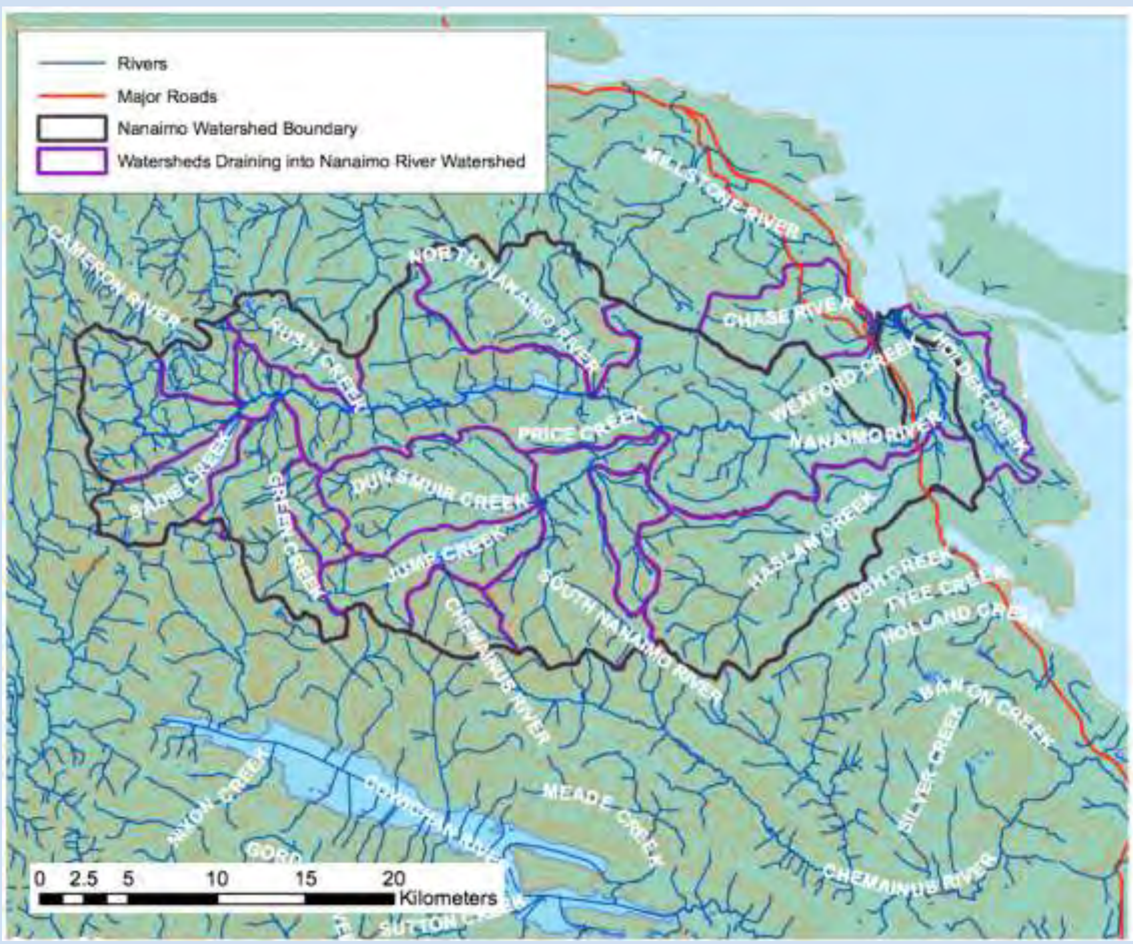
The Nanaimo River Estuary is the largest estuary on Vancouver Island, covering approximately 1,000 hectares. It is one of the highest-ranking estuaries in terms of fisheries resource value, productivity, and social/recreational value according to the Ministry of Environment.

The Nanaimo River Estuary was once the breadbasket of the Snuneymuxw First Nation: an abundance of aquatic and terrestrial species provided food and medicine to the villages that circled the estuary. Today, the ecological balance in the estuary has been changed by 100 years of coal mining and production, agricultural development, urban growth, and industrial intensification. The estuary is closed to shellfish harvesting, and other contaminants have entered into the estuarine system. However, more than a decade of partnership among key players in the estuary is resulting in positive change, with restoration and balance as the goal.

OVERVIEW

The Nanaimo River estuary is the largest estuary on Vancouver Island. The major watersheds of the Nanaimo and Chase Rivers, plus the drainages of Wexford, Beck, Holden and York Creeks together drain an area of approximately 84,000 hectares (Figure 1). The lower 12 km of the Nanaimo River and its estuary lie within the Nanaimo Lowland, a relatively low area along the east coast of Vancouver Island underlain by sedimentary rocks comprised mainly of conglomerate, sandstones and shales.[8]

Figure 1: Watersheds and drainages converging on the Nanaimo River estuary.



[8] The following is in part excerpted from the Nanaimo Estuary Management Plan, which is available at www.nanaimoestuary.ca.

The Nanaimo estuary area has a wide variety of oceanographic conditions related in part to a fairly complex shoreline and topographic configuration. The rivers and streams introduce a considerable amount of fresh water into Nanaimo Harbour from fall to spring. However, when the Fraser River is in freshet during May and June, fresh water can move into the Nanaimo area from the Strait of Georgia. Surface waters in the harbour are strongly influenced by winds, while the deeper waters have a significant tidal component. Wave action in the inner part of the estuary is limited by the protection of the islands and points, but northwesterly winds can affect the outer delta of the Nanaimo River. In general, the rate of flushing increases towards the north. Tides in the Nanaimo River Estuary are mixed and mainly diurnal, with two high and two low tides of different heights in a tidal day of about 25 hours. Tidal rise and fall corresponds to those in Georgia Strait. Currents in the estuary are mainly derived from winds and to some extent tides, but river runoff contributes little to circulation patterns except during peak run-off. During large tidal amplitudes, currents from tides, particularly the ebb, can be quite strong.

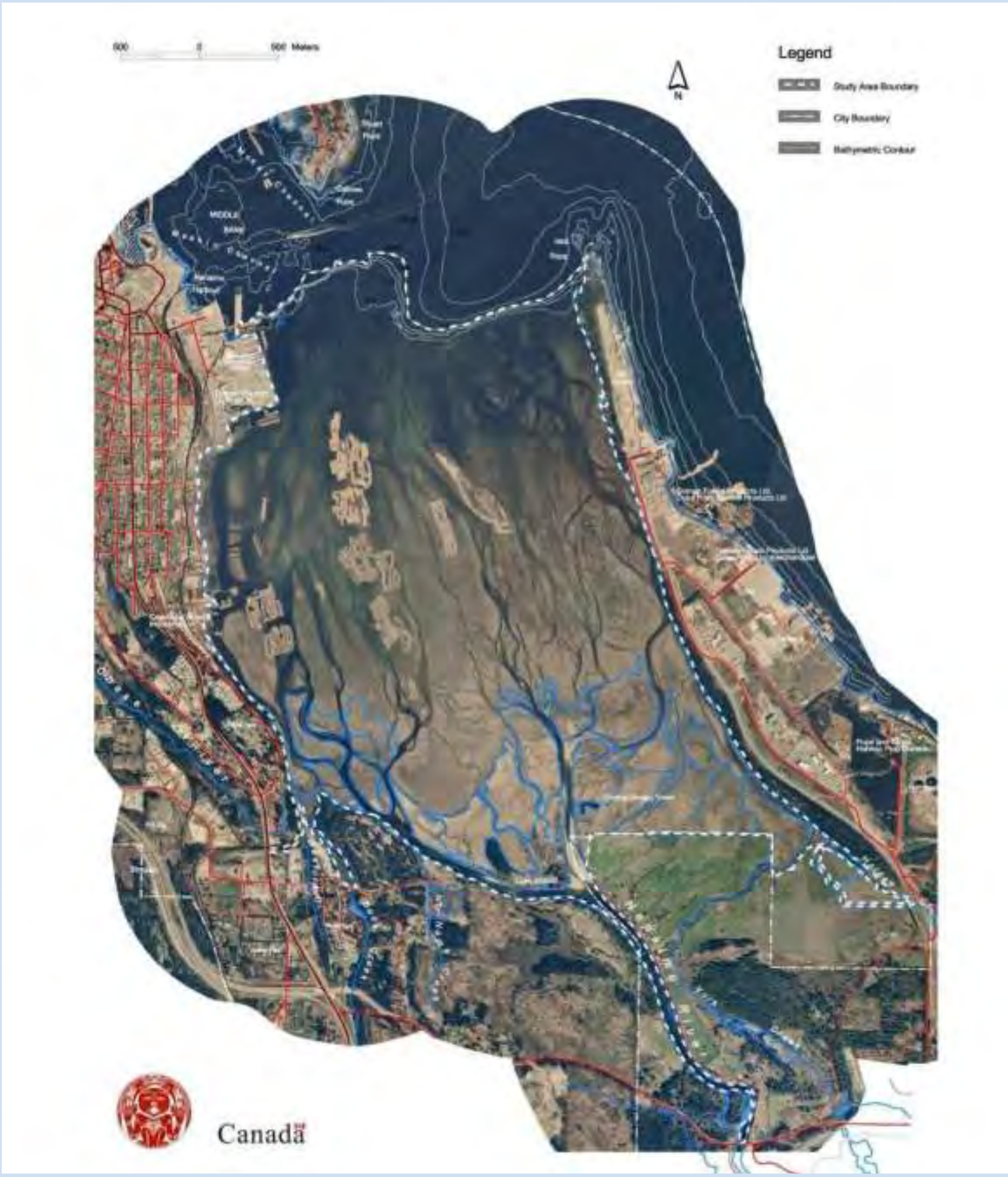
Benthic invertebrates are a key link in the salmon-supporting, detritus-based food web of the Nanaimo estuary. Dungeness crab populations near Jack Point support fisheries, but bivalve shellfish harvesting has been closed since 1949 due to coliform contamination. Five species of Pacific salmon and two species of migratory trout historically occurred in the estuary. The estuarine and near-shore environments are important in supporting the residency of juveniles. The Nanaimo estuary is also utilized by juvenile herring. The estuary supports riparian, marsh and intertidal floral communities. Eelgrass beds occur over a large area in subtidal zone, extending up into the intertidal area. The upland vegetation, where recently undisturbed, is characteristic of the Coastal Douglas-fir moist maritime biogeoclimatic subzone. The Nanaimo estuary, in conjunction with surrounding areas, is used by thousands of over-wintering birds. The estuary is critical to waterfowl survival during severe winter weather, and is part of the larger supported by the estuary.

The first human inhabitants of the area were the people of the Snuneymuxw First Nation. Records from 1850 show that they occupied several villages on Nanaimo Harbour and the Nanaimo River, and their population is roughly estimated to have been approximately 5,000.

The Hudson’s Bay Company established a base in Nanaimo in the mid 1850s to develop the Nanaimo coalfields. With the depletion of the coal resources in the 1950s, the economy of the area became dependent on the forest industry, forest products manufacturing, and tertiary industries. A small amount of farming still occurs in the watershed, limited by the availability of arable land.

The Port of Nanaimo and the forest products industry are the principal industrial users within the estuary. The estuary is used extensively for recreation, and tourism uses are expanding with the new Port of Nanaimo Cruise Ship Terminal. Population growth will likely place additional pressures on the estuary.

Aerial photo of the Nanaimo River Estuary (Source: Nanaimo Estuary Management Plan).



Estuaries and coastal wetlands comprise less than 3% of BC’s coastline, while providing habitat to over 80% of all coastal fish and wildlife species. In British Columbia, approximately 500 species of named plants and animals are associated with wetlands and estuaries, and 70 of those species are federally listed as endangered or threatened.

Vancouver Island contains more estuaries with a higher rank than any other eco-region in the province (1). Of the eight Class 1 estuaries in BC, four are located on Vancouver Island; one of them being the Nanaimo River Estuary.

Despite their importance and rarity, approximately 43% of the province's estuaries are threatened by coastal development, modification, and pollution; approximately 60% of marsh habitat along the Strait of Georgia estuaries already has been lost.

STAKEHOLDERS

In the early 2000s, a number of organizations came together to prepare an overall management plan for the Estuary; it was agreed this plan would serve as a guiding document, encouraging collaboration among the groups and agencies with jurisdiction in the estuary, but that the document would not legislate or otherwise regulate the activities of any of the partners.

The Nanaimo Estuary Management Plan was completed in 2004, after more than two years of discussion and two public consultation events. More than 10 years later, the partners in the plan (along with some newer partners including Vancouver Island University) continue to work together on issues of cross-jurisdiction and shared interests in the Nanaimo River Estuary. The overall objective of the partnership is to integrate activities and achieve shared goals that focus on restoration and balance.

The partners include:

- Snuneymuxw First Nation
- Department of Fisheries and Oceans
- Nanaimo Community Coalition
- Georgia Strait Alliance
- Log Storage and Industry Association
- Ministry of Environment
- Nanaimo Port Authority
- The Nature Trust
- Ducks Unlimited Canada and Canadian Wildlife Service
- Vancouver Island University
- Ministry of Transportation and Infrastructure
- City of Nanaimo
- Regional District of Nanaimo

RISKS AND IMPACTS

From time immemorial to only several centuries ago, impacts on the Nanaimo River Estuary would have been limited to fishing and the harvesting of foodstuffs by the people who lived around the estuary. Over time, new and often competing uses have been grafted onto estuaries as their coastal location, topography, and habitat richness are seen as valuable to an ever-widening range of activities (2). Environmental impacts in estuaries has been much studied since the 1960s, with the general conclusion that the addition of urban, industrial, and agricultural uses in these fragile ecosystems has been environmentally detrimental (3).

Building on research evolving from 1970s, risks for the estuary are understood to be the product of centuries of interplay between economic, political, and institutional factors and the natural environment, in highly complex repeated interactions that are currently only superficially understood (4).

Further research is needed to understand how long-missing elements in local ecology can be restored and made more resilient, potentially increasing the estuary's capacity to persist and regenerate.

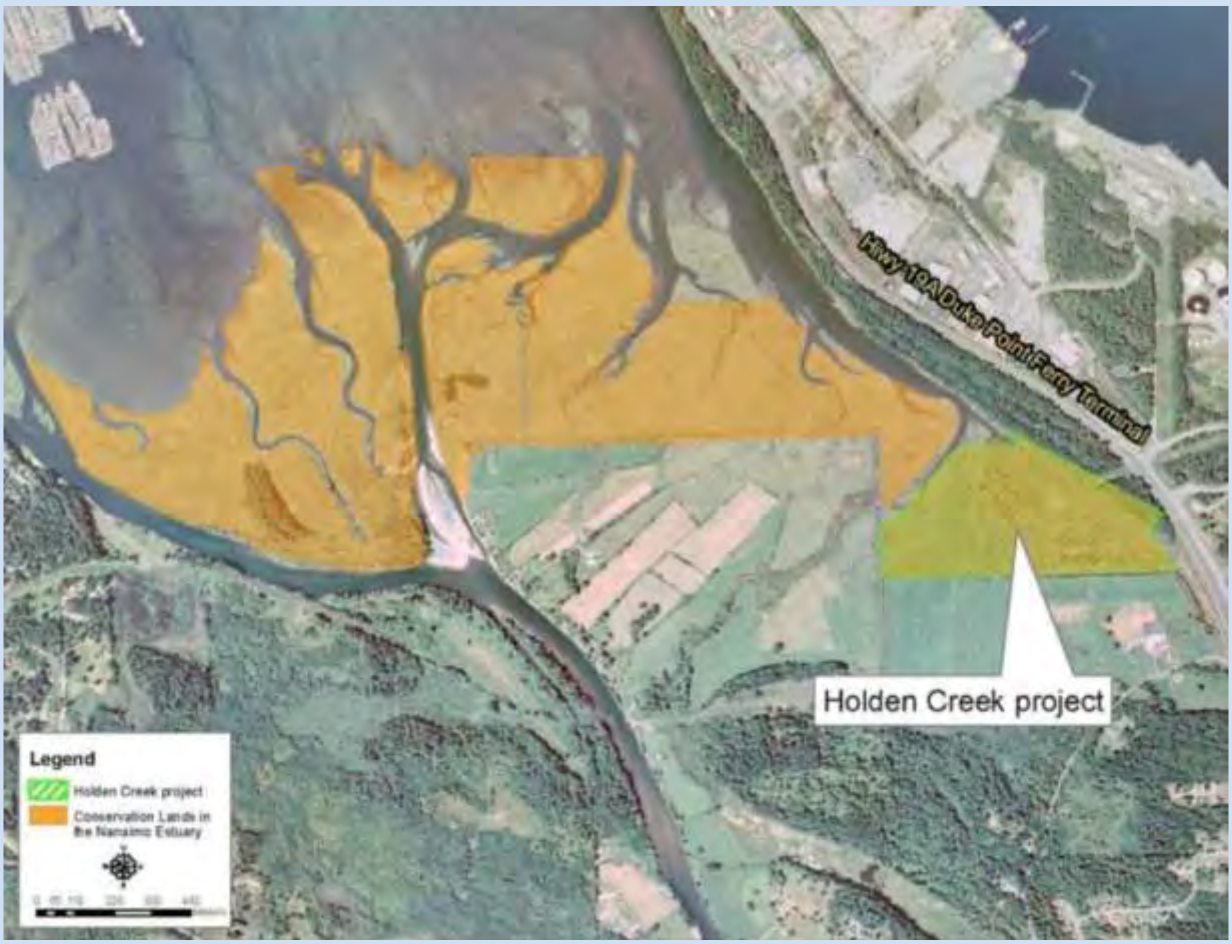
OPPORTUNITIES

The most important action that will secure and enhance the future of the Nanaimo River Estuary is the continued efforts of all agencies and levels of government to work collaboratively for the betterment of the estuary. For example, a project moving forward in summer 2011 is the development of a plan for eelgrass planting in the estuary with a 10-15 year planning horizon. The objective behind this plan is to focus efforts and financial resources on areas with the greatest likelihood of hosting successful eelgrass replacement. This project is funded by the Log Storage and Industry Association and the Nanaimo Port Authority, with student involvement from Vancouver Island University. All partners on the Nanaimo River Estuary Committee will be involved in this project.

Project partners have undertaken other critical works. In recognition of the importance of the Nanaimo River Estuary, the Pacific Estuary Conservation Program (a partnership that includes Ducks Unlimited Canada, The Nature Trust of BC, Habitat Conservation Trust Foundation, Canadian Wildlife Service, Fisheries and Oceans Canada and BC Ministry of Environment) began securing habitat in the Nanaimo Estuary in 1987. Since that time a total of 8 acquisitions have been completed covering 180 hectares of habitat; intertidal marshes, farmland and riparian areas.

Restoration of the estuary began in 1988 with the removal of sections of low dykes in the tidal marshlands to re-establish natural tidal flows and vegetation. The most recent restoration project was completed in 2006 where the conservation partners restored over 22 hectares of tidal marshlands by breaching the northern dike on Holden Creek (Figure 2).

Figure 2: in 2006, conservation partners restored over 22 hectares of tidal marsh by breaching the northern dike on the Holden Creek Project, restoring traditional fish channels and upgrading the southern dike to protect a private farm. The project was funded by conservation partners, the Ministry of Transportation, BC Ferries and BC Transmission Corporation.



A future project is the initiative of a comprehensive research program. Funding is being investigated for a major research project focused on social-ecological issues in the Nanaimo River Estuary. The research project will be divided into five stages. In Stage 1 (from time immemorial to 1700) archival records, artifacts, and in-depth interviews will record the deep history of the Snuneymuxw First Nation, while geological analysis of the area will establish a baseline for later research on coal mining. Stage 2 (to 1820) will examine the impacts of colonial expansion on the estuary. Archival records and documents will inform much of this research. Stage 3 (to 1920) will explore the founding of Nanaimo, coal mining and processing. Research into politics, governance, legal issues, and changes to fisheries will also proceed in this stage. Stage 4 (to 1980) covers new industries, tourism, and urban development. Stage 5 (the Estuary today) will focus on cross-jurisdictional issues, restoration, and balance. Instead of taking a piece-meal approach to understanding issues in the estuary, a comprehensive research program will enable a holistic and layered understanding of the changes that have built over time in the Nanaimo River Estuary.

INFORMATION GAPS

Funding is needed to proceed with a wide range of research projects and practical actions in the Nanaimo River Estuary. In addition, outreach to those working to restore and balance uses in other estuaries along the Salish Sea is critical and is currently underway. Through sharing ideas and resources, greater success will be achieved in meeting the goals of restoration and balance in the Nanaimo River Estuary.

BIRDS SIGHTED AT THE NANAIMO RIVER ESTUARY 2009-2011

RYAN CATHERS

Winter: the Nanaimo River Estuary becomes home for many species of waterfowl during the cold stormy months of November through late February. Among some of the more common species observed are Canada Geese, Trumpeter Swan, Gadwall Duck, American Wigeon , Mallard Duck, Northern Pintail, American Green-winged Teal, Ring-necked Duck, Greater Scaup, Bufflehead Duck, Common Goldeneye, Common Merganser, and Red-breasted Merganser. During the cold winter days the estuary can be the most reliable location to observe Northern Harriers and Short-eared Owls hunting one of the Island's largest Townsend's Vole populations. Northern Shrike can frequently be seen hunting from the hedgerows and old oak trees for small song birds. Western Meadowlark can be observed singing their gorgeous songs perched on small bushes in the middle of the estuary.

Many types of sparrows use the estuary including Spotted Towhee, American-tree Sparrow, Chipping Sparrow, Vesper Sparrow, Savannah Sparrow, Fox Sparrow, Song Sparrow, Lincoln's Sparrow, Swamp Sparrow, White-throated Sparrow, White and Golden-crowned Sparrows, Dark-eyed "Oregon" Junco, and the occasional Dark-eyed "Slate-coloured" Junco.

Spring/Fall : The spring and fall migrations bring many shorebirds or "peeps" to the estuary and the adjacent Holden Creek estuary during the months of March-April and August-September. Common species at these two locations include Black-bellied Plover, Semipalmated Plover, Greater Yellowlegs, Lesser Yellowlegs, Killdeer Plover, Spotted Sandpiper, Black Turnstone, Semipalmated Sandpiper, Western Sandpiper, Least Sandpiper, Dunlin, Short-billed Dowitcher, Long-billed Dowitcher, and Wilson's Snipe. Less common birds and rarities that make occasional appearances include American Plover, Pacific Golden Plover, American Avocet, Solitary Sandpiper, Willet, Whimbrel, Marbled Godwit, Ruddy Turnstone, Sanderling, Baird's Sandpiper, Pectoral Sandpiper, Wilson's Phalaropes, Red Phalaropes, and Red-necked Phalaropes.

Spring also brings many species of wood warblers and finches to the estuary including Orange-crowned Warbler, Yellow Warbler, Yellow-rumped Warbler, Palm Warbler (only a few records), Common Yellowthroat, Wilson's Warbler, Purple Finch, House Finch, and abundant American Goldfinch. Many swallows use the estuary as both hunting and nesting grounds. Tree Swallows, Violet-green Swallows, and Northern Rough-Winged Swallows can be seen hunting over the fields for small flying insects. Barn Swallows are frequently seen around the Holden Creek Estuary where they collect mud to build nests.

REFERENCES

To find out more about the Nanaimo River Estuary, please see www.nanaimoestuary.ca

Literature Cited

1. CWS Technical Report Series #476, 2007

2. Lotze, H.K., H.S. Lenihan, B.J. Bourque, R. H. Bradbury, R.G. Cooke, M.C. Kay, S.M. Kidwell, M.X. Kirby, C.H. Peterson, J. B. Jackson 2006. Depletion, Degradation, and Recovery Potential of Estuaries and Coastal Seas *Science* 23 Vol. 312. no. 5781, pp. 1806 – 1809.

3. Cohen, A.N., and J.T. Carlton 1998. Accelerating Invasion Rate in a Highly Invaded Estuary. Science 279:5350. 555-558.

4. Ommer, R. 2007 Coasts Under Stress: Restructuring and Social-Ecological Health. McGill-Queens University Press.

FISH

JESSICA WOLF, B.SC.

The author would like to express her gratitude to the following people for their important contributions to this paper:

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Michael McCulloch –Fisheries Specialist, Ministry of Forests, Lands and Natural Resource Operations

Brian Banks and **Henry Bob** – Nanaimo River Stewardship Society

TALES FROM THE RIVER……

As they attempted to leap White Rapids falls, summer run Chinook returning up Nanaimo River were hitting a rock wall and falling into a dry bowl that the river had carved eons ago. For many years the local fishery officer included in his budget $15,000 to remove these obstructions, but every year this request for funding was denied.

When Fish and Game club members became aware of the need to blast the rock outcropping and bowl, they arranged for their blasting expert to direct members where to drill the holes. The work took place in around 1980.

Members took turns being suspended over the falls in a harness attached to a rope held by other club members, with a portable gas-powered rock drill in hand. Once the holes were drilled, charges were placed and the two obstructions were blown into oblivion. Not more than 30 seconds after the blast, a 20 -25 pound Chinook leapt the falls where the rock outcropping had been and proceeded upstream.

Total cost of this successful project? Two cases of beer for participating members after the job was done. This project clearly demonstrates the valuable contributions volunteers make to restoring and enhancing salmon habitat.

Wayne Harling

Member of Nanaimo Fish and Game Protective Association

OVERVIEW

The Nanaimo River supports a complex assemblage of fish species. Salmon, which spend most of their lives feeding in the ocean, return to Nanaimo River to reproduce. Every type of Pacific salmon is found here; chinook, coho, chum, pink and the occasional sockeye (1). Steelhead, sea-going rainbow trout, also return to Nanaimo River to spawn (1,2).

Other species spend their entire lives in the lakes, wetlands, or streams of the watershed - like prickly sculpin, Aleutian sculpin, stickleback, Dolly Varden char, and rainbow and cutthroat trout (1,2). Landlocked sockeye salmon, called Kokanee, can also be found in Nanaimo Lakes (2). Pumpkinseed and small mouth bass are non-native species that compete with native species for food and habitat in the freshwaters (3). The tidal portion of the river holds small flounders and sturgeon have been seen to enter the river (1).

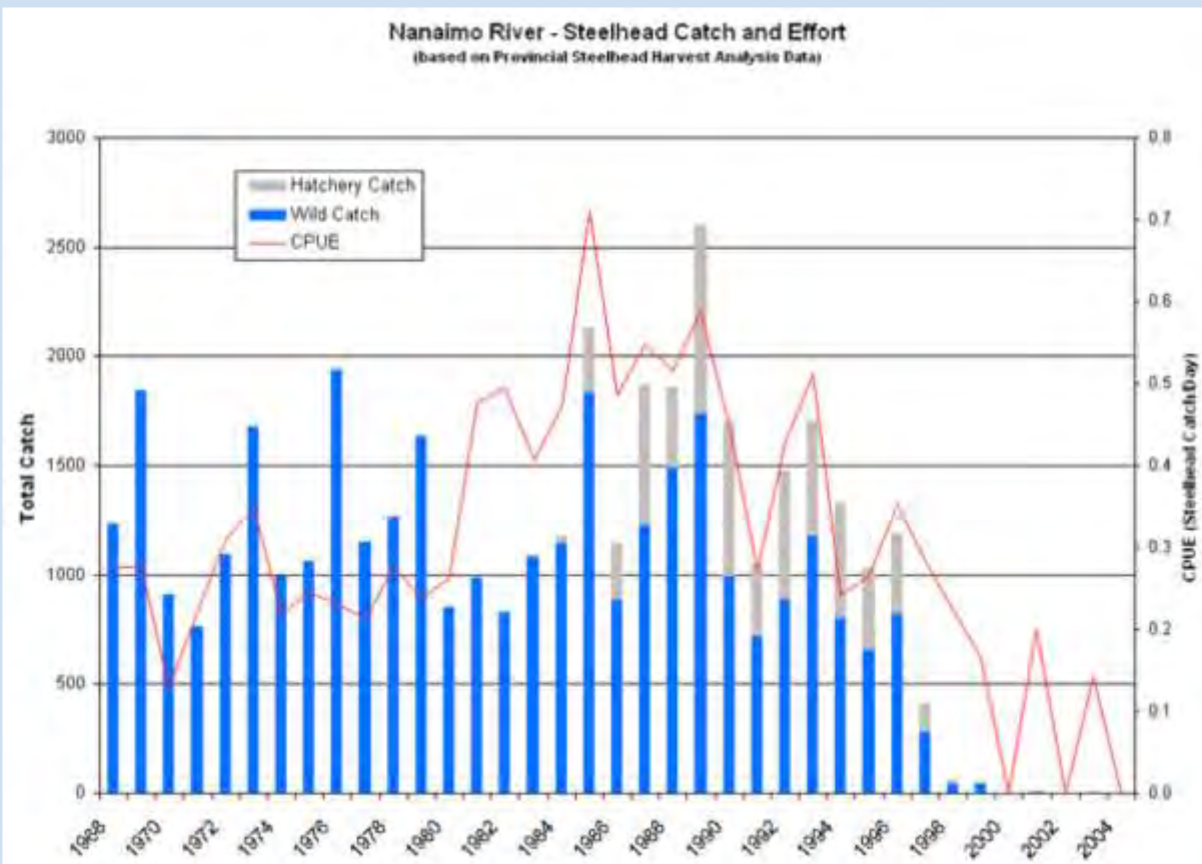
Members of the *Island Waters Fly Fishers* fishing for Chum salmon in late October. Some club members remember when Steelhead and other species were plentiful in Nanaimo River and yearn for restoration to that time.

Nanaimo River's fish have long been central to the culture and subsistence of the Snuneymuxw First Nation and coastal settlers (4). Nanaimo River's chum salmon are targeted in a commercial fishery when the population is sufficient (1). The river has historically been a hot spot for recreational fishing, but low fish returns coupled with strict regulations have reduced the recreational fishery substantially.

Fish are an important food source for the areas terrestrial, aerial and marine wildlife. Kingfishers, mergansers, osprey, eagles, otters and black bears are some of the animals that rely on Nanaimo River's fish for survival. Seals and whales also rely on sea-going salmon that hatch from Nanaimo River. Chinook and chum salmon from Nanaimo River are potential food sources for southern resident killer whales whose range includes marine waters near Nanaimo. These whales are listed as Endangered under Schedule 1 of the federal Species at Risk Act (5).

Coastal cutthroat trout and Dolly Varden char are species of special concern. They are designated as Blue Listed by the province, which recognizes their vulnerability due to habitat loss and over-fishing, but doesn't afford them any legal protection (2,6). Rainbow and steelhead trout are not currently provincially listed as a species at risk, but are subject to intensive management and protection afforded through restrictive angling regulation (2). The Nanaimo River contributes chinook to the "Lower Georgia Straight chinook" population, which has been recognized as a population that needs to be stabilized (1).

Figure 1: Steelhead harvest data (1988-2004). (Source: Greater Georgia Basin Steelhead Recovery Plan).



The Nanaimo River was historically one of the top five steelhead rivers on Vancouver Island and supported a strong recreational fishery with over 1,000 Steelhead caught each year. In recent years this fishery has been subject to intensive management, including temporal and spatial angling closures, after the population dropped from several thousand to several hundred by the year 2000 (Figure 1). In 2002 their wild stock status was listed as an extreme conservation concern in the Georgia Basin Steelhead Recovery Plan (7), and in 1998 the hatchery program was suspended due to lack of wild brood stock from Nanaimo River and changes to the Provincial Fisheries policies regarding hatchery augmentation.

Pink salmon were nearly extirpated from the Nanaimo River in the 1950s. Through a hatchery program using eggs from another local watershed, the pink population is rebuilding.

Protection of fish and their habitats is spread over provincial and federal jurisdiction. The Provincial Fisheries Agencies (Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and the Ministry of Environment (MOE)) take the lead role in the governance and conservation of non-salmon freshwater fish. The province oversees licensing of freshwater recreational fishing, takes primary responsibility for land and water use decisions on Crown lands and utilizes a variety of statutes to sustainably manage fish habitat. Fisheries and Oceans Canada (DFO) is responsible for First Nation fisheries, commercial and recreational fisheries in tidal waters, salmon fisheries in non-tidal waters and has the lead responsibility for fish habitat protection.

A more detailed description of some fish species found in Nanaimo River follows. Figure 2 shows the upper limits of the distribution of these species within the watershed.

Federally Managed Fish

Chinook salmon (*Oncorhynchus tshawytscha*): there are three genetically unique runs of Chinook in Nanaimo River, named for the time of year they return; spring, summer and fall.

- Spring run Chinook enter the river in early spring. They tend to hold in the area between 2nd and 4th lake and spawn there in the fall (1).
- Summer run Chinook enter from late spring and into summer, mostly hold in First Lake, then drop back down into the river by the outlet of First Lake to spawn in the fall (1).
- Fall run Chinook enter from late August to October and generally spawn within the first 10 km in early October (8). Most fry leave the river soon after emerging, with peak of downstream migration occurring in late April.

On a good year, the counts are typically about 500-700 summer run Chinook, and 1500-2000 for the fall run (9). In August 2009 only about six spring run Chinook were counted, though historically they were more abundant. The Nanaimo River Hatchery counts all three runs and enhances the summer and fall runs by taking broodstock and releasing fry (8).

Coho salmon (*Oncorhynchus kisutch*): coho start entering the river in early October, and the peak of spawning occurs from November to early December (8). Coho have been observed spawning throughout the river, including tributaries in the First Lake territory, and the way up to Fourth Lake (1). The fry stay in the river for a year before heading to sea, which makes them more vulnerable to destruction of in-stream habitat.

Assessing coho stocks is difficult as their peak run occurs when the river is high and turbid. Consequently there are not concrete numbers for returning coho. Hatchery staff see coho during snorkel counts in October. Based on the effort put into capturing coho for broodstock, they estimate that their numbers were low a few years ago but have been climbing for the last couple of years (9).

Pink salmon (*Oncorhynchus gorbuscha*): historically 5,000-10,000 Pink salmon were reported in the system (8). They would enter the river in August and spawn in the side channels of the lower 6 km of Nanaimo River and in Haslam Creek annually. In 1979 and 1980 less than 100 Pink were observed. Blackman (1981) attributed this decline to mine washings in Haslam Creek (8).

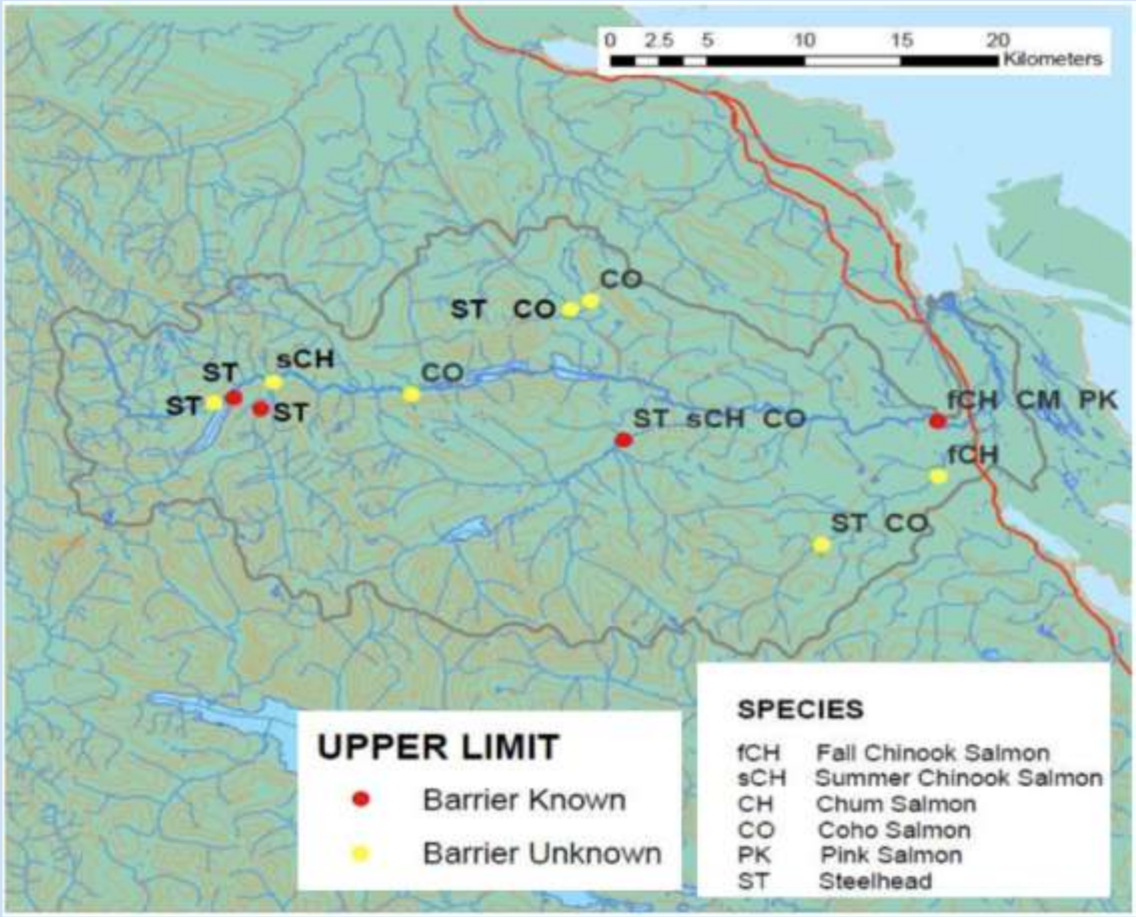
Nanaimo River fish hatchery staff holding up a male coho salmon during broodstock capture. Adult salmon are collected and spawned at the hatchery. Their eggs are then incubated and hatched, and the young fish (fry) are fed and released back into Nanaimo River.

Since the population had dropped too low for the population to recover naturally, the Nanaimo River Hatchery took eggs from the Quinsam Hatchery and released fry into the Nanaimo Harbour. This has rebuilt the Pink population to a high of 50,000 in 2009 (9).

Chum salmon (*Oncorhynchus keta*)**:** chum begin to enter the river in late September, with spawning peaking in early November (8). They spawn in the side-channels of the lower 7 km of the mainstem and in Haslam Creek. Fry leave the river soon after emerging, with the peak migration in early May. Historically there were about 50,000 – 100,000 and their numbers are currently in the range of 50,000 depending on the year (9).

Sockeye salmon (*Oncorhynchus nerka*)**:** there was never a natural run of Sockeye. The occasional ocean-going sockeye enters Nanaimo River in the fall, perhaps a result of an attempt to introduce them long ago (9).

Figure 2: Upper limits of the distribution of some fish species in the Nanaimo River.



A freshwater variety of sockeye, called Kokanee, live and spawn in the Nanaimo Lakes. A few adults spawn in the river and these are thought to be strays or a relict population of riverine fish (2).

Provincially Managed Fish

Rainbow trout and steelhead (*Oncorhynchus mykiss)***:** stream resident (fluvial) and lake origin (adfluvial) rainbow trout stocks can be found using the mainstem river for both rearing and spawning, and are typically observed in close proximity to lacustrine habitat like the Nanaimo Lakes chain.

Some rainbow trout are sea-going (anadromous), and they are known as steelhead. The Nanaimo River has been known to support winter migrating steelhead, which enter the river from December to April, with peak spawning in April and May (8). Summer steelhead have also been observed in the upper watershed (2). Rearing typically occurs in the mainstem and larger tributaries such as Haslam Creek, South Fork Nanaimo and Green River.

Coastal cutthroat trout ***(****Oncorhynchus clarki clarki)*: there are resident and sea-going (anadromous) cutthroat trout in the main river and most tributaries (2). Adult sea-going and resident coastal cutthroat trout can be found foraging throughout the watershed with critical rearing habitats spread throughout the smaller sub-watersheds located primarily in the lower watershed below White Rapids (2). Resident forms of cutthroat trout are present in headwater lakes and streams located in the upper portion of the watersheds. Known spawning areas for sea-run cutthroat trout are the side-channels of the mainstem, and Thatcher Creek, Holden Creek, Beck Lake Creeks, and lower Haslam Creek. Ocean life is spent primarily in the inter-tidal areas and seldom far from the mouth of Nanaimo River (8). This species has tremendous potential as a recreational sports fish if properly managed.

Dolly Varden char *(Salvelinus malma)***:** Dolly Varden char are found throughout the watershed in low abundance although most stocks appear to be associated with lake habitats and small steep headwater stream reaches typically found in non-anadromous reaches.

STAKEHOLDERS

Key stakeholders participating in the use and protection of fish species include:

- **Snuneymuxw First Nations –** Nanaimo River is part of their traditional territory (4). Salmon have been, and continue to be, vital to their subsistence and livelihood. The Snuneymuxw are negotiating allocations of Nanaimo River Chum, Coho and Chinook salmon through treaty negotiations with the federal and provincial governments (10).
- **Nanaimo River Stewardship Society** – The Society operates a fish hatchery that enhances the four pacific salmon species present in Nanaimo River. The Society also conducts stock assessment, habitat assessment and restoration, and delivers education programs
- **Regional District of Nanaimo (RDN) -** Development in the Nanaimo River watershed is guided by the Official

FROM THE ARCHIVES ……..

…On the Nanaimo river the Indians have a very ingenious contrivance for taking salmon, by constructing a weir; but, instead of putting baskets they pave a square space, about six feet wide and fourteen feet long, with white or light-coloured stones. This pavement is always on the lower side of the weir, leading to an opening. A stage is erected between two of these paved ways, where Indians, lying on their stomachs, can in an instant see if a salmon is traversing the white paved way. A long spear, barbed at the end, is held in readiness, and woe betide the adventurous fish that runs the gauntlet of this perilous passage!

Excerpt from The Naturalist in Vancouver Island and British Columbia by John Keast Lord, published in 1866.

Community Plan for Area A, the Regional Growth Plan and the new regional bylaws that conform to provincial Riparian Areas Regulations. The RDN is also responsible for managing a regional park in the riparian area of the lower Nanaimo River.

- **Fisheries and Oceans Canada (DFO) -** Under the Fisheries Act, the DFO is responsible for the management of fisheries, fish habitat and aquaculture, and also has responsibilities under the Species at Risk Act. On the Nanaimo River, DFO is involved in fish habitat protection and restoration projects, stock assessment, research, management of fisheries, compliance and enforcement, community involvement initiatives and stewardship activities.
- **Provincial Fisheries Agencies (MFLNRO and MOE) -** The province exercises authority, under the federal *Fisheries Act*, for the management of freshwater fisheries. They establish legislation, policies and procedures for managing fishing and hunting activities, and for the allocation of fish and wildlife resources for recreational and commercial use. The goal is to conserve the natural diversity of fish and fish habitat and to sustainably manage the freshwater sport fishing in B.C.
- **Private Landowners –** The upper watershed is privately owned forestry lands, and the lower watershed is comprised largely of residential, agricultural and Snuneymuxw reserve land. These landowners are instrumental to the protection of riparian forests that provide fish habitat.
- **Water license holders** – Harmac Pulp Operations and City of Nanaimo. Harmac draws water from Nanaimo River for their pulp mill operations, and the City of Nanaimo draws water for their citizens. Both groups release water from their dams to maintain a minimum flow for fish throughout the summer, and to aid salmon migration in the fall.
- **Nanaimo Fish and Game Protective Association –** This conservation group protects the right of people to hunt and fish, and is committed to conserve and protect our forests, water and wildlife. Members volunteer on many fish habitat restoration and enhancement projects.
- **Island Waters Fly fishers -** A Nanaimo club that promotes the art of fly fishing and fish conservation and enhancement.
- **Commercial fishermen** – Their livelihood relies on the healthy salmon populations
- **Tourism businesses** benefit from sport fishing, whale watching and other nature recreation opportunities fed by healthy salmon populations.
- **Nanaimo and Area Land Trust, The Land Conservancy of BC**, and other conservation groups whose mandate is to protect wildlife habitat.
- Anglers, naturalists, and recreational users of all kinds.

RISKS AND IMPACTS

Declines in fish abundance in the Nanaimo River have been observed or inferred for several species, life history variants or ecotypes (2). It is difficult to determine the exact cause and magnitude of decline as historic benchmarks and current stock assessment is either incomplete or of insufficient resolution to detect change. Confounding this problem is the cyclically variable marine survival patterns exhibited by all of the sea-going species.

Declines with fisheries resources can typically be linked with concurrent declines in habitat quality and productivity, and unsustainable levels of harvest (2). Fish in Nanaimo River have been under increasing pressure with the continued expansion of the forest industry, urbanization, commercial fisheries, sport fisheries, and domestic and industrial water usage.

Forest Harvesting, Agriculture and Residential Developments

In pristine watersheds, riparian vegetation, particularly large conifers, provides much of the future supplies of large woody debris for in-stream fish habitat (11). Optimum rearing habitat for salmonids requires cover, and historically in these coastal streams large woody debris provided in-stream cover for fish rearing in deeper pools. In Nanaimo River the recruitment of large woody debris is most important for salmon habitat in the tributaries, and less so in the mainstem river (3). A climax riparian community also contributes to the creation and maintenance of over-wintering areas such as overflow channels and off-channel ponds, and stabilizes the stream-banks to prevent dramatic changes in channel morphology (11).

Historic logging practices and other land uses often removed most of the conifers from the riparian area of main-stem and tributary channels (11). This can accelerate the rate of occurrence of disturbances such as major floods and debris torrents, and contribute to stream-bank instability and channel changes - to the detriment of fish habitat. Gaboury and McCulloch (2002) report evidence of channel morphology changes in the Nanaimo River watershed, as indicated by channel widening, extensive gravel bars, pool-infilling, reduced pool frequency, and a lack of functional in-stream large woody debris. The loss of large conifer recruitment from the riparian areas to the stream channels has impacted both in-stream and off- channel summer and winter rearing habitat in the watershed. This has particularly impacted juvenile salmon and trout that rear and over-winter in freshwater. In addition, it has affected adult fish that require suitable holding pools for migration and spawning.

There has been a long history of road and hill slope instability in logged areas of the upper Nanaimo, and these sites are known to cause sediment transport into lakes and streams inhabited by salmon and trout (7). These events generally coincide with fish egg and alevin development periods, having a negative impact on their survival. Blackman (1981) reports that chinook egg to fry survival in Nanaimo River was often low because of siltation damage and bed shifts during heavy freshets.

Similar changes to channel morphology and watershed processes, and consequently to fish habitat, can occur as a consequence of agricultural or residential developments, such as in the lower reaches of Haslam Creek (11) and the main-stem of Nanaimo River below Hwy 1. Urbanization can impact fish habitat and productivity by confining river channels and destroying their natural sinuosity, creating agricultural, domestic and industrial pollution, and removing vegetation from riparian and estuary habitats (7).

The upper 85% of Nanaimo River watershed is privately owned and managed as forest lands under the Private Managed Forest Land Act. One of the management objectives under this Act is the retention of sufficient streamside mature trees and understory vegetation to protect fish habitat (12). Although not required by law, private forestry companies typically have riparian management guidelines that conform to provincial and federal riparian areas regulations. Timberwest, one of the companies with holdings in Nanaimo River, reports that their riparian planning area practices with streamside buffers (fish bearing or not) are designed to be above legal requirements (13).

Unlike forest operations on crown lands, there is no opportunity for public review of private forest management plans. This makes it difficult for stewardship groups to participate in ensuring that fish habitat objectives are met. Privately owned forest lands are not subject to regional bylaws governing stream protection.

Water Licenses

The survival of fish in Nanaimo River is dependent on high water quality, adequate flow, and ideal temperatures. Changes in flow can negatively affect migration of adult salmon upstream for spawning, and also critically impact the rearing of juvenile fish in the summer (7).

Two water licenses holders draw a significant amount of water from the watershed. The City of Nanaimo draws the public water supply from a reservoir on Jump Creek, a tributary of South Nanaimo River. Harmac also withdraws water for their pulp mill operations from the pump house below the Island Highway. To ensure a steady flow they created a dam on Fourth Lake.

The 1993 *Nanaimo River Water Management Plan* made a series of recommendations to meet the conservation needs of wild salmon and trout populations (7). The plan recommended a preferred range of fisheries (mainly steelhead) maintenance flows from 3.9-7.9 cms (138-279 cfs or 10-20% of mean annual discharge), with a target flow of 5.9 cms (208 cfs or 15% mad) for the 35 km section between the Island Highway bridge and Fourth Lake, when adequate storage was available. The City and Harmac work cooperatively to release water from their dams at critical times to ensure enough water for summer rearing and fall spawning.

Temperature is another critical factor. Harmac's outlet from the dam on Fourth Lake releases cold water from the bottom of the lake, which has the unintended effect of "chilling" flows downstream for several kilometers (<10°C) below Fourth Lake, reducing the summer growth and subsequent survival of juvenile fish (7,8).

Fish Passage Obstructions

An historic obstacle to fish migration has been the White Rapids Falls. In the past many salmon died or were injured attempting to jump White Rapids Falls, causing pre-spawning mortality (8). Some restoration work, including blasting and the construction of weir have improved fish passage here, but more work might be beneficial.

Other natural barriers exist in the watershed, and, depending on the species, may prevent migration upstream to suitable spawning habitat, or downstream to feeding grounds or the ocean. Low water flows can also create barriers to upstream fish migration, such as at the "Borehole" (9).

Increasing passage for certain fish species may have unforeseen consequences for the survival of other fish species and caution is warranted. Unique ecotypes of fish have evolved in Nanaimo River in response to existing natural barriers. The removal of fish passage obstructions may impact their survival by introducing competition from other species that previously did not have access to this habitat (3).

Barbed treble hooks collected from the bottom of a pool in Nanaimo River are evidence of illegal fishing. These were likely used in attempt to snag chinook or other salmon.

Sport and Commercial Fishing

Past harvesting of Nanaimo River fish stocks for both the sports and commercial fisheries, together with other pressures, may have contributed to the decline of Steelhead and other fish species in Nanaimo River (7). Current provincial fisheries regulations preclude the harvesting of wild trout and steelhead as one measure to rebuild populations.

The extent of illegal fishing is difficult to monitor, but can have a negative impact on the survival of fish populations, particularly those which are already at risk. Poaching is most detrimental if occurring before or during spawning (1).

Marine Survival

Ocean conditions have had a big impact on salmon populations that return to Nanaimo River to spawn (1). Reduced marine survival has a direct and overwhelming impact on adult abundance, age and size at return (7). Marine productivity (survival and growth) may be affected by global warming, decadal oscillation or other long-term environmental trends.

Seals feeding in the estuary and lower river reaches may be impacting Nanaimo river fish populations, particularly if they have modified their behaviour to selectively feed on stocks not traditionally the mainstay of their diet or are using hunting techniques not typically observed in pristine habitats with other abundant food sources (3). Changes in seal behaviour to increased predation on hatchery reared fish have been documented on the Puntledge River, but this has not been studied on Nanaimo River.

Nutrient Depletion

Declines in salmon spawning in the Nanaimo River have reduced the abundance and distribution of salmon carcasses, and thus decreased marine-derived nutrients brought to the ecosystem. This reduces the overall stream productivity (7).

Funding

One of the biggest obstacles to protecting fish and fish habitat is the lack of funding and human resources to undertake thorough stock assessment and analysis, to carry out habitat restoration and protection initiatives, to ensure compliance with fisheries regulations, and to participate in collaborative planning with stakeholders to ensure fish protection objectives are met.

The BC Conservation Foundation states in their Greater Georgia Basin Steelhead Recovery Plan that completion of prescribed restoration works is contingent on funding support (7). Provincial government priorities have shifted and restoration projects are no longer funded at the same level as they were a decade ago. Funding for the operation of Nanaimo River Hatchery hasn't increased in 18 years, while the cost of operating has increased annually (1). Any initiative to acquire and protect riparian buffers would require a significant fundraising component.

OPPORTUNITIES

Fish Habitat Restoration, Enhancement and Protection

Habitat creation and protection is important to help combat negative impacts fish populations have been experiencing (1). Protecting the fish and fish habitat values of the Nanaimo River requires a comprehensive strategy that includes:

- protect/enhance spawning and rearing habitat for all species (14);
- protect riparian (14) and upslope habitat values (2);
- ensure in-stream habitat health (woody debris, in-stream diversity of habitat, reduce channelization) (14);
- maintain/enhance off channel habitat (for coho and other species) (14);
- maintain/enhance water quality for fish (temperature, dissolved oxygen, reduce pollution sources etc.) (14);
- ensure water quantity, quality and temperature for spawning and rearing of salmonids (14); and,
- identify limiting factors for individual stocks and the habitats they depend on and undertake strategic restorations (2).

Habitat Creation and Restoration Projects

In their assessment of potential fish habitat restorations for five east Vancouver Island watersheds, Gaboury and McCulloch (2002) proposed spawning enhancement and in-stream restoration designs for sites in the Nanaimo River watershed (11). The report recommended the improvement of spawning habitat for rainbow trout and steelhead through the placement of spawning gravel immediately upstream of First Lake at an estimated cost of $20,960. Installation of rock-ballasted large woody debris structures were recommended rearing habitat improvements in 51 sites along Haslam Creek, a tributary to the lower Nanaimo River at an estimated cost of $139,595. Another 60 sites were identified in Deadwood Creek, locally known as the "North Fork" of the Nanaimo River, for $168,210.

Lack of funding has prevented most of these recommendations from being implemented to date, however spawning gravel was added immediately below the dam on the South Fork of Nanaimo River, and also between first and second lakes. Follow up assessments showed use by multiple species for spawning but also showed extensive movement of the placed spawning material (3).

DFO and MWLAP have investigated the enhancement potential of numerous off-channel sites in Nanaimo River (7). Gaboury and McCulloch (2002) identified potential sites for off-channel development sites on Haslam and Deadwood Creeks, but they need further assessment to determine feasibility (11). Griffith (1992) evaluated side-channel development potential in the lower Nanaimo River floodplain, downstream of the Island Highway. While some sites were "flagged" as possible candidates, no actions were taken because of anticipated high costs (15). It is recommended that these (and other) sites now be reassessed, in partnership with DFO's Habitat Restoration Unit (7). Approval from private landowners will be required to access the floodplain along most of these watersheds.

There have been investigations of improving fish passage at the Bore Hole and White Rapids in the Nanaimo River, but only limited work has been undertaken by DFO to improve spring and summer chinook passage at the Bore Hole. Similarly, ongoing investigations of fish passage problems in the river's lower canyon (i.e., "Bore Hole" and "White Rapids") need to be focused and coordinated between Provincial and Federal fisheries agencies. A consensus on possible actions like blasting and fishway design must consider the needs of all anadromous species relying on upstream spawning and rearing areas (7).

Riparian and Fish Habitat Protection

Encroachments from urban and industrial activities will continue to challenge fish habitat protection needs (7). The regional, provincial and federal governments all play an important role in fish habitat protection. The entire Nanaimo River system - the water, the riparian areas, and any parts that contribute to salmonid habitat, be that their spawning grounds or nursery, rearing, food supply and migration areas on which fish depend to carry out their life processes, are all protected under the federal Fisheries Act (14).

Young fish, like this coho salmon fry, need an abundant source of food and good quality rearing habitat to survive.

In July of 2004 the Provincial Ministry of Environment enacted Riparian Areas Regulations (RAR) under the Provincial Fish Protection Act in cooperation with the Department of Fisheries and Oceans Canada. This new legislation is designed to protect the features, functions, and conditions that support fish processes in riparian areas.

Under RAR, the Regional District of Nanaimo cannot allow development in watercourse areas to proceed without an assessment report. This includes development near any ditch, spring, pond, lake, or wetland that supports fish habitat. As a result, the Regional District of Nanaimo is in the process of amending its Watercourse Protection Development Permit Areas in each Official

Community Plan to conform to the provincial directive to implement the Riparian Areas Regulation.

Any proposed development located within 30 meters of any body of water that provides fish habitat will need an assessment report prepared by a qualified environmental professional to be accepted by the Provincial Fisheries Agency before the RDN can approve it. The report is used to determine how far a development must be located from a watercourse and what must be done to preserve the riparian area within this buffer area for the purpose of fish protection.

The Riparian Areas Regulation applies to all new residential, commercial, and industrial developments. It does not apply to reconstruction or repair of existing structures, farm uses on agricultural lands, or lands subject to the Forest Act or Private Managed Forest Land Act.

Since much of the Nanaimo River watershed lies within Private Managed Forest Land, it is essential to work cooperatively with the two forest companies to ensure that logging practices enhance rather than compromise fish habitat (7). It is particularly important to retain riparian buffers and ensure logging does not create slope instability and lead to sediment transport into lakes and streams. Acquisition of riparian buffers, particularly along fish bearing streams, would enable the community to ensure their protection in perpetuity.

Nutrient Enrichment

Another potential restoration tool is the use of artificial stream enrichment to increase rearing habitat productivity (7). This would be totally dependent on the province developing and receiving approval to use an organic fertilizer product, like compacted pollack. The prime area for fertilizer treatment to benefit steelhead would be from the outlet of First Nanaimo Lake, downstream to White Rapids in the lower canyon, including lower reaches of the north and south forks of the Nanaimo River. The Provincial Fisheries Agencies, in conjunction with Trout Unlimited Canada, have compiled background water chemistry and stream flow data for this section, so that fertilizer loading rates can be calculated for the late May to August period. Discussions with regional health officials, other agencies and licensed water users would be needed prior to implementation of an enrichment project.

Water

A review of the effectiveness of the Nanaimo River Water Management Plan should be undertaken to ensure the recommendations and available water each years continues to meet conservation needs of wild salmon and trout populations (7). The feasibility of water flow and temperature improvement opportunities below reservoirs could also be examined. A continued cooperative relationship with Harmac, the City of Nanaimo and fisheries agencies will help maintain a minimum water flow throughout the dry summer and early fall (1).

Changes in Fourth Lake water release mechanism resulting in higher water temperatures would provide an additional 15 km of rearing habitat (8). Flow release options for Fourth Lake were examined to determine if water temperatures could be increased to benefit trout rearing in the Nanaimo River downstream of the lake outlet pipe (11). A detailed feasibility assessment is recommended to be solicited from a civil engineer in order to estimate cost for a multi-port outlet structure with valved inverts at a range of elevations to take advantage of the warmer surface waters in the lake over the withdrawal period.

Estuary

Degradation of estuarine environment has reduced quality and quantity of nursery areas for Chinook and other fish (8). The restoration and protection of the estuary nursery areas are necessary if Chinook is to recover to historic levels.

Stock Enhancement and Harvesting Regulations

Annual monitoring of fish populations is essential to inform management decisions and monitor the success of restoration and enhancement projects.

The release of fry may be the quickest and most efficient means of rebuilding selected fish populations in Nanaimo River (8). To use the full production potential of the system, hatchery raised fry and smolts could be planted in underutilized areas. Continued funding for the Nanaimo River Hatchery is important to ensure the recovery and stability of certain stocks (7).

Restrictions on fresh and salt water fisheries are necessary to help reduce pre-spawning mortality and rebuild/maintain populations (8). The Steelhead Recover Plan recommends continued seasonal steelhead closure until stock recovers appreciably, and encouragement of steelhead conservation with the Snuneymuxw First Nation (7).

Nanaimo River recreational fishery is closed all year from the power line crossing at "Bore Hole" upstream to fishing boundary signs at the mouth of Boulder Creek. There is also no fishing from the Cedar Road bridge upstream approx. 400 m to the white square boundary signs near the Hwy 19 bridge from Sept 15-Oct 30, and no fishing upstream of the Hwy 1 bridge from Dec 1-May 31. Artificial fly only is permitted upstream of the westernmost of the two Nanaimo Lakes, known locally as "Second" Lake, including tributaries (16).

Region-wide, a new regulation requires the release of all wild origin trout in streams (only hatchery origin, those with a healed scar in place of adipose fin, can be harvested.) This regulation does not apply to lakes. All wild trout and wild steelhead from streams and all char (includes Dolly Varden) must be released. Single barbless hooks must be used and a bait ban applies (16). Catch quotas and more detailed regulations can be seen at http://www.env.gov.bc.ca/fw/fish/regulations/docs/1113/fishing-synopsis_2011-13_region1.pdf

Education and Information Sharing

Stewardship initiatives on Nanaimo River will rely on the support and cooperation of all stakeholders. To foster these partnerships, it is important to include all stakeholders in planning processes so that the diverse interests are taken into consideration (7,14).

Strong stewardship groups, working closely with government fisheries agencies, are the best hope for preserving critical habitat for wild fish. Volunteers and stewardship groups make essential contributions to habitat restoration and protection initiatives (7).

Information sharing and education are also key ingredients to successful stewardship. A public education program would raise awareness of the importance of healthy fish populations to our community, and create awareness of how people can help protect them. This should include information about regional, provincial and federal streamside protection bylaws and fishing regulations. A landowner education program within the watershed could provide information about mechanisms and incentives to protect riparian habitats on their lands.

The sharing of information among stakeholders is also key. A web-based library could be established for uploading and sharing all information related to fish in the Nanaimo River watershed (14). Reports, data and photographs that currently exist only in hard copy should be digitized and uploaded (for instance any data, aerial photographs, and slides archived at the Nanaimo River Hatchery).

INFORMATION GAPS

Further research and interpretation of historical information would contribute to a comprehensive stewardship plan. This could include:

- Identify historical benchmarks of fish populations and fish habitat
- Interpretation of abundant raw habitat data archived at the Nanaimo River Hatchery, including historical slides and aerial photos that could be scanned and used in mapping to increase understanding of the watershed changes over time (14)
- A review of all restoration and enhancement projects to date and their outcomes
- Identification of current factors limiting productivity of all fish species
- Establish benchmarks and system for monitoring overall watershed health and fish habitat potential
- Conduct current fish stock assessments, and compare to historical data, in order to determine current status of all fish species populations in the watershed

REFERENCES

Literature Cited

1. Brian Banks – *Nanaimo River Stakeholder Survey* submitted to Nanaimo and Area Land Trust, 2011.

2. Michael McCulloch – *Nanaimo River Stakeholder Survey* submitted to Nanaimo and Area Land Trust, 2011.

3. McCulloch pers comm.

4. Voices of the Snuneymuxw First Nations. http://www.snuneymuxwvoices.ca/english/index.asp

5. Fisheries and Oceans Canada. 2008. Recovery Strategy for Northern and Southern Resident Killer Whales in Canada. *Species at Risk Act* Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa.

6. Pearson, Mike and Healey, M.C. 2011. Species at Risk and Local Government: a Primer for BC. Stewardship Centre of British Columbia, Courtenay BC.

7. BC Conservation Foundation. 2003-2006. Greater Georgia Basin Steelhead Recovery Action Plan for Nanaimo River Watershed. http://www.bccf.com/steelhead/focus7.htm#nan and http://www.bccf.com/steelhead/crisis.htm

8. Blackman, Brian. 1981. Nanaimo River Stock Assessment and Enhancement Proposals.

9. Banks pers. comm.

10. Snuneymuxw Treaty Negotiations. April, 2003. Draft Consultation Agreements-In-Principle Summary. Snuneymuxw First Nations, Province of BC and Government of Canada.

11. Gaboury and McCulloch. 2002. Fish Habitat Restoration Designs for Five East Vancouver Island Watersheds. Ministry of Water, Land and Air Protection, Nanaimo BC.

12. Bill 88. Private Managed Forest Land Act Honourable Stan Hagen, Minister Of Sustainable Resource Management, November 6, 2003.

13. Iannidinardo, pers comm.

14. Michelle Bigg – *Nanaimo River Stakeholder Survey* submitted to Nanaimo and Area Land Trust, 2011.

15. Griffith, R.P. 1992. Feasibility of fisheries enhancement undertakings in selected Vancouver Island streams. *prepared for:* Outdoor Recreation Foundation of BC, and Ministry of Environment, Lands and Parks, Nanaimo, BC. pp 86-94.

16. Freshwater Fishing Regulations Synopsis 2011-2013. Region 1 - Vancouver Island Regional Regulations. Ministry of Forests, Lands and Natural Resource Operations. http://www.env.gov.bc.ca/fw/fish/regulations/docs/1113/fishing-synopsis_2011-13_region1.pdf

FISH HABITAT ASSESMENT

Updating and Prioritizing Restoration Options

On behalf of

Nanaimo Area Land Trust

140 Wallace Street

Nanaimo BC

Canada

Prepared

January 2014

by

D.R. Clough Consulting

Lantzville B.C.

OVERVIEW

This synopsis was written to provide an update and prioritization of habitat assessment and restoration prescriptions of the Nanaimo River Watershed. It came about through the interest of Nanaimo Area Land Trust working with the Nanaimo River Watershed Roundtable and their interest in completing a Nanaimo River Watershed Baseline Report. The key document of interest in their action was the 2002 publication by Marc Gaboury and Mike McCullough, "FISH HABITAT RESTORATION DESIGNS FOR FIVE EAST VANCOUVER ISLAND WATERSHEDS". Since it was written 12 years ago, they asked for a biological review of the document by our company. We took the report as well as several other recent documents on the watershed to come up with recommendations.

METHODS

There are several documents we collected to review the habitat status and restoration prescriptions to make this report. The recent knowledge base started with the Nanaimo River Water Management Plan published by BC Environment in 1993. The Haslam Creek tributary habitat condition was published in year 2000 by Rob Hanelt, RPBio of Aquaterra Environmental for the Ministry of Environment and Nanaimo Fish and Game Protective Association. This report covered the habitat condition of the lower three reaches of Haslam Creek. In 2002, Marc Gaboury and Mike McCullough published restoration prescriptions on Five East Coast Vancouver Island Streams including the Nanaimo River Watershed. In 2007, D.R. Clough Consulting on behalf of the Nanaimo Airport Commission and Nanaimo Fish and Game Protective Association prescribed and undertook LWD treatments within Reach 1 of Haslam Creek. In October 2009, D.R. Clough Consulting completed the habitat assessment status report for the Haslam Watershed including Reaches 4 - 8 (to Haslam Lake).

The objective of the Haslam Creek Habitat Inventory and Gaboury & McCullough Restoration Plan is to develop a better understanding of the environmental impacts on the Haslam Creek watershed, and develop a long-term fish habitat restoration program.

This report was based on a review of the existing literature. It was then compared to any follow up reports, orthophoto interpretation and the personal knowledge of the author. No follow up reporting has been conducted on Deadwood Creek of which Gabroury & McCullough identified another 60 prescriptions which were not discussed below. The costing figures provided were updated to 2013 values using the Bank of Canada inflation calculator.

RESULTS

Figure 1 below shows the existing 59 prescriptions from the 2002 Restoration Plan as well as the follow up 2010 Urban Salmon Habitat Program report. The original restoration prescriptions were reviewed at their proposed locations. Given the 12 years and significant storm events (especially the 2006 flood year) resulted in many changes to the Haslam River bank. While Figure 2 shows the costing upgrades from 2002 there has been significant habitat damage with channel movement, erosion, and deposition. The majority of the LWD described in the original assessment has been washed away or relocated elsewhere.

Figure 1: Updated Summary of Prescriptions (Haslam Creek)

Location	Site Number	Structure	Bank	Update comments
0+183	1	LWD LT 6	Right	Channel has head cut Pool and LWD are no longer present. Anchor tree have been washed away
0+250	2	LWD LT 6	Left	Pool and LWD are no longer present longer present will need to be imported
0+278	3	LWD LPS 5	Right	still valid design site should be expanded
0+324	4	LWD LO4	Right	not applicable after 2006 floods
0+438	5	LWD LT6	Right	still valid design site should be expanded
0+575	6	LWD LT6	Left	Existing LWD site should be added to work was completed in 2009
0+600	7	LWD LPS 5	Left	Existing LWD site should be added to work was completed in 2009
0+686	8	LWD LO4	Left	not applicable after 2006 floods
0+768	9	LWD LT6	Right	still valid design site should be expanded
0+830	10	LWD LT6	Left	still valid design site should be expanded with additional ballast
1+049	11	LWD LO-4S.	Right	high risk not recommended
1+125	12	LWD LO3	left	designed with existing LWD unknown if is still present
1+289	13	LWD LO4	Right	high risk not recommended
1+949	14	LWD LSP5	Right	significant erosion LWD works have been undertaken by NAC
2+044	15	LWD 01 S	right	Needs further work which was planned in 2013 but not completed
2+108	16	LWD LT6	Right	completed

2+200	17	LWD LSP5	Right	completed
2+303	18	LWD LT3	Right	completed
2+362	19	LWD LO1S	Left	high risk not recommended anchor trees may have been removed
2+810	20	LWD L04	Right	high risk not recommend post 2006 storm
3+109	21	LWD LT6	Left	Existing LWD no longer present
3+185	22	LWD LT6	Right	still valid design site should be expanded with additional ballast
3+410	23	LWD LO1S	both	anchor point may have been eroded post 2006 if still present design would still be valid
3+517	24	LWD LO1S	Right	need to import ballast
3+746	25	LWD DJ-5	Right	unknown how erosion has affected channel width will require additional ballast
3+892	26	LWD LT6	Left	vegetation removal completed since 2002 adverse effects
3+989	27	LWD	Right	unknown if LWD is still present
4+116	28	LWD LO1S	Left	still valid design site should be expanded with additional ballast
4+210	29	LWD LT6	Right	Existing LWd is gone
4+279	30	LWD LT6	Right	still valid design site should be expanded with additional ballast
4+290	31	LWD LT6	Right	still valid design site should be expanded with additional ballast
4+373	32	LWD LT6	Left	anchor point may have been erroded post 2006 if still present design would still be valid
4+504	33	LWD LT6	Right	eroded in 2006 storm
4+596	34	sweeper	right	eroded in 2006 storm
4+900	35	LWD LT6	Left	still valid design
4+929	36	LWD LSP5	left	high risk location
5+015	37	LWD DJ-5	Left	less existing LWD than in perscription
5+834	38	LWD LT6	right	significant erosion LWD may have washed away
6+059	39	sweeper	Right	LWD washed away in 2006
6+299	40	LWD LT6	Left	pool is gone but design still functional

6+332	41	LWD LT3	Left	design still valid
6+405	42	LWD LT3	Right	involves stream excavation adjacent Trailer Park
7+049	43	LWD LT6	Left	LWD Likely washed away since 2002
5+341	44-49	offchannel	Right	channel has received flood water need armour and excavation
5+515	50-51	offchannel	Right	channel has received flood water need armour and excavation
1+239	52	offchannel	Left	250*2m offchannel
1+436	53	offchannel	Right	100m offchannel
4+665	54	offchannel	Right	50x3m presently dry
5+410	55	offchannel	Right	near old rr crossing wet in summer
5+583	56	offchannel	Left	186x3m good summer flow
5+838	57	offchannel	Right	105m length subsurface for 15m at confluence
6+534	58	offchannel	Right	60m length in summer
Nanaimo River Second Lake outlet				
0+238	59	SG	na	Spawning gravel 2nd Lake still valid

COSTING

The 2002 cost of restoration was taken from Table 32 of Gaboury & McCullough. The costs were then expanded to 2014 estimates based on market costs of recent projects. This table covers the entire cost of the 2002 restoration, we couldn't easily separate the individual projects that are now not recommended. We noted the biggest cost increases were in Rip Rap Costs, Trucking and Excavators since 2002.

Figure 2: Cost Estimates Upgrades

Cost Estimate: 2013 Cost Upgrades					
	Haslam Creek	Deadwood Creek	Nanaimo River	Total Cost ($)	Adjusted Cost ($)
Major Equipment	66195	76410	13540	156145	276376.7
Man Power	25170	30420	6960	62550	110713.5
Light Equipment	2000	2000	0	4000	7080
Materials	67230	59380	1460	128070	226683.9
Total Cost	**160595**	**168210**	**20960**	**349765**	**620854.10**

*Adjusted cost based on inflation of 27% plus 50% habitat damage since 2006

DISCUSSION

Gaboury & McCullough, 2002 also identified 60 LWD sites in Deadwood Creek and spawning gravel placement just below the outlet of Second Lake in the Nanaimo River mainstem. It is unknown how the Deadwood Creek sites have held up from these large storm events. To date there have been no follow up inspections. The Nanaimo Fish and Game USHP survey went further upstream into the headwaters including the canyon reach and Haslam Lake, this survey identified the potential sediment sources during future storms events.

The above tables of Haslam Creek identified 59 restoration sites. The impacts were a result of development practices including forestry, agricultural, urban development, transportation and utilities crossings, and water removal. Of these sites;

- nine include off channel habitat,
- one spawning gravel,
- the remaining 49 sites are LWD treatments.

Since 2002, the watershed has received extensive flood waters in 2006, 2007, 2009 and 2010. These storms eroded hundreds of meters of bank, removing most of the functional LWD and depositing large volumes of sediment within the lowest 2km of streambed. Nanaimo Airport Commission in partnership with Nanaimo Fish and Game Protective

Association and Nanaimo River Stewardship Society has undertaken some big LWD placement projects in the lower reach. These placements helped hold the bank together during these large floods, sadly the areas in between the restoration sites continue to degrade (Figure 3).

RECOMMENDATIONS

- complete the design for spawning gravel at Second Lake (59),
- investigate the Off Channel sites (44-58)
- undertake LWD sites 1-3, 5-7,9,10,12,14 and 15 (lowest reaches, highest fish use).
- A follow up inspection of Deadwood Creek should also be completed prior to further activities.

Brad Remillard, RPBio

& Dave Clough, RPBio

REFERENCES

Gaboury & McCulloch, (2002) Fish Habitat Restoration Designs for Five East Vancouver Island Watersheds.

VEGETATION & ECOSYSTEMS

JOE MATERI, RP BIO.

"Loss of forest in the Coastal Douglas-fir Biogeoclimatic Zone, or CDF, is a big issue in the Nanaimo River Valley right now, as it is across southeast Vancouver Island. There wasn't all that much forest to start with in this part of the Island, and almost 80 % of it is privately owned. These old growth and mature fir forests have been heavily impacted: they are under a lot of pressure from urban and rural development, and represent some of the most valuable timber in our region. About half of the original CDF forest on Vancouver Island has been converted to other uses…only about 40 % of the CDF Zone is still forested. Currently, less than 5% of the zone is old forest and less than 20% is mature.

Re-digitizing of the Sensitive Ecosystem Inventory (SEI) mapping on southeast Vancouver Island found that over 11% of the area occupied by the SEI ecosystem types in the early 1990s had been disturbed by 2002. Older forest types experienced the highest rate of loss, while older second-growth stands had the greatest area of loss. The re-digitizing study showed that the greatest losses of sensitive ecosystems occurred in the Nanaimo region."

Marlene Caskey
Senior Ecosystem Biologist
Ministry of Forests, Lands and Natural Resource Operation

OVERVIEW

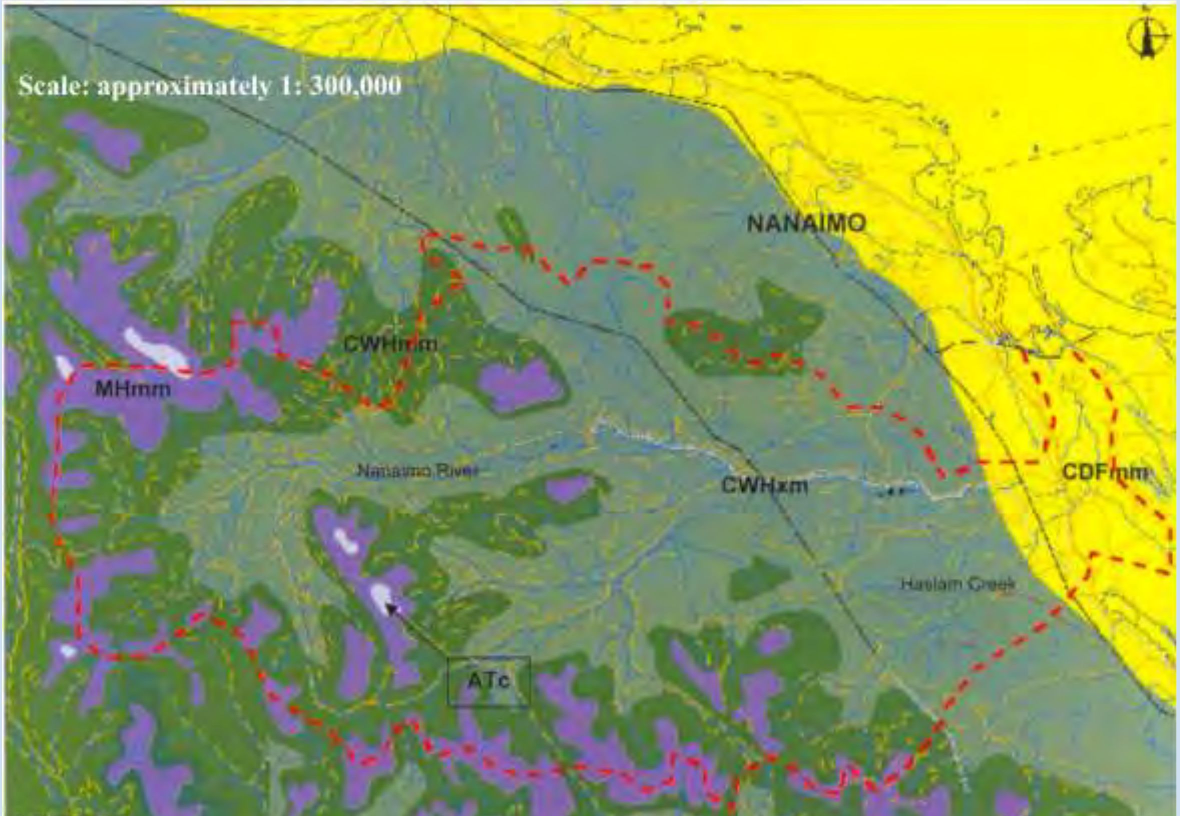
The Nanaimo River Valley extends inland for over 50 km from the mouth of the Nanaimo River. Over its length, the variation in elevation, climate, soil types, and moisture regimes has produced a rich assemblage of plant communities. The watershed is comprised of four Biogeoclimatic Zones (Figure 2) spread across more than 75,000 hectares (or 750 km^2). From lowest to highest elevation, these Biogeoclimatic Zones are the Coastal Douglas-fir (CDF), the Coastal Western Hemlock (CWH), the Mountain Hemlock (MH), and the Alpine Tundra (AT).

Coastal Douglas-fir: this is the lowest elevation zone, extending from tidewater to approximately 80 m above sea level, near Cassidy. It accounts for a small proportion of the watershed, less than 7 %. The Moist Maritime Subzone is the only subzone within the Coastal Douglas-fir zone, and is characterized by warm, dry summers and mild, wet winters. Precipitation is lower here than areas further inland, as moisture-laden systems from the west are "wrung-dry" from rising and cooling over the Vancouver Island Mountains. In summer, periods of drought can persist for several weeks here. Typical forest sites within the subzone are dominated by Douglas-fir, with a lesser occurrence of Grand Fir and Western Red cedar. Understory vegetation is typically comprised of Salal, Dull Oregon Grape, Ocean-spray and Oregon Beaked Moss (1).

Coastal Western Hemlock: two subzones of this forest type account for over three-quarters of the watershed's total area: the Very Dry Maritime Subzone and the Moist Maritime Subzone. The Very Dry Maritime Subzone, which covers almost half the watershed, occurs immediately above the Coastal Douglas Fir Zone, and extends up to about 700 m elevation. This subzone has a similar climate to the latter, but forests here include Western Hemlock as co-dominant tree species with Douglas-fir. Understory composition can be similar to the Coastal Douglas Fir Zone, but Ocean-spray is replaced by Red Huckleberry in the shrub layer (1). Within the watershed, much of the Coastal Western Hemlock Very Dry Maritime Subzone has been logged in the past few decades. This subzone currently supports second-growth stands ranging from about 30 to 70 years in age.

The Moist Maritime Subzone occurs above the Very Dry Subzone, reaching to approximately 1000 m in elevation. It occurs over about 30 % of this watershed. This subzone features cool temperatures, short growing seasons, and relatively high snowfall. The forest canopy in Moist Maritime Subzone typically includes a mixture of Western Hemlock, Amabilis Fir and Douglas-fir. Yellow Cedar and Mountain Hemlock trees often appear at the upper margins of the subzone. The understory of the Moist Maritime Subzone is usually dominated by various types of blueberries (Vaccinium spp.) and Salal (1).

Figure 1: Biogeoclimatic Zonation within the Nanaimo River watershed (2).



LEGEND

Biogeoclimatic Zones	Abbreviation	Colour	Proportion of watershed
Coastal Douglas Fir: Moist Maritime Subzone	CDFmm	yellow	7%
Coastal Western Hemlock: Very Dry Maritime Subzone	CWHxm	dull green	47%
Coastal Western Hemlock: Moist Maritime Subzone	CWHmm	bright green	29%
Mountain Hemlock: Moist Maritime Subzone	MHmm	purple	16%
Alpine Tundra: Coastal Subzone	ATc	grey	1%

Mountain Hemlock: this is one of the two high-elevation Biogeoclimatic Zones occurring within the watershed. The Mountain Hemlock Zone accounts for about 15 % of the watershed's area. It is comprised of a single subzone, the Moist Maritime, and a single variant, the Windward Variant. Depending on aspect and terrain, the lower limit for the Mountain Hemlock Moist Maritime Subzone varies between 800 m and 1000 m elevation. The upper limit for this subzone is approximately 1300 m. This subzone experiences harsh environmental conditions, having long, wet, and cold winters with significant snowfall accumulation. Summers are typically short and cool. The cover by Mountain Hemlock, Amabilis Fir, Yellow Cedar, and blueberries in the upper part of this zone transitions to the stunted conifers and heathers characteristic of the Parkland zone (1).

Alpine Tundra: atop the highest peaks in the watershed, a few small areas break into the Coastal Subzone of the Alpine Tundra. This region is devoid of trees, but supports a few low-growing shrubs, herbs, bryophytes and lichens. Vegetation here is forced to exist between patches of ice, rock, and snow.

Understanding the distribution of forested ecosystems in this watershed at a smaller scale is complicated by the types of mapping available, and by the rate at which land is being developed or harvested. Due to the scarcity of Crown Lands in the Nanaimo River watershed, only small areas are covered by provincial Forest Cover Maps (i.e. Map Sheets 92B.091, 92F.010 and 92G.001). In any event, these maps focus on tree canopy cover, leaving understory vegetation to be inferred. Private forest companies with holdings in the watershed have similar mapping, but neither lends itself to a landscape-level analysis of ecosystem distribution. Broad Terrestrial Ecosystem (BTE) mapping by the former Ministry of Environment is better-suited to ecosystem analysis as it involves understory description, and covers the entire Nanaimo River watershed (3). However, the small-scale of the mapping (1:250,000) results in the omission of some small-but- important ecosystems, particularly wetlands. BTE mapping for the watershed was obtained from Mr. Tony Button, Ecosystem Information Specialist at the BC Ministry of Environment in Victoria. The BTE map polygons indicate that at least 10 distinctive natural ecosystem types are present in the Nanaimo River watershed (Table 1). The most commonly occurring BTE units in the watershed are the Amabilis Fir-Western Hemlock (49 polygons), Coastal Western Hemlock-Douglas-fir (41 polygons), and the Mountain Hemlock-Amabilis Fir (20 polygons). Of the roughly 170 BTE polygons covering the watershed, only 10 are classified as the Coastal Douglas-fir (CD) type.

A few other specialized forest ecosystems and some wetland ecosystems were captured in the lower half of the Nanaimo River watershed during the East Vancouver Island and Gulf Islands Sensitive Ecosystem Inventory Project (SEI), a joint effort by the BC Ministry of Environment, Lands and Parks and Environment Canada in the mid 1990's. The goal of the SEI mapping project was to identify, classify, and map ecosystems and other habitats with high biodiversity values, and provide guidance for land use decisions in a rapidly developing area (4). The 1:20,000 scale mapping was completed in 1997, and was based on 1994 air photo coverage. The SEI mapping indicates that six additional natural ecosystems are present in the Nanaimo River watershed, for a total of 16 ecosystems (Table 1). Some representative photos of ecosystems occurring in the watershed are shown in Figure 2.

Table 1. Summary of natural ecosystems within the Nanaimo River Watershed based on Broad Terrestrial Ecosystem (3) and Sensitive Ecosystem Inventory (4) map coverage.

Code	Biogeoclimatic Subzone	Ecosystem Description	Similar Biogeoclimatic Site Associations
Broad Terrestrial Ecosystem (BET) Map Units			
AV	Alpine Tundra: Coastal Mountain Hemlock: Moist Maritime Coastal Western Hemlock: Moist Maritime	Avalanche Track: linear shrubby units dominated by willows, Sitka alder and copperbush due to snow/rock fall.	n/a
CD	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Coastal Douglas-fir: dry conifer forest with salal, Oregon grape, & red huckleberry	Fd - Salal (01) HwFd - Kindbergia (01)
CG	Coastal Douglas Fir: Moist Maritime	Coastal W. Red cedar – Grand Fir: rich forest with O. grape, sword fern, van. leaf.	CwBg - Foamflower (06)
CW	Coastal Western Hemlock: Very Dry Maritime	Coastal Western Hemlock- Douglas-fir: mixed conifers with salal, red huckleberry, O.-grape, sword fern, and vanilla-leaf.	Fd - Sword Fern (04) Cw - Sword Fern (05) HwCw - Deer Fern (06) Cw - Foamflower (07)
ES	Coastal Douglas Fir: Moist Maritime	Estuary: salt-tolerant herbs, esp. Lyngby sedge and silverweed, sea asparagus.	n/a
FR	Coastal Western Hemlock: Moist Maritime	Amabilis Fir–Western Hemlock: mixed conifers with blueberries, salal, foamflower, and vanilla leaf.	HwBa - Pipecleaner Moss (01)
HP	Mountain Hemlock: Moist Maritime	Mountain Hemlock Parkland: irregular cover of subalpine conifers and shrubs.	HmBa - Mtn-heather (02)
MF	Mountain Hemlock: Moist Maritime	Mountain Hemlock-Amabilis Fir: understory of blueberries, false azalea, & heathers.	HmBa - Blueberry (01)
RO	All	Rock: steep to level outcroppings with thin soils and little vegetative cover.	n/a

Table 1 (continued).

Code	Biogeoclimatic Subzones	Ecosystem Description	Similar Biogeoclimatic Site Associations
SR	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Sitka Spruce - Blk Cottonwood Riparian: deciduous-dominated floodplain forest with Indian plum, dogwood , salmonberry & willows.	Act - Willow (09) Ss - Salmonberry (08) Act - Red-osier Dogwood (09)
Sensitive Ecosystem Inventory (SEI) Map Units			
HT	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Terrestrial Herbaceous: Natural grasslands or moss- and lichen-dominated vegetation; less than 20 % shrub cover.	n/a
WD	Coastal Douglas Fir: Moist Maritime	Woodland: open stands comprised of Garry Oak, Arbutus, and/or Douglas-fir.	Fd-Pl – Arbutus (02) Fd – Onion grass (03)
WN: sp	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Swamp: wooded wetland dominated by cedar and skunk cabbage or salmonberry, willows, ninebark, and Pacific crab-apple.	Cw - Skunk Cabbage (11) CwSs - Skunk Cabbage (12)
WN: bg	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Bog: low-nutrient wetland with sphagnum substrates supporting sedges, skunk cabbage, & Labrador tea.	Pl - Sphagnum (10) Pl - Sphagnum (11)
WN: ms	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Marsh: nutrient-rich, herb-dominated wetland, typically with a high cover by cattail or sedges.	n/a
WN: sw	Coastal Douglas Fir: Moist Maritime Coastal Western Hemlock: Very Dry Maritime	Shallow Water Wetland: permanently wetted areas < 2 m deep in mid-summer; rooted vegetation is sparse.	n/a

Figure 2: Representative photos of biogeoclimatic zones in the Nanaimo River Watershed.

As indicated in Figure 3, the largest area of SEI Polygons in the watershed includes more or less contiguous blocks of older second-growth forest (SG) located west and northwest of Cassidy, mostly within the CWHxm Subzone. At 60 to 100 years of age, the SG polygon type is not considered "sensitive" unless it occurs in the CDF zone. Larger blocks of SG forest were mapped

Figure 2 (continued).

because they have high general biodiversity values. Two types of SG polygon were identified within the watershed, a coniferous type (co) and a mixed one having a significant deciduous component (mx). Both types occur in the watershed. The other "non-sensitive" SEI ecosystem type possessing high biodiversity values is the Seasonally Flooded Agricultural Field (FS). This introduced plant community is scattered along the lower parts of the valley. Large FS units occur adjacent to the Nanaimo River Estuary, around Michael Lake, and along Hokkanen Creek.

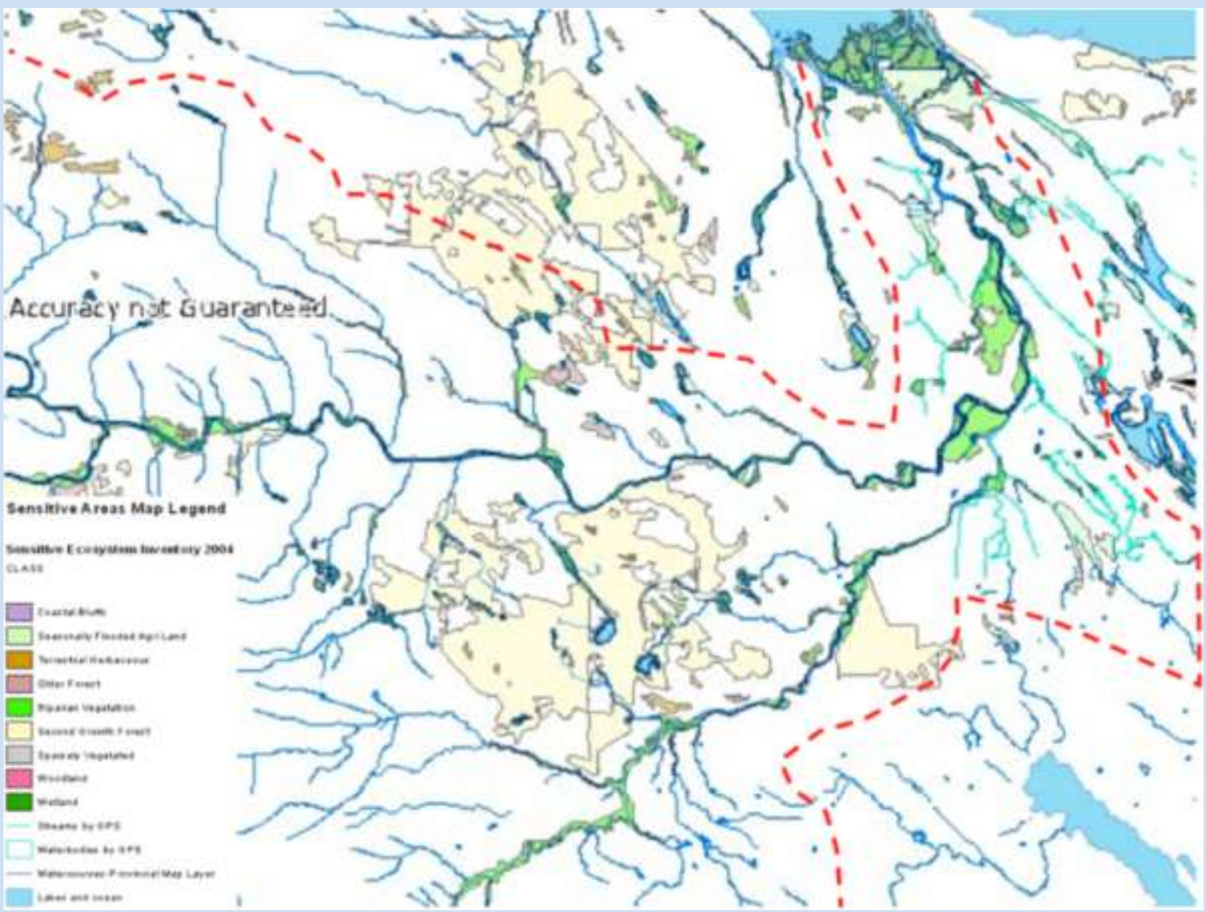
The most extensive of the sensitive ecosystem types is Riparian ecosystem (RI). It occurs as linear bands along the middle and lower reaches of the Nanaimo River, and along much of Haslam Creek. The Riparian units in this watershed represent mostly young structural stages (Structural Stage 3). Very few mature riparian stands were mapped in this watershed, and fewer still old stands have been identified.

Across the lower Nanaimo River Valley in various irregular shapes and sizes are SEI Wetland (WN) units. By far the largest single Wetland unit, with nearly 130 hectares (ha) of marshland, is the Nanaimo River Estuary. In addition to the Tidal Marsh ecosystem, detailed mapping of the estuary prepared for the Nanaimo Estuary Management Plan (5) identifies four sparsely vegetated ecosystem types including: Mudflat, Sand and Gravel Flat, Gravel/Cobble Reef, and Gravel Bar (Figure 4).

Figure 2 (continued).

Many of the other SEI Wetlands in the watershed are small in area (1 to 10 hectares) and widely dispersed. Loose clusters of wetlands occur near North Nanaimo Creek, North Haslam Creek, First Lake, Quennell Lake, and Whiskey Lake. The largest freshwater wetland unit in the entire watershed occurs at McKay Lake (SEI No. N0700). It is roughly 25 ha in size. Wooded wetlands, termed swamps (modifier "sp"), are the most frequently occurring SEI wetlands in the watershed, with more than 40 polygons. Swamps in the watershed typically have a high cover of willows or skunk cabbage. The marsh (ms) and shallow water wetland (sw) types often occur as complexes. They are distributed fairly evenly across the lower part of the watershed. Nutrient-rich fens and nutrient-poor bogs are very uncommon in the watershed. For example, only two fen and two bog polygons are shown on SEI Map sheet 92G.001. Fens in the region typically support a dense growth of hardhack and/or sedges, while bogs support a diverse and specialized plant assemblage over sphagnum mosses.

Figure 3: Distribution of sensitive ecosystems in the lower Nanaimo River Valley.



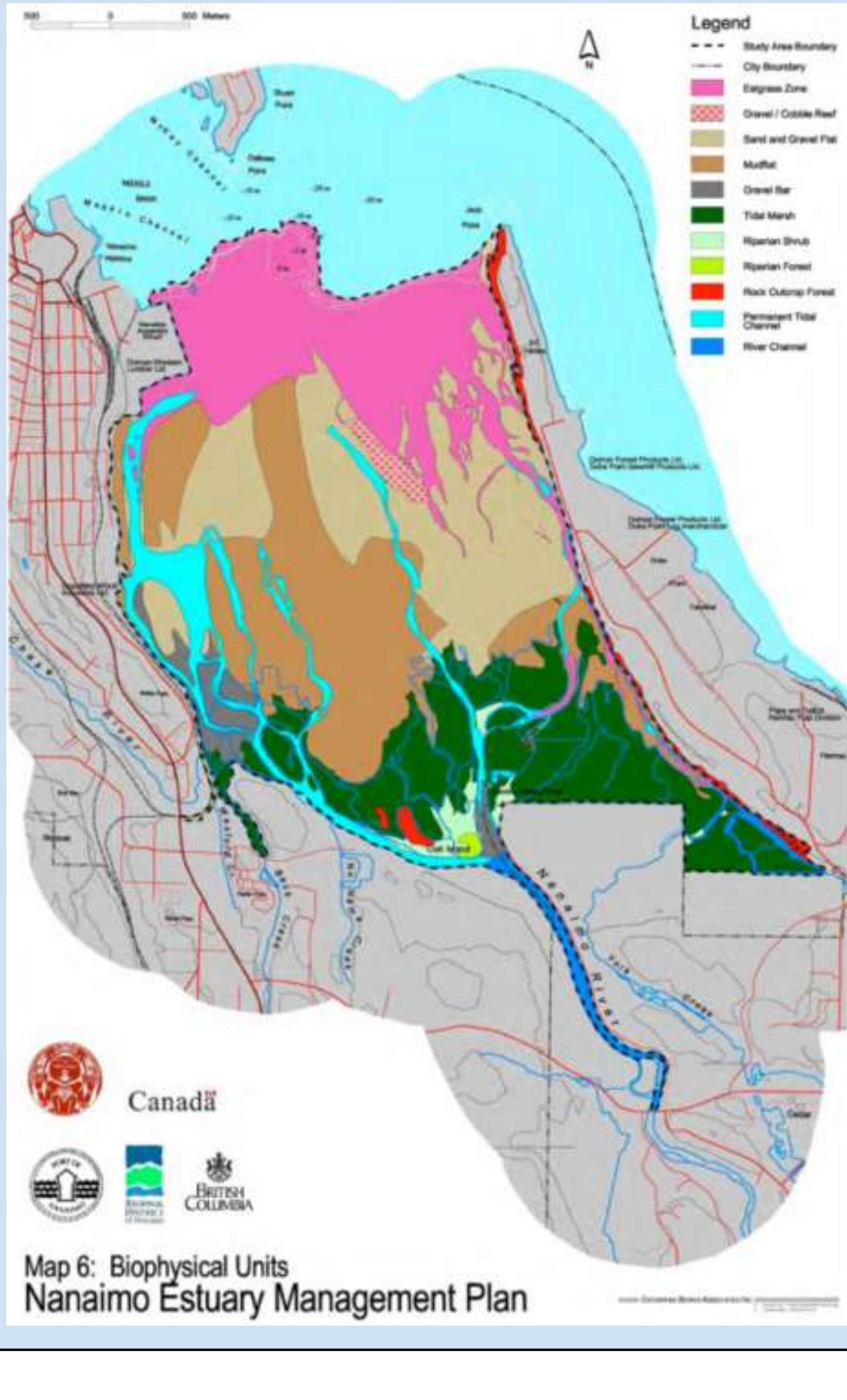
Bryophyte- and lichen-dominated Terrestrial Herbaceous (HT) SEI units are clustered on bluffs overlooking the middle reaches of Haslam Creek, Whiskey Lake, and along Blackjack Ridge. Some HT units include a significant cover of grasses and various drought-tolerant shrubs (e.g. kinnickinnick, Saskatoon, ocean spray, and hairy manzanita). It should be noted that no Coastal Bluff (CB) or Sparsely Vegetated (SV) SEI polygons occur within Nanaimo River watershed.

STAKEHOLDERS

Every landowner in the Nanaimo River watershed is a potential stakeholder in ecosystem protection. However, depending on the location of their properties within the valley, some may have a more important role in the protection of sensitive ecosystems than others. The following land owners are considered to have key roles in managing ecologically sensitive areas:

- **The Nature Trust of B.C.**: holds title to conservation lands at the Nanaimo River Estuary, the single largest wetland SEI unit in the watershed. This organization's mandate is to protect ecologically sensitive habitat throughout the province. The estuary land is leased to the Province of BC and is managed by it.
- **Snuneymuxw First Nation**: The Snuneymuxw First Nation has four of its six reserves located near the Nanaimo River Estuary. Their lands encompass SEI Polygons including Riparian, Wetland, and Seasonally Flooded Agricultural Field units.
- **Island Timberlands**: holds title to tracts of forest land on the western margins of the Coastal Douglas Fir Zone. If still standing, a forest patch in SEI Polygon No. NO669A off Timberlands Road, which is Second-growth Forest with an Older Forest component, would be of particular conservation interest.
- **BC Ministry of Forests, Lands, and Natural Resource Operations**: manages forest harvest on the 1900 hectare McKay Lake Ungulate Winter Range and 400 hectare Haslam Ungulate Winter Range, which include Wetland, Riparian, Terrestrial Herbaceous and Second-growth SEI units. The Wetland units in the McKay UWR include the largest freshwater wetland in the watershed and a rare bog ecosystem.
- **BC Parks:** manages Hemer Provincial Park on the western shores of Holden Lake. This 93 ha park includes SEI wetlands and includes mature forest stands in the Coastal Douglas Fir Zone.
- **The Land Conservancy of B.C.:** holds title to 56 hectares of conservation lands within the Nanaimo River Regional Park, encompassing a number of Riparian SEI units.

Figure 4: Biogeoclimatic zones in the Nanaimo River estuary (5).



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- **Regional District of Nanaimo**: the RDN Parks and Recreation Department operates and maintains two leased properties in the lower part of the Nanaimo River Valley containing Riparian and Wetland SEI units; Nanaimo River Regional Park and the Morden Colliery Trail.
- **City of Nanaimo:** owns and maintains Jack Point/Biggs Park adjacent to the Nanaimo River Estuary. The 33 ha park system includes the largest of just a few Woodland SEI units in the watershed.
- **Other Private Landholders**: private landholders in the lower part of the watershed own properties containing large Riparian and Seasonally Flooded Agricultural Field Units, as well as smaller Wetland Units.

RISKS AND IMPACTS

Over the past few decades, impacts to vegetation resources in the Nanaimo River watershed have occurred primarily through human activity (e.g., logging, agriculture, and roads) as opposed to natural factors (e.g., wildfire or insect infestation).

Logging: In this watershed, the historical pattern of logging likely mirrored that of other coastal communities on Vancouver Island. From the early 1900's through the 1930's coastal forest companies pushed rail lines up into major river valleys, "high-grading" the best timber, and transporting logs to train cars via steam power (the so-called "steam donkeys"). The era of truck-based logging began in the 1940's on the coast. Truck logging allowed road networks to be extended into areas previously inaccessible for harvest. Technological innovations led to the clear-cut harvest method that progressed up major valleys, in most cases stopping only at the steepest terrain. At times, poor road-building practices led to or exacerbated the generation of landslides. The impact of historical timber harvest is seen in the Nanaimo River watershed, where remnant old-growth stands are largely restricted to higher elevations and other areas previously considered inoperable. The pattern of logging here has produced a landscape with large tracts of closed-canopy young and mid-successional forest with poor understory development. Historical harvest methods afforded little protection to streams and their associated riparian forest ecosystems.

More recently, forestry practices on private and Crown land have evolved to provide better protection of hydrological systems and riparian forest. On Crown lands, forest management now includes consideration of successional stage representation and silvicultural methods to improve forest health and productivity, among other things. These improvements suggest that the main risks from logging will be a scarcity of old-growth forest due to short harvest rotations and fragmentation of mature forest cover due to smaller, more dispersed cut-blocks. Provided soil and hydrological values are conserved as required by the Private Managed Forest Land Act, the private forest land base in this watershed should retain its capacity to regenerate forests.

Largely removed from the context of industrial forestry, ecosystems in the eastern part of the Nanaimo River watershed have been subjected to impacts of a more permanent nature. In the 1980's there was a growing realization that the pace of population growth and land development

Table 2. SEI Polygon Loss between 1992 and 2002 by Disturbance Type and Primary Ecosystem: Nanaimo Sub-unit (6).

Disturbance Type	Loss (ha)							Other Ecosystems	
	CB	HT	OF	RI	WD	WN	SV	FS	SG
Agriculture	0.0	0.0	0.0	0.6	0.0	16.2	0.0	0.0	0.0
Clearing/Logging	0.0	3.8	237.2	79.5	0.0	18.3	0.0	0.0	1992.4
Industrial	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Roads	0.0	0.0	22.6	4.0	1.7	2.9	0.0	1.7	16.0
Rural Use	0.5	0.0	0.3	8.7	0.0	5.5	0.0	1.5	5.9
Trails/Recreation	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban Use	0.0	0.8	0.0	1.6	0.0	6.5	0.0	0.0	0.0
Total	0.5	5.0	260.1	93.7	1.7	33.5	0.0	3.2	2014.3

LEGEND

CB = Coastal Bluff
HT = Terrestrial Herbaceous
OF = Older Forest
RI = Riparian Habitat
WD = Woodland
WN = Wetland
SV = Sparsely Vegetated
FS = Seasonally Flooded Agric. Field
SG = Second-growth Forest

could impact fragile ecosystems in this part of the watershed and across the Georgia Depression. This concern was the impetus for the original SEI mapping project completed during the 1990's. Recent disturbance mapping of the original SEI Polygons (3) provides some insights into the nature of impacts to sensitive ecosystems in the Nanaimo area. The disturbance mapping results for the Nanaimo SEI Sub-unit, which extends from Ladysmith to Bowser, are summarized in Table 2.

Table 2 suggests that Clearing/Logging is the primary disturbance agent for SEI units in this watershed. This impact is felt primarily on Second-Growth (SG) forest ecosystems. However, Older Forest (OF), Riparian Forest (RI), and Wetland (WN) units have also been impacted to a lesser extent. Road networks were shown to be a distant second to Clearing/Logging. Impacts to sensitive ecosystems from Roads accrued mostly to Older Forest and Second-growth Forest. Agriculture and Rural Use had similar and low levels of impact. Rural Use impacted both Riparian Forest and Wetlands, while Agriculture impacts were largely directed at Wetland ecosystems.

OPPORTUNITIES

Implementation of the Riparian Areas Regulation (RAR) and improved forestry practices have highlighted a significant shift towards improved stewardship of sensitive Riparian ecosystems in recent years, especially near fish-bearing waters and larger wetlands. However, there is considerable room for improvement in stewardship of some other sensitive ecosystems, as discussed below.

Older Douglas-fir Forest Ecosystems – Given that the total area of the watershed is over 75,000 hectares, and most of the watershed is forested, the scarcity of older fir-dominant stands is striking (<150 ha). Because opportunities to secure Older Forest within the CDF Zone are very limited, acquiring older second-growth fir forest in the lower Nanaimo River Valley should be a high priority. Stands adjacent to existing protected areas and those containing sensitive woodland, wetland, or riparian features would be of particular interest.

Garry Oak Ecosystems – the main areas containing this rare ecosystem are protected in Biggs Park/Jack Point and Nanaimo River Estuary Conservation Area. Although protected, these habitats are vulnerable to alteration by invasive exotic vegetation. A program to keep Garry oak habitats clear of Scotch Broom, Gorse, and other invasive plants would help maintain the viability of the this ecosystem.

Cedar-Shore Pine Bog Ecosystems – This regionally uncommon ecosystem type is particularly sensitive to hydrological and soil water chemistry changes. Stewardship agreements should be developed to ensure the few pockets of bog land occurring in the watershed are not adversely affected by adjacent timber harvest or other land development activities (e.g. blasting, roads).

Wetland Ecosystems – Recent disturbance mapping indicates that agricultural developments impact Wetland SEI units in the Nanaimo Sub-unit disproportionately. Wetland areas have been a focus for agricultural development on Vancouver Island for decades owing to their rich and moist soils. A landowner contact and education program could help address wetland issues and suggest farm practices that would help maintain the integrity of wetlands within the watershed.

Other Forested Ecosystems – In addition to the sensitive ecosystems discussed above, there are many more common forest ecosystems which contribute to the biological diversity and resiliency of the watershed. Although they represent the early and middle stages of forest succession, many of these stands have important roles in reducing forest fragmentation, maintaining moist microclimates, buffering sensitive ecosystems, and providing travel/security cover for wildlife. Many common forest types possess habitat elements of considerable value to wildlife (snags, large woody debris) and support species characteristic of the region. Within degraded natural ecosystems, common forest types may provide refuge for species at risk (e.g., Red-legged Frog). With good stewardship, strategically located younger forests represent an opportunity to "re-connect" isolated habitats and re-establish interior forest conditions in key areas. Over the long term, these younger stands can develop into part of the old-growth forest network of the future.

INFORMATION GAPS

- Additional background information should be collected to identify the size, condition, ownership of, and threats to remaining tracts of second-growth Douglas-fir forest in the lower part of the Nanaimo River Valley.
- The condition of remaining Garry Oak ecosystems in the watershed should be assessed to determine if there are any priority areas for invasive plant control.
- Potential sites where Garry Oak ecosystem restoration might be feasible within the watershed should be investigated, including existing protected areas and privately owned lands.
- Ground verification of the handful of bog ecosystems in the watersheds is recommended as the first step in developing Stewardship Plans for them.
- Hardcopy maps from the SEI re-digitizing project should be obtained and reviewed in order to determine which wetland units have been impacted in the watershed and which may be at risk. Such a study may permit a more targeted campaign to be launched for protecting sensitive wetlands within and near agricultural areas.
- A detailed spatial analysis of existing Broad Terrestrial Ecosystem mapping should be conducted to gain a clearer understanding of the relative contribution of each general ecosystem type to the Nanaimo River watershed.

REFERENCES

1. Green, R.N. and K. Klinka. 1994. A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region, B.C. Ministry of Forests, Burnaby. 285pp.
2. Nuszdorfer, F.c., K.L. Nuszdorfer, A.M. Scagel, K. Klinka, T. Lewis, and R.N. Green. 1994. Biogeoclimatic Units of the Vancouver Forest Region; Map Sheet 5 of 6 – Southern Vancouver Island and Sunshine Coast. Province of British Columbia. Ministry of Forests Research Branch, Scale 1: 250,000.
3. Resources Inventory Committee. 1998. Classification and Correlation of the Broad Habitat Classes Used in 1:250,000 Ecological Mapping. Ecosystems Working Group. Province of B.C. Victoria.
4. Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth and C. Cadrin. 1998. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands, 1993-1997. Volume 1: Methodology, Ecological Descriptions and Results. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.
5. Berris. C. 2006. Nanaimo Estuary Management Plan. Report Prepared for Nanaimo River Estuary Steering Committee by Catherine Berris Associates Inc. 81 pp. + appendices.
6. AXYS Environmental Consulting Ltd. 2005. *Re-digitizing of Sensitive Ecosystems Inventory Polygons to Exclude Disturbed Areas – Summary Report.* Report prepared for Canadian Wildlife Service by AXYS Environmental Consulting Ltd. 27pp.

SPECIES AT RISK

JOE MATERI, R.P. BIO.

TALES FROM THE RIVER……

"We found marmots in the high mountains south of Alberni, and nowhere else. In the more open portions of the King Solomon Basin, and the surrounding peaks and ridges [near the Nanaimo River headwaters] they were fairly abundant, but we met with them at no other point, nor could we learn of their presence in other parts of Vancouver Island. Of course the greater part of the island… is a wilderness of forest and glacier-covered mountains, of which very little is known, and the species may possibly be found elsewhere, but the summer's investigations proved at least that it does not occur in all apparently suitable localities…The marmots had established themselves, burrowing under the rocks, and apparently never wandering far from home".

Excerpt from 1912 Publication "Report on a Collection of Birds and Mammals from Vancouver Island" by Harry Swarth (1).

Overview

The Nanaimo River watershed supports a range of flora and fauna that are considered provincially "at-risk". Some of these are ranked by the B.C. Conservation Data Centre (CDC) as critically imperiled (or Red-listed), while others are ranked as threatened or vulnerable (i.e. Blue-listed).

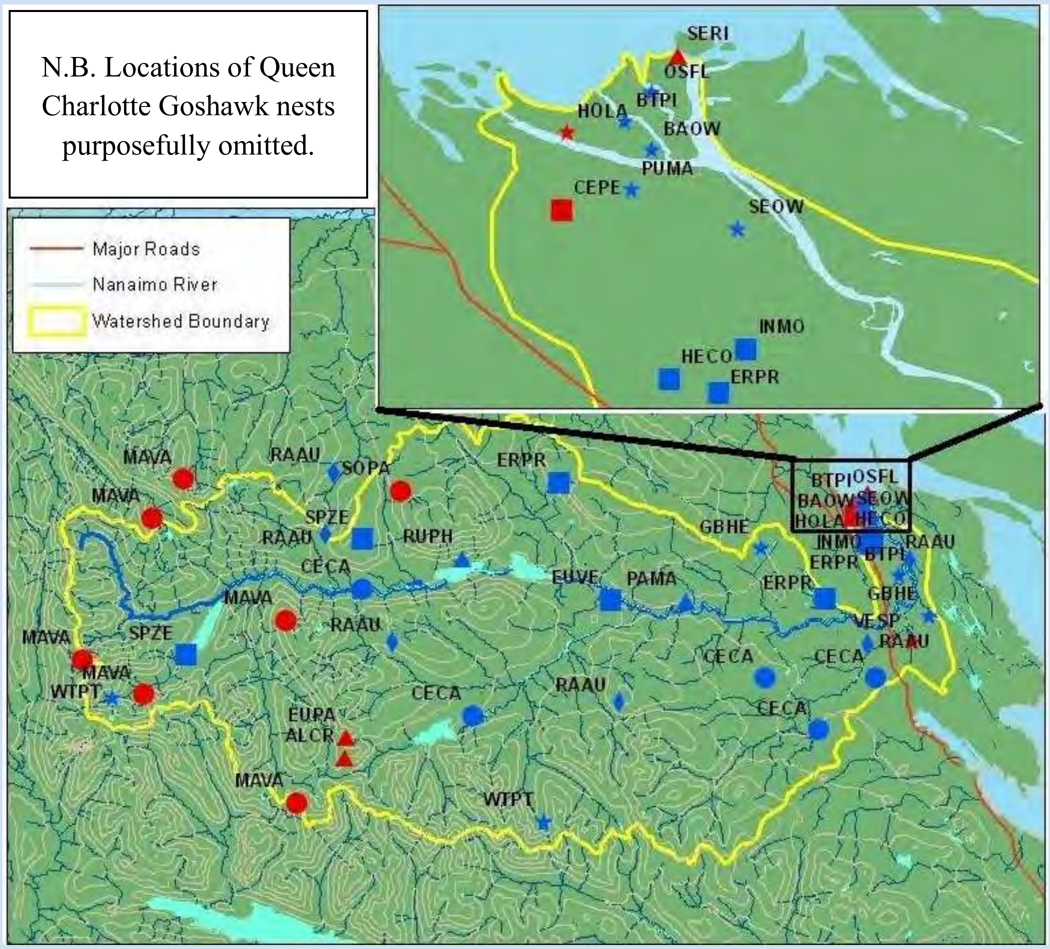
Red-listed mammals

Occurrence records exist for three Red-listed mammals within the Nanaimo River watershed. Of these, the Vancouver Island subspecies of **Wolverine** (*Gulo gulo vancouverensis)* has not been seen in the watershed since the 1970's (2). The **Vancouver Island Marmot** (*Marmota vancouverensis*) still occurs on Green Mountain, Butler Peak, and Mount Hooper within the watershed, typically on steep, warm-aspect slopes with lush forbs (3). Forming the core of the southern marmot population, the Nanaimo area currently supports between 100 and 150 individuals (4). A third Red-listed mammal, a subspecies of the **American Water Shrew** (*Sorex palustris brooksi*), is known to occur in the upper reaches of Dash Creek, just past Second Lake (5). This rare insectivore frequents stream and wetland margins, favouring fast-flowing streams where boulders and woody debris are abundant (6).

Blue-listed mammals

The Nanaimo River watershed is an important area for **Roosevelt Elk** (*Cervus canadensis roosevelti*), a Blue-listed subspecies whose distribution in B.C. is restricted to Vancouver Island and the adjacent coastal Mainland. Elk in the Nanaimo River watershed form a major part of the South Island Meta-population. Resident herd strength here is currently over 300 animals, with about 200 in the northern part of the watershed (MOE Sub-Unit 5-4), 80+ in the South Fork area (MOE Sub-unit 5-3; MOE file data), and small numbers across the middle-to-lower parts of the valley (7, 8).

Figure 1: Distribution of documented locations for Species at Risk in the Nanaimo River Watershed from government sources and gray literature.



Legend

Circle = Mammal Star = Bird Triangle = Plant Diamond = Amphibian Square = Butterfly

Red Symbol = Red-listed Species Blue Symbol = Blue-listed Species

Species Codes

RAAU	**= Red-legged Frog**	**SPZE**	**= Bremner's Fritillary Butterfly**
GBHE	**= Great Blue Heron**	**CEPE**	**= Common Wood-nymph Butterfly**
WTPT	**= White-tailed Ptarmigan**	**EUVE**	**= Dun Skipper**
NOGO	**= Queen Charlotte Goshawk**	**ERPR**	**= Propertius Duskywing Butterfly**
PUMA	**= Purple Martin**	**HECO**	**= Western Branded Skipper**
VESP	**= Vesper Sparrow**	**INMO**	**= Moss' Elfin Butterfly**
BTPI	**= Band-tailed Pigeon**		
WEME	**= Western Meadowlark**	**PAMA**	**= Macoun's Groundsel**
BASW	**= Barn Swallow**	**ALCR**	**= Olympic Onion**
SEOW	**= Short-eared Owl**	**EUPA**	**= Olympic Mountain Aster**
HOLA	**= Horned Lark**	**SERI**	**= White-top Aster**
BAOW	**= Barn Owl**	**RUPH**	**= California-tea**
OSFL	**= Olive-sided Flycatcher**	**CAFÉ**	**= Green-sheathed Sedge**
SOPA	**= American Water Shrew**		
CECA	**= Roosevelt Elk**		
MAVA	**= Vancouver Island Marmot**		

In recent years, elk numbers have been increasing in the northern and central parts of the watershed, as forest in these areas has been harvested. Numbers have remained fairly stable in the South Fork area, where little logging activity has occurred over the past few years (9).

Blue-listed amphibians

A Blue-listed amphibian, the **Northern Red-legged Frog** (*Rana aurora*) appears widely distributed across the Nanaimo River watershed (Figure 1). Local occurrence records for this frog range from approximately 20 m at Thatcher Creek to 370 m elevation at Dunsmiur Creek. Wind (2008) found that most breeding ponds for Red-legged Frogs in this valley are fairly small, between 100 m^2 and 500 m^2 in surface area (10).

Red-listed birds

According to information posted on the Georgia Basin Ecological Assessment and Restoration Society (GBEARS) website, Red-listed **Marbled Murrelets** (*Brachyramphus marmoratus*) were present and nesting in small patches of remnant old-growth forest along the South Nanaimo River in 1998-99 (11). At that time, at least 200 breeding birds were observed feeding in near shore waters off Nanaimo. A radio-tagging study of this species, carried out by the Simon Fraser University's Marbled Murrelet Recovery Team with assistance from GBEARS, found some nesting adults crossed between the east and west coasts of Vancouver Island on a regular basis. Adult murrelets typically forage in marine waters and bring fish to young in nests several times per day. Most often, they build their nests on mossy branches of old coniferous trees (12).

Rare woodland hawks known as **Queen Charlotte Goshawks** (*Accipiter gentilis laingi*) nested in the central part of the Nanaimo River Valley in the late 1990's (5) but the current status of the single nest there is unknown. Goshawks have been reported hunting near the estuary (13).

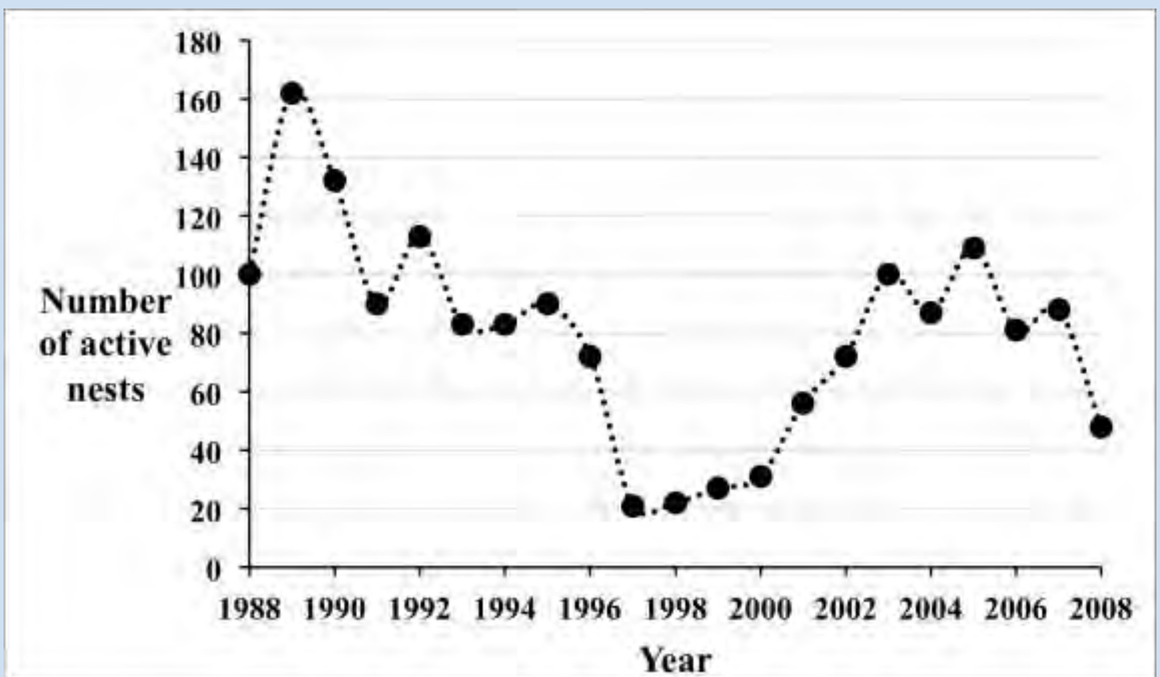
Recent records exist for several Red-listed migratory birds in the Nanaimo River watershed. All observations come from the lower part of the valley, with a few that are largely confined to the estuary. Five to ten Red-listed **Vesper Sparrows** (*Pooecetes gramineus affinis*) nest in dry grassland habitats around the Cassidy Airport, and are sometimes seen at the Nanaimo River

Estuary (14). Near tidewater, non-breeding **Western Meadowlarks** (*Sturnella neglecta*) and **Horned Larks** (*Eremophilia alpestris strigata*), both Red-listed species, have been observed at the estuary in recent years (13), but neither is expected to nest there.

Blue-listed birds

Records exist for the resident Blue-listed **White-tailed Ptarmigan** (*Lagopus leucura saxatilis*) on Mt. Hooper and Mt. Whymper dating from 1980, but no more recent records were found in the CDC database. Blue-listed **Great Blue Herons** (*Ardea herodius fannini*) have historically nested in the lower parts of the watershed, typically within easy flying distance (<10 km) of important feeding areas around the Nanaimo River Estuary (15). Historically, small heron colonies existed near Cedar Road and Whiskey Lake within the watershed. Larger colonies were found near Holden and Quennel Lakes just outside the watershed (Figure 1) (16). There are currently no known active nests in the watershed. Ministry of Environment (MOE) files show the number of active heron nests supported by the Nanaimo River Estuary has ranged from 21 to 162 over the past two decades (Figure 2). The most recent data (2008) place heron nest numbers in the lower part of that range, with 48 active nests.

Figure 2: long-term nesting trends of Great Blue Heron close to the Nanaimo River Estuary.



The Blue-listed **Barn Owl** (*Tyto alba)* has been observed in open areas surrounding the estuary (13). This species has recently been reported roosting at a blueberry farm in Yellow Point, a few kilometers south of the estuary.

The Blue-listed **Purple Martin** (*Progne subis*) and **Barn Swallow** (*Hirundo rustica*) nest at the Nanaimo River Estuary. In the early 1900's, the former was noted "in considerable numbers" around Nanaimo (1). Purple Martin numbers were very low in Nanaimo between the 1950's and 1995 (17). Since 1995, the number of active nests at the Nanaimo River Estuary has increased from 5 to 13, due largely to the installation of artificial nest boxes (18).

Blue-listed **Band-tailed Pigeons** (*Patagioenas fasciata*) are reported by local birders at Morden Colliery Provincial Park and the Nanaimo River Estuary. They are known to nest at the latter (13). Another Blue-listed passerine, the **Olive-sided Flycatcher** (*Contopus cooperi*) has been recorded in forests near the estuary (13). This species, which reaches its highest densities in the Georgia Depression, is expected to nest in pockets of mature forest throughout the watershed. In addition to the above, small numbers of Blue-listed **Short-eared Owls** (*Asio flammeus*) regularly over-winter at the Nanaimo River Estuary, where their rodent prey is abundant.

Listed Invertebrates

Six rare butterflies have been documented within the Nanaimo River watershed, but recent records exist for only three; the Red-listed **Common Wood-nymph** (*Cercyonis pegala incana*) and Blue-listed **Propertius Duskywing** (*Erynnis propertius*) and **Moss' Elfin** (*Incisalia mossii mossii*). Recent records for the three species are located near the mouth of the Nanaimo River (13, 19). The Blue-listed **Western Brander Skipper** (*Hesperia comma oregonia*) has historically occurred near the mouth of the river as well. Historic records for the Blue-listed **Bremner's Fritillary** (*Speyeria zerene bremnerii*) and **Dun Skipper** (*Euphyes vestries*) are distributed across the central and upper parts of the Nanaimo River Valley (20). The Dun Skipper was found mid-valley in the late 1980's but apparently disappeared by the mid-1990's.

Listed Plants

Several rare vascular plants have been noted by the CDC within the Nanaimo River watershed. Rare plant occurrence records are scattered across the watershed, extending from the mouth of the river up into the subalpine zone. At the Nanaimo River Estuary, there are both recent and historical records for the Red-listed **White-top Aster** (*Sericarpus rigidus*), while at the Haley Lake Ecological Reserve both the Red-listed **Olympic Onion** (*Allium crenulatum*) and Blue-listed **Olympic Mountain Aster** (*Eucephalus paucicapitatus*) have been recorded. In between, Blue-listed **California-tea** (*Rupertia physodes*) has been found in dry forest above Second Lake, while the Red-listed **Green-sheathed Sedge** (*Carex feta*) has been found on outcrops above the Nanaimo River (near Stark Creek). Along the middle part of the valley, a Blue-listed plant of dry open forests exists, known as **Macoun's Groundsel** (*Packera macounii*) (5).

STAKEHOLDERS

The **BC Ministry of Environment**, Environmental Stewardship Division, has the lead role in managing Species at Risk. They plan and conduct inventories for Species at Risk, carry out research on "at-risk" taxa, and disseminate information through status reports, online databases, and other publications. Other important stakeholders are discussed briefly below:

- **BC Ministry of Forests, Lands, and Natural Resource Operations**: manages forest harvest on Crown Lands, and is responsible for wildlife and habitat management.
- **Forest Companies**: two forest companies, Island Timberlands and Timber West hold title to large tracts of land in the central and upper parts of the Nanaimo River watershed. The Private Forest Land Act allows the government to identify critical wildlife habitat on private lands, and encourages agreements with the Province to protect critical habitats. Private timberlands are not subject to the Forest and Range Practices Act or the Identified Wildlife Management Strategy.
- **The Nature Trust of B.C.**: holds title to conservation lands for migratory birds near the head of the Nanaimo River Estuary. This organization's mandate is to protect ecologically sensitive habitat throughout the province. The estuary land is leased to the Ministry of Environment (MOE) and is managed by it.
- **The Land Conservancy of Canada:** holds title to 56 hectares of conservation lands within the Nanaimo River Regional Park.

- **Snuneymuxw First Nation**: The Snuneymuxw First Nation has four of its six reserves located near the Nanaimo River Estuary. Any works on Reserve lands are subject to the federal Species at Risk Act.
- **NavCanada**: this federal agency is responsible for management and operation of the Collishaw Airport in Cassidy, where Vesper Sparrows are known to nest. Any works on NavCanada lands are subject to the federal Species At Risk Act.
- **Regional District of Nanaimo**: the RDN Parks and Recreation Department operates and maintains two leased properties in the lower part of the Nanaimo River Valley supporting species at risk; Nanaimo River Regional Park and the Morden Colliery Trail.
- **Other Private Landholders**: smaller private landholders, particularly those owning property adjacent to the Nanaimo River, have properties that may supporting rare or threatened species.

RISK AND IMPACTS

Impacts to Species at Risk present in the Nanaimo River watershed vary widely in severity.

- Forest harvesting near Vancouver Island Marmot colonies had a severely negative impact. Marmots declined drastically in this watershed over the 1980's as a result of their attraction to cut-over areas. Natural predation rates were high in these areas, and herb-dominated cover quickly gave way to trees (21).
- Human activities in the watershed have likely had only a minor impact on American Water Shrews, as this species was likely never abundant on Vancouver Island.
- Early valley-bottom logging boosted forage production for wintering Roosevelt Elk within the watershed, benefiting them while high-quality snow interception and security cover were still abundant. As industrial forestry progressed more rapidly up the valley, it is possible that elk were negatively impacted for a time, as tracts of early successional forest replaced older cut-over areas, and new clearings became more distant from forest edges.
- Northern Red-legged Frogs are still widely distributed and fairly abundant in the watershed. However, the species is currently threatened by cumulative permanent losses of wetland habitats (particularly small wetlands) and forested non-breeding habitat, decreased habitat connectivity, and traffic-related mortality.
- It is believed the Nanaimo-area Purple Martin population declined in the 1940's due mainly to changes in building construction which had previously provided nesting habitat (17). In more recent decades, the removal and natural decay of marine pilings further reduced nesting opportunities. Fortunately, local populations have adapted to artificial nesting structures located in natural or naturalized settings.

- Queen Charlotte Goshawks require large tracts of mature forest for raising young, and have a high degree of nest site fidelity (12). As a result, goshawks in the watershed have likely been negatively impacted by logging of old-growth and mature second-growth forest, and by competition with other raptors better adapted to the resulting forest mosaic. The permeation of logging roads into dense forest has made nesting goshawks more vulnerable to disturbance during the nesting season.
- Nesting habitats for the Great Blue Heron in the watershed have declined as a result of the conversion of forest to other land uses including: residential, industrial and agricultural developments. Increased human presence during the breeding season has likely also had a negative impact on nesting success for this sensitive species. In recent years, the declines have apparently been exacerbated by eagle predation on young herons (16).
- In previous years, vegetation maintenance around the Cassidy Airport probably impacted some Vesper Sparrows nesting in the extensive dry grasslands around it. Since 2003, a species-specific stewardship plan has been implemented there to maintain nesting habitat, limit pesticide use, and control invasive vegetation (22).
- In recent years, several members of the birding community have remarked that over-zealous birders and photographers are disturbing wintering Short-eared Owls on the Nanaimo River Estuary. The resulting impact on the owl's hunting success may be affecting winter survival and breeding season productivity.
- By and large, alpine habitats on Vancouver Island are not threatened by the same forces affecting productive forest land and lowland areas (12). As a result, human impacts on the White-tailed Ptarmigan and rare alpine plants in the Nanaimo River watershed have probably not been significant.
- Rare butterflies in this watershed and elsewhere in the region have been impacted by a number of factors. Development of open lowlands and dry semi-open forest types has led to the disappearance of food plants for adults and larvae. The proliferation of Scotch Broom has had a severe impact on the previously open natural meadows used by butterflies. Habitat fragmentation has limited the ability of butterfly populations to recolonize sub-optimal habitats during years of good butterfly reproduction (23).

OPPORTUNITIES

While managing Species at Risk is largely the responsibility of provincial and federal government agencies, there are several opportunities to improve stewardship of this group, including:

- Prioritizing land acquisitions with a high potential to support species at risk (e.g. Garry Oak meadows, wetland/riparian habitats, and open Douglas-fir forest);
- Landowner contact and education promoting the importance of protecting smaller natural wetlands and adjacent forest;
- Scotch Broom removal parties focusing on patches in dry, open forest and woodlands within protected areas;
- Development of viewing/photography guidelines and signage to minimize wildlife disturbance to sensitive species at the Nanaimo River Estuary;
- Advocating for a regional conservation strategy that protects movement and dispersal corridors for Roosevelt Elk and other forest-dependent species with large home ranges. Increased conflict between land development and elk may be an emerging issue, particularly on the west side of the TransCanada Highway.

INFORMATION GAPS

There are a number of challenges associated with managing Species at Risk, not the least of which is that a complete picture of where they occur and what they require to thrive is often lacking. Inventory for rare species can be time-consuming, require specialist expertise, and have unintended negative consequences (e.g. unintentionally killing water shrews during live trapping). In the case of the Nanaimo River watershed, there are several threatened or endangered species where that knowledge gap is closing. In recent years, important studies documenting bird use of the Nanaimo River Estuary (13), amphibian use of the South Fork area (10), and rare butterfly occurrence (24) have been completed.

For several "at-risk" taxa, recovery teams have already been formed to research and implement stewardship plans (e.g., Vancouver Island Marmot, Vesper Sparrow, and Purple Martin). In others, major landholders are co-operating with government agencies to integrate habitat management for Species at Risk into operational planning (e.g., Roosevelt Elk and Queen Charlotte Goshawk). Nevertheless, there are a number of rare species/groups where significant information gaps still exist due to limited resources. A list of actions to aid in the addressing data gaps follows:

- Given the significant threats to locally nesting Great Blue Herons, and the downward trend in nesting activity, nest inventory and closer monitoring of nests within a 10 km radius of the estuary is recommended. The profile of the species could be raised through landowner notification and education.

- A Red-legged Frog study focusing on the lower part of the Nanaimo River watershed, where land development is more concentrated, is recommended. The study should attempt to document breeding areas, identify adjacent core forest habitats, and discuss traffic-related mortality/habitat connectivity issues.
- Information on the status of the Queen Charlotte Goshawk in the central and upper parts of the watershed does not appear to have been updated for approximately 10 years. Call-playback surveys following Resources Inventory Committee Standards would help to clarify the current status of this species.
- Rare plant information for the watershed is considerably out-of-date. Inventory to confirm the occurrence of plants in historic locations along with targeted searches in new locations is recommended.
- Information on the occurrence of rare snails, fungi, lichens and mosses in the watershed appears to be largely lacking. Inventory should be considered for existing and planned protected areas within the watershed.

REFERENCES

Literature Cited

1. Swarth, H.S. 1912. *Report on a Collection of Birds and Mammals from Vancouver Island*. University of California Publications in Zoology. Vol. 10: No.1, 124pp.

2. Banci, V.A. 1982. The Wolverine in British Columbia: Distribution, Methods of Determining Age and Status of Gulo gulo vancouverensis. Research Branch Ministries of Environment and Forests. IWIFR-15. Victoria , B.C. 90pp.

3. Bryant, A.A. and Janz, D. 1996. Distribution and Abundance of Vancouver Island Marmots (Marmota vancouverensis). Canadian Journal of Zoology 74: 667-677.

4. Marmot Recovery Foundation, 2009. *Meta-population Groups Reduce Risks.* Marmoteer Issue 24, Fall 2009.

5. Conservation Data Centre. 2011. Rare Element Mapped Known Occurrences. B.C. Ministry of Environment. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Jun. 7, 2011).

6. Cannings, S.G., L.R. Ramsay, D.F. Fraser, and M. Fraker. 1999. *Rare Amphibians, Reptiles, and Mammals of British Columbia.* Wildlife Branch & Resources Inventory Branch, Ministry of Environment, Lands, & Parks, Victoria, BC. 198pp.

7. Materi, J. and R. Dolighan. 2002. *Assessment of McKay Lake and Haslam Creek Elk Winter Range Units, Arrowsmith Timber Supply Area.* Report Prepared for Ministry of Forests, South Island Forest District. 27pp. + appendices.

8. Blood, D.A. 2002. *Proposed Timberlands Road Gravel Pit: Assessment of the Natural Environment.* Report prepared for Woodridge Holdings Ltd. By D.A. Blood and Associates Ltd. 12pp. + appendices.

9. Brunt. K., June 2011, personal communication. Senior Wildlife Biologist, Region 1, B.C. Ministry of Environment, E-mail: kbrunt@gov.bc.ca.

10. Wind, E. 2008. Amphibians as Indicators of Wetland Habitat Conservation under Variable Retention Harvesting. Report prepared for Western Forest Products. 12pp.

11. Georgia Basin Ecosystem Assessment and Recovery Society. 2011. *GBEARS Projects: Marbled Murrelet*. http://www.georgiabasin.ca/mamu.htm (accessed July 29, 2011).

12. Fraser, D.L., W.L. Harper, S.G. Cannings, and J.M. Cooper.1999. *Rare Birds of British Columbia.* Wildlife Branch and Resources Inventory Branch, B.C. Ministry of Environment, Lands and Parks, Victoria, B.C., 244pp.

13. Berris. C. 2006. *Nanaimo Estuary Management Plan.* Report Prepared for Nanaimo River Estuary Steering Committee by Catherine Berris Associates Inc. 81 pp. + appendices.

14. Beauchesne, S.M. 2002. *Coastal Vesper Sparrow Stewardship Account.* Report prepared for the Vertebrates at Risk Recovery Action Group of the Garry Oak Ecosystems Recovery Team. 16pp.

15. Chatwin. T., June 2011, personal communication. Species-At-Risk Biologist, Region 1, B.C. Ministry of Environment, E-mail: tchatwin@gov.bc.ca

16. Gebauer, M.B. and I.E. Moul. 2001. *Status of the Great Blue Heron in British Columbia.* Ministry of Environment, Victoria, B.C. Wildlf. Working Rept. No. WR-102. 66pp.

17. Fraser, D.L., C. Siddle, D. Copely and E. Walters. 1997. *Status of the Purple Martin in British Columbia*. B.C. Ministry of Environment, Lands, and Parks. Wildlife Branch. Victoria. Wildlife Working Report WR-89.

18. Cousens, B., June 2011, personal communication. Georgia Basin Ecological Assessment and Restoration Society E-mail: pmartins@island.net

19. Garry Oak Ecosystems Recovery Team. 2011. *Species at Risk: Vertebrates, Butterflies & Plants*. http://www.goert.ca/pubs_at_risk.php (accessed June 13, 2011).

20. Royal BC Museum. 2011. *E-Fauna of BC.* http://www.geog.ubc.ca/biodiversity/efauna/ (accessed June 23, 2011).

21. Bryant, A.A., and R.E. Page. 2005. Timing and Causes of Mortality in the Endangered Vancouver Island Marmot (Marmota vancouverensis). Canadian Journal of Zoology. 83: 674-682.

22. COSEWIC. 2006. COSEWIC Assessment and Status Report on the Vesper Sparrow affinis subspecies Pooecetes gramineus affinis in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 pp.

23. Baron, N. and F. Backhouse. 1999. *Rare Butterflies of Southern Vancouver Island and the Gulf Islands.* BC Ministry of Environment, Lands and Parks Brochure.5pp.

24. Lilley, P., N.Page, and J. Heron. 2009. *Surveys for Taylor's Checkerspot and Other Butterfly Species at Risk on Southeastern Vancouver Island (2009)*. Report prepared for B.C. Ministry of Environment by Raincoast Applied Ecology. 16pp. + appendices.

Wildlife and Terrestrial Habitat

Joe Materi, RP Bio.

Tales from the River……

"I've been spending time in the Nanaimo River Valley since I was a baby. My parents had a cabin in the bush above First Lake and later one back along Deadwood Creek. I grew up camping and fishing in that valley, and later hunting with my dad. There were lots of deer around when I was young. The deer numbers dropped off quite a bit when wolves moved into the valley sometime in the early 80's. I didn't see the wolves very often, but I did see a couple from time to time…some friends saw packs of wolves. I remember there were always lots of bears in the valley, probably helped out by all the logging that was going on. You'd see bears feeding along most of the logging roads in the springtime. At least that hasn't changed much over the years."

Ted Barsby Jr.,

Nanaimo Fish and Game Protective Association

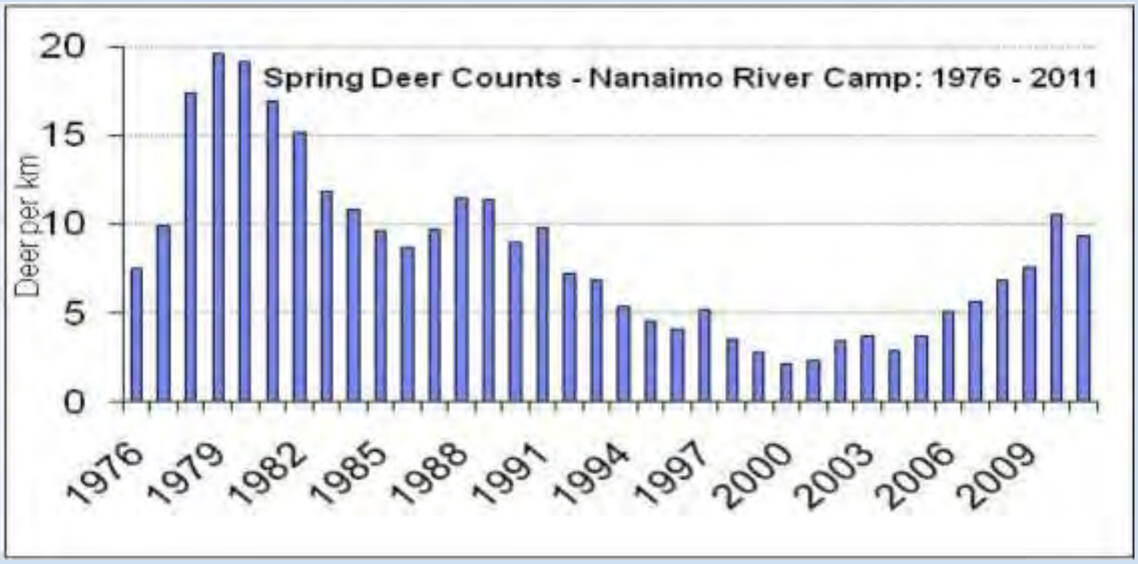
OVERVIEW

Stretching across some 750 km^2 (75,000 hectares) of forests, fields, and wetlands, the Nanaimo River watershed supports a wealth of wildlife. A large suite of mammals are represented here including: ungulates, large carnivores, mustelids (weasel family members), rodents, and insectivores. Many of the large and wide-ranging mammals that occur in the watershed make use of the main valley and tributary valleys as movement and dispersal corridors, as do some smaller forest-dependent amphibians.

Both of Vancouver Island's ungulate species, the Black-tailed Deer and Roosevelt Elk, occur in the watershed. Much of the western part of the watershed is in the Moderate Snowpack Zone (1). In this zone, snowfall accumulations that threaten ungulate survival occur at 5 to 15 year intervals, on average. The lower part of the valley is in the Shallow Snowpack Zone, where snowfall rarely affects winter survival. Columbian Black-tailed Deer are generally plentiful in the eastern part of Vancouver Island (2), occurring in forests of various ages. Spring deer count data from Management Sub-unit 5-4, covering the northern part of the watershed, suggest deer numbers have rebounded from an historic low occurring around the year 2000. Still, deer only appear to be about half as abundant currently as during the late 1970's (Figure 1). Herds of Roosevelt Elk, a Blue-listed subspecies associated with forest edges, wetlands, and riparian forest, are currently fairly stable, numbering around 300 in the watershed. Elk are mostly found in the upper half of the watershed, but a few range down to areas near the TransCanada Highway. There are two government-designated elk winter ranges in the central part of the watershed, one near Haslam Creek and another near McKay Lake.

Large carnivores are relatively abundant within the Nanaimo River watershed. The mix of wetlands, riparian areas, forest patches, and forest clearings provide optimal habitat for Black Bears. Typically on Vancouver Island, bears reach densities of 1 bear for every 5 to 10 km^2 (3), which would extrapolate to a watershed population of 75 to 150 bears. The availability of spawned-out salmon in streamside areas up to Second Lake provides much-needed source of food in the autumn before bears hibernate. Over the past two decades, the annual Black Bear harvest in Management Unit 1-5 has ranged from 18 to 76 individuals (4). About one-third of these (6 to 25 bears) would be expected to come from the three Sub-units comprising the Nanaimo River watershed.

Figure 1: long-term trends in Black-tailed deer abundance.



Wide-ranging Cougars occur regularly within the Nanaimo River watershed, attracted by the presence of deer and elk. Research in nearby Northwest Bay found that individual cougars require 26 to 65 km^2 (5), which produces an estimated watershed population of about 10 to 30 cougars. There have been cougar sightings from the Nanaimo River Estuary to First Lake in recent years (Table 1). Cougars undoubtedly also occur in the high country near the headwaters of the Nanaimo River. Since 1990, the annual Cougar harvest in Management Unit 1-5 has ranged from 1 to 11 individuals (4). Between one and four of these cougars would be expected to come from the Nanaimo River watershed each year. On Vancouver Island, Grey Wolves occur at densities in the range of one wolf per 50 to 150 km^2. Wolves travel widely in search of ungulate prey, covering 20 km to 30 km each day, on average. This suggests wolves would pass through the Nanaimo River watershed and adjacent watersheds on a regular basis.

Several mustelids (members of the weasel family) are strongly associated with habitats present in the Nanaimo River watershed. Most mustelids are wide-ranging, and some are largely nocturnal, making direct observations of them difficult. Mink and River Otter have been recorded along both freshwater and marine shorelines within the watershed. Marten have been noted near the Nanaimo River Estuary (6), but they are usually associated with mature coniferous cover having abundant downed logs and high surface complexity. They are expected to occur at low densities in the larger remaining patches of mature forest within the watershed.

Six species of rodents have been documented within the Nanaimo River watershed including the Vancouver Island Marmot, American Beaver, Common Muskrat, Red Squirrel, Deer Mouse, and Townsend's Vole. The rare Vancouver Island Marmot is restricted to Green Mountain and a few neighbouring peaks. Marmots are discussed in more detail in the Species at Risk chapter of this report. Beavers are widely distributed across the watershed, from Thatcher Creek in the east to Healy and Shelton Lakes in the west. Some beavers, usually adult males, have created dens by tunneling into the banks of the swift-flowing Nanaimo River. Although capable of overland travel, the highly aquatic Common Muskrat is closely associated with marsh habitats, with a preference for those well-stocked with cattail and bulrushes. Wetland complexes near Jump Lake, North Nanaimo Creek, Third Lake and the estuary appear to be the best-suited areas within the watershed for this species. Townsend's Voles have an affinity for herb-dominated habitats that are flooded including marshes, swamps, abandoned pastureland, and the estuary while Deer Mice are habitat generalists.

Four species of bats have been recorded near the Nanaimo River Estuary in recent years (6), however, little is known about their distribution across the watershed.

The Eastern Cottontail was introduced to the Metchosin area of Vancouver Island in 1964 and it arrived in the Nanaimo River watershed in 1983 (13). Since then, populations have likely grown and spread along roads and other clearings to inhabit many areas of the valley bottomlands. This rabbit prefers brushy riparian areas where food is abundant, but can be expected almost anywhere significant shrub and herb cover is present.

Two species of insectivore have been documented in the Nanaimo River watershed; the Vagrant Shrew and the American Water Shrew. The former is a common species that is associated with moist forested habitats, while the latter is a rare species that is closely tied to stream environments.

In addition to mammals, the Nanaimo River watershed supports nesting by several birds of prey (Figure 2). In the lower half of the watershed, there are records for eight Bald Eagle nests along the Nanaimo River, and another seven along Biggs Park/Jack Point (14). Allowing that some of these are alternate nests used by a breeding pair, this area appears to support at least six breeding pairs of Bald Eagles. At the opposite end of the watershed, there are two known Golden Eagle nests, a typical one on a rocky ridge on Tangle Mountain, and an unusual tree nest on the southern slope of Mount De Cosmos (12).

A nest of the rare Queen Charlotte Goshawk, a large woodland hawk, was found in the late 1990's near the middle reaches of the Nanaimo River, but the current status of this nest is not known. A number of other woodland hawks and falcons have been observed in the watershed during the breeding season including the Cooper's Hawk, Sharp-shinned Hawk, and Merlin. These raptors typically have heavily concealed nests which are difficult to locate, and no nest records were found for these species. Tall deciduous trees are commonly seen along the margins of agricultural fields in the lower Nanaimo River Valley appear attractive for nesting Red-tailed Hawks, but no nests of this species have been documented in the watershed. At least one pair of Red-tailed Hawks is suspected of nesting in the Cassidy area.

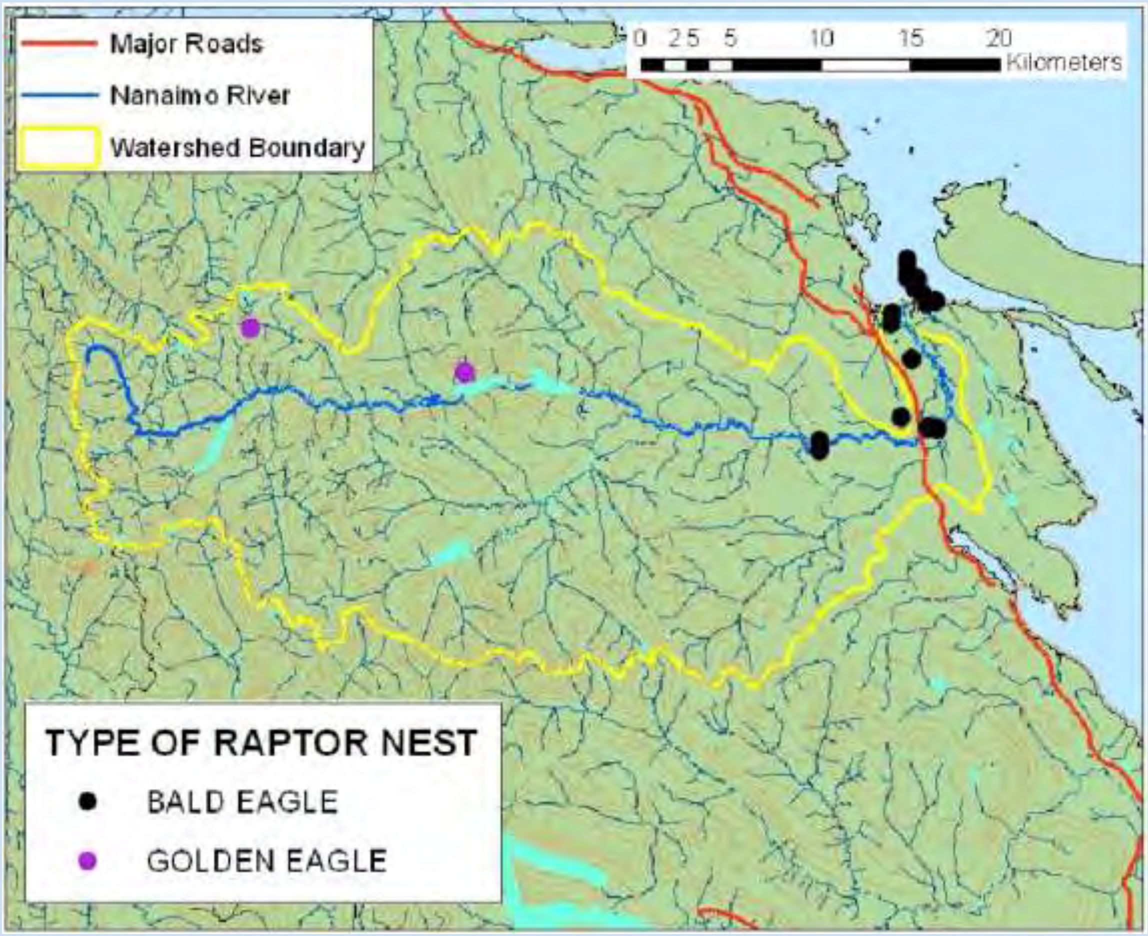
Records of owls appear on local birding websites for areas within or near the watershed. Owl species mentioned include the: Great Horned Owl, Barred Owl, Western Screech-owl, Northern Saw-whet Owl and Northern Pygmy-owl. While all but the two latter species are considered resident, no documented nesting locations are known for this group in the watershed. Barn-owls are sometimes seen at the Nanaimo River Estuary, and in the nearby Yellow Point area. One Barn Owl has recently been reported to roost at a blueberry farm near Michael Lake, just east of the watershed boundary (15).

With its abundant wetlands and moist forests, the Nanaimo River watershed has the full complement of native amphibians occurring on Vancouver Island. Common pond-breeding amphibians include the Pacific Treefrog, Rough-skinned Newt, and Long-toed Salamander. The Red-legged Frog, Western Toad, and Northwestern Salamander have more stringent breeding habitat requirements, limiting their distribution to some extent. Two introduced pond-breeders also occur in the watershed. The American Bullfrog is common in wetlands of the lower Nanaimo River Valley, while the Green Frog is known from one location at the Nanaimo Area Land Trust's native plant nursery. Occurrence records for three entirely terrestrial salamanders were found in the Royal BC Museum Guide for amphibians; the Western Red-backed Salamander, Wandering Salamander, and Ensatina (16).

Table 1: Summary of recent mammal observations from the Nanaimo River Watershed.

Species	Source(s)	Comments
Cougar	Berris (2006) (6) C. Davies (pers. comm.) (7)	G. Monty observation at estuary. Seen near First Lake
Black Bear	K. Brunt (pers. comm.) (8)	Sign common in forested areas.
Grey Wolf	D. Blood (2002) (9)	Southwest of Cassidy, river likely a travel corridor
Roosevelt Elk	K. Brunt (pers. comm.) (8) Blood (2002) (9) Materi (2003) (10)	Most occur in South Fork & Nanaimo River Camp Areas. Sign southwest of Cassidy Sign within Haslam UWR
Black-tailed Deer	K. Brunt (pers. comm.) (8) Materi (2003) (10)	Occur throughout region. Nanaimo R. Camp; Haslam UWR; Nanaimo R. Reg. Park
Marten	Berris (2006) (6)	G. Monty observation at estuary. Low densities in typical forests of Vancouver Island
River Otter	Berris (2006) (6) J. Materi (pers. obs.)	G. Monty & M. Gebauer observations at estuary. Sign near mouth of Thatcher Ck.
Mink	Berris (2006) (6) J. Materi (pers. obs.)	G. Monty observation at estuary. Nanaimo R. Regional Park
Raccoon	Berris (2006) (6)	G. Monty observation at estuary.
American Beaver	T. Barsby (pers. comm.) (11) J. Materi (pers. obs.)	Second, Panther, & Echo Lakes Thatcher Ck.; Lwr. Nanaimo R.
Vanc. Island Marmot	D. Doyle (pers. comm.) (12)	Green Mountain and area
Eastern Cottontail	Blood (2002) (9) J. Materi (pers. obs.)	Southwest of Cassidy Nanaimo R. Regional Park
Red Squirrel	Blood (2002) (9)	Southwest of Cassidy
Muskrat	Berris (2006) (6)	G. Monty observation at estuary; attracted to wetlands with herbaceous emergent vegt.
Townsend's Vole	Blood (2002) (9) Berris (2006) (6)	Southwest of Cassidy G. Monty & M. Gebauer observations at estuary.
Deer Mouse	Blood (2002) (9)	Southwest of Cassidy
American Water Shrew	CDC website	Trapped by D. Lindsay at Dash Creek in 2002; highly aquatic.
Vagrant Shrew	Berris (2006) (6)	G. Monty observation at estuary.

Figure 2: Generalized distribution of documented raptor nests in the Nanaimo River Watershed.



N.B. Queen Charlotte Goshawk nest sites purposefully omitted.

Only a handful of native reptile species have been documented within the watershed, including three species of garter snakes. Despite its name, the Western Terrestrial Garter Snake is often found near aquatic habitats, including the Nanaimo River Estuary. The other two species of garter snakes are common and widespread in the region, and have considerable overlap in habits and habitats. The Northwestern Garter snake is considered more terrestrial than the Common Garter snake (16). One lizard, the Northern Alligator Lizard, is distributed fairly sparsely across the region. It typically occurs in open rocky habitats, often near mature forest patches.

STAKEHOLDERS

As stated on the BC Ministry of Forests, Lands, and Natural Resource Operations website reviewing the BC Wildlife Act:

> "Ownership of all live wildlife (as defined in the *Wildlife Act*) is vested in the government of British Columbia. Ownership has been given to the Crown in legislation so that the government can properly manage and protect British Columbia's wildlife resources in the public interest."

As a result the **BC Ministry of Forests, Lands, and Natural Resource Operations** is the main stakeholder in managing wildlife and habitats within the watershed. However, there are a number of other important stakeholders that are involved in habitat management directly or indirectly, including:

- **Forest Companies**: two forest companies, Island Timberlands and Timber West hold title to large tracts of land in the central and upper parts of the Nanaimo River watershed. The Private Forest Land Act allows the government to identify critical wildlife habitat on private lands, and encourages agreements with the Province to protect critical habitats. Private timberlands are not subject to the Forest and Range Practices Act or the Identified Wildlife Management Strategy.
- **Nanaimo Fish & Game Protective Association**: this organization has been involved in various local conservation projects for decades. It assisted with the purchase of the RDN's Nanaimo River Regional Park, and is currently involved in riparian habitat restoration near the Cassidy Airport. It recently purchased 33 hectares of forest land from Island Timberlands in the watershed, some of which will be re-planted following harvesting.
- **The Nature Trust of B.C.**: holds title to conservation lands for migratory birds near the head of the Nanaimo River Estuary. This organization's mandate is to protect ecologically sensitive habitat throughout the province. The estuary land is leased to and managed by the Ministry of Environment (MOE).
- **The Land Conservancy of B.C.:** holds title to 56 hectares of conservation lands within the Nanaimo River Regional Park.
- **Snuneymuxw First Nation**: The Snuneymuxw First Nation has four of its six reserves located near the Nanaimo River Estuary. Activities on Reserve lands therefore have some potential to affect wildlife using the estuary on a regular or seasonal basis.
- **Regional District of Nanaimo**: the RDN Parks and Recreation Department operates and maintains two nature parks in the lower part of the Nanaimo River Valley; Nanaimo River Regional Park and the Morden Colliery Trail.

- **Other Private Landholders**: smaller private landholders may have properties including important wildlife habitats (e.g., wetlands, riparian forest), key habitat elements (e.g. raptor nests, snags, veteran trees), or providing linkages between important habitats (e.g. forest linking two or wetlands).

RISK AND IMPACTS

Forest harvesting in the upper part of the watershed has likely been detrimental to Sooty Grouse populations. Unlike most birds, this species undergoes migration up-slope in the winter, to feed on coniferous buds and needles. With many summer habitats closing over and many winter habitats lacking suitable food plants, Sooty Grouse populations are likely to stay depressed over the short-to-medium term.

Columbian Black-tailed Deer have general forage and cover requirements that are easily met within the Shallow Snowpack zone. However, harvest of mature timber in the central and upper parts of the watershed has reduced the quantity of deer winter range within the Moderate Snowpack Zone.

Historical forestry activities in the western part of the watershed have mostly been compatible with the persistence of Roosevelt Elk herds. Early forest harvesting created abundant winter forage adjacent to good snow interception and security cover, benefitting elk. However, as large-scale clearings progressed up the valley, winter forage became increasingly distant from suitable forest cover, creating a negative impact on elk. With the exception of riparian forest, special elk habitats such as wetlands, avalanche tracks, and rock outcroppings have been minimally impacted by logging. Road networks, although often gated, have increased the potential for human disturbance and illegal harvest of elk.

Black Bears have generally benefited from decades of new clearings following timber harvest, each producing an abundance of bear forage plants for up to 7 years post-harvest. However, the loss of large diameter trees and snags across industrial forestry areas has reduced the availability of high-quality denning habitat and escape cover.

The preponderance of early- and mid-successional stages in logged-over parts of the watershed has reduced habitat quality for wildlife requiring interior forest conditions, including the Marten, the Queen Charlotte Goshawk, and terrestrial salamanders.

Forest fragmentation through land clearing, roads, and development has isolated some wetlands and reduced natural habitat connections for others, especially in the lower part of the watershed. It has had the largest impact on amphibians, mustelids, and forest songbirds.

The loss of cavity-bearing snags throughout the watershed has reduced habitat quality for a large number of species, but perhaps most significantly for secondary cavity users, which cannot create their own cavities. Species in this category include three small owl species: the Northern Pygmy-owl, Northern Saw-whet Owl, and Western Screech-owl.

In recent years, the widespread removal and/or collapse of abandoned farm buildings in the lower part of the watershed has led to a reduction in Barn Owl nest sites, while the loss /conversion of abandoned pasturelands has reduced habitat for Townsend's Vole, their main prey.

The proliferation of roads across the watershed has likely led to increases in traffic-related wildlife mortality. While a wide range of wildlife is lost to road-kill, native amphibians and reptiles appear to be impacted disproportionately.

OPPORTUNITIES

- Explore opportunities to acquire forested land capable of providing interior forest conditions. As edge effects are generally reduced within a horizontal distance of three full tree lengths from the forest edge, properties adjacent to existing protected/retention areas would provide for proportionately larger areas of interior forest.
- Host a workshop for owners of smaller properties in the watershed who are interested in maintaining or improving biodiversity within their holdings. The workshop could be used to promote a number of concepts including snag, veteran tree, and large woody debris retention, as well as maintaining wetland connectivity.
- Promote the use of conservation covenants to protect and improve habitat connectivity between wetlands and between forest patches.
- Support a nest box program for the lower watershed that would see younger forest patches enhanced for a variety of cavity-dependent birds including woodpeckers, bark-gleaners, and swallows. Ensure boxes are installed well into wooded areas to avoid being used European Starlings.
- Support a program for the lower watershed that would install artificial nesting structures for Barn Owls and Western Screech-owls in appropriate habitats.

INFORMATION GAPS

- A landscape-level analysis focusing on important elements of habitat connectivity (e.g., upland-to-upland, riparian-to-upland, riparian-to-riparian, wetland-to-upland) would be useful to assess the extent of habitat fragmentation within the Nanaimo River watershed. Habitat fragmentation has the potential to impact wide-ranging species requiring movement and dispersal corridors, and those with smaller home ranges that undergo seasonal migrations.
- To facilitate future land acquisitions in the watershed, prepare a database of properties of interest covering: civic address, land type/size, key biophysical attributes, assessed value, proximity to protected areas, and overall ranking.

- Undertake phone interviews in the region to determine the level of public interest in attending a “Biodiversity for Small Properties” workshop and the best time/venue for such a workshop.
- Conduct systematic call-playback surveys for Barn Owls and Western Screech-owls in the watershed to determine priority sites for the installation of artificial nest structures. Review and critique nest structure designs, determine program implementation costs.
- Identify and document amphibian/reptile road-kill “hot-spots” on public roads within the watershed, with a view to approaching the BC Ministry of Transportation and Infrastructure to fund the installation of small wildlife passage facilities.
- Little is known about the status of most inconspicuous-nesting raptors, and some conspicuous-nesting raptors occurring in the watershed. Consideration should be given to multi-species raptor inventory in the lower part of the watershed, where development pressures are most intense.
- As little is known about bat occurrence across the watershed, it is recommended that a systematic inventory for this species group be undertaken.

REFERENCES

Literature Cited

1. Nyberg, J.B. and D.W. Janz. (eds) 1990. *Deer and Elk Habitats in Coastal Forests of Southern British Columbia.* Special Report Series 5, B.C. Ministry of Forests, Research Branch, Victoria. 310 pp.

2. Shackleton, D. 1999. *Hoofed Mammals of British Columbia.* Royal B.C. Museum, Victoria, B.C. 268 pp.

3. British Columbia Fish and Wildlife Branch 1980. Preliminary Black Bear Management for British Columbia. 32 pp.

4. Ministry of Environment file data on black bear and cougar harvest

5. Hatter, I.W. 1982. Predator-ungulate relationships in second growth forests on Vancouver Island. Problem Analysis. Research, Ministries of Environment and Forestry. IWIFR-5. Victoria, B.C. 54 pp.

6. Berris. C. 2006. *Nanaimo Estuary Management Plan.* Report Prepared for Nanaimo River Estuary Steering Committee by Catherine Berris Associates Inc. 81 pp. + appendices.

7. Davies. C. June 2011. former Nanaimo Field Naturalists member, Nanaimo E-mail: cldavies@telus.net

8. Brunt. K. June 2011. Senior Wildlife Biologist, Region 1, B.C. Ministry of Environment, E-mail: kbrunt@gov.bc.ca

9. Blood, D.A. 2002. *Proposed Timberlands Road Gravel Pit: Assessment of the Natural Environment.* Report prepared for Woodridge Holdings Ltd. By D.A. Blood and Associates Ltd. 12pp. + appendices.

10. Materi, J. 2003. *Roosevelt Elk Winter Range Enhancement Demonstration Site: Implementation Planning Report.* Report prepared for Ministry of Water, Land, and Air Protection. Nanaimo. 20pp. + appendices.

11. Barsby, T. July 2011. Nanaimo Fish and Game Protective Association Ph. (250) 754 – 2010.

12. Doyle, D. June 2011. Wildlife Biologist, Region 1, B.C. Ministry of Environment, E-mail: ddoyle@gov.bc.ca

13. Merilees, B. K. Langelier and K. Machin. 1992. *The Arrival of the Eastern Cottontail in Nanaimo*. Thrush (2) 4: 9-11.

14. WiTS – Wildlife Tree Stewardship Website. http://www.hancockwildlife.org/article.php/ (accessed July 7, 2011).

15. Birding on the Net. *June 13, 2011 Nanaimo Bird Report*. http://birdingonthe.net/mailinglists/BCVI.html (accessed July 7, 2011).

16. Matsuda, B.M., David M. Green, and Patrick T. Gregory. 2006. Amphibians and Reptiles of British Columbia. Handbook, Royal British Columbia Museum, Victoria, British Columbia. 266 pp.

THE COUVERDON PROPERTIES

BIOGEOCLIMATIC AND HABITAT ASSESMENTS

The Couverdon Properties are lands that have transitioned out of TimberWest forestry use and are now designated for residential sale. There are 11 lots surveyed, numbering #3 – #13, of which lot #10 has been privately purchased and lot #11 is not currently for sale. A riparian strip of land bordering lot #11 has been secured by the Regional District of Nanaimo as parkland.

The Nanaimo & Area Land Trust has commissioned a Coastal Douglas-fir assessment and a baseline bio-inventory report of lots #11, #12 and #13 to gauge the conservation values of some or all of these properties to add to the parkland in this area.

Lot #11 is actively used as access as a safe haul-out area for recreational paddling activities.

The commissioned reports are represented in the following two chapters.

COASTAL DOUGLAS-FIR ASSESMENT OF THE COUVERDON PROPERTIES

Lots 11, 12, and 13, along the Nanaimo River, in Nanaimo, BC

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June 2013

EXECUTIVE SUMMARY

On May 16, 2013, Paul Chapman (NALT) and Emily Barnewall (BBC) visited three Couverdon properties (Lots 11, 12, and 13) along the Nanaimo River Road in Nanaimo, BC. The lots lie in the Coastal Western Hemlock near the Coastal Douglas Fir biogeoclimatic zone boundary. The purpose of the survey was to determine if these properties contained Coastal Douglas Fir (CDF) characteristics as the CDF boundary can be variable based on site characteristics. We visited each of the three properties and conducted one detailed ground plot and two visual plots per property. Plots were chosen based on the interpretation of air photos provided by NALT and on site characteristics during the field visit. The parcels range from older, mature forests to young shrub/herb dominated immature forests. Portions of this parcel have been logged recently (< 20 years ago) and limited fire activity. We found that the parcels contain a mix of Coastal Douglas Fir and Coastal Western Hemlock depending on site aspect and elevation. These parcels are likely in the transition zone between these two biogeoclimatic zones.

INTRODUCTION

The Coastal Douglas Fir (CDF) biogeoclimatic zone is one of the rarest biogeoclimatic zones in British Columbia (MoF 1999a). The CDF is distributed along the southeastern portions of Vancouver Island from Victoria to Powell River and most of the southern gulf islands, and portions of the Sunshine Coast and Lower Mainland. It ranges in elevation from sea level to 150 m in most areas, and can be as high as 380 m in the Cowichan Valley and southwestern section of Salt Spring Island (Madrone 2008). The CDF is composed of multiple plant community types. The largest of which is the Douglas-fir / dull Oregon grape plant community and one of the most charismatic is the Douglas-fir / Alaska oniongrass which contains the Garry Oak meadow. The moister plant community types such as the western red cedar leading stands are some of the least protected plant community types, with less than 5 % protection.

The coastal western hemlock (CWH) lies adjacent to the CDF and is the dominate biogeoclimatic zone on Vancouver Island (MoF 1999b). The CWH is found from sea level to 450 m in the Sunshine coast, Haida Gwaii and northern Vancouver Island or above 150 m when adjacent to the CDF. As with the CDF, the CWH is composed of multiple plant communities, some of which are unique to the CWH and some that are shared with the CDF. The CWH is made up of 15 subzones, with the xm (very dry maritime subzone) being the closest to the CDF (Green and Klinka 1994). The CWHxm has more western hemlock, less grand fir and dogwood, less dull Oregon grape and trailing blackberry, and more lanky moss in comparison to the CDF.

The CDFmm 01 (Douglas-fir / dull Oregon grape) is the zonal, or the most typical plant community type in the CDF (Green and Klinka 1994). This plant community encompasses a wide variety of plant species (not all of which are observed at every site) and can be found on varying soil and aspect. The CWHxm 03 (Douglas-fir – western hemlock / salal) is the plant community that is the most similar to the CDFmm 01. Both these sites share the same terrestrial ecosystem mapping (TEM) map code - DS. Table 1 shows a comparison of plant species found in the two plant community types. Two sources of plant species lists have been included to show the variability in the interpretation of these plant communities. The plant species abundance is as important as the plant species composition.

Table 1. Representative and associative species found in the Douglas-fir / dull Oregon grape and the Douglas-fir – western hemlock / salal plant community types from Green and Klinka (1994) and Madrone (2008).

Plant Species	**Douglas-fir / dull Oregon grape (CDF)**		**Douglas-fir – western hemlock / salal (CWH)**	
	Green and Klinka, 1994	Madrone, 2008	Green and Klinka, 1994	Madrone, 2008
Douglas-fir	X	X	X	X
Arbutus	X	X		X
Bigleaf maple	X	X		
Western red-cedar	X	X	X	X
Grand fir	X	X		
Western flowering dogwood	X			
Shore pine	X		X	
Western hemlock		X	X	X
Salal	X	X	X	X
Dull Oregon grape	X	X	X	X
Bald-hip rose	X		X	
Oceanspray	X	X	X	X
Western trumpet honeysuckle	X			
Snowberry	X			
Red huckleberry		X	X	
Sword fern	X	X	X	
Vanilla leaf	X		X	
Bracken fern	X	X	X	
Trailing blackberry		X		
Twinflower			X	X
Electrified cat’s tail moss	X		X	X
Oregon beaked moss	X	X	X	X
Step moss	X	X	X	X
Lanky moss			X	

The Couverdon properties are currently listed for sale by Couverdon Ltd. The Nanaimo Area Land Trust (NALT) is considering purchasing these properties with other stakeholders. Knowing if this property contained some CDF would increase the conservation value of these properties. The purpose of the project is to determine if these properties contain characteristics of the CDF, CWH or if this is a transition zone between the two biogeoclimatic zones. These parcels overlap the CDF and the CWH and are south facing (which suggests a warmer, dryer aspect), which is more conducive to CDF. The immature forests have been replanted since harvesting but we do not know which tree species have been replanted. The trees in the immature forests may be unreliable in assessing the BEC zone as these are not the natural, regenerated species.

METHODOLOGY

Aerial photos were available from NALT via Couverdon Ltd as part of Couverdon's real estate promotional material and Google satellite imagery was also used. Based on the aerial photos, we decided to conduct one ground plot and two visual plots in each lot for better representations of the lots. Each ground plot was conducted in a different ecosystem type, rather than in the oldest, most mature portions of each lot. This was to glean a better picture of the properties since they lie adjacent to each other. A ground plot consists of documenting all plant species, the layer they occupy, and their percent cover within a 20 m by 20 m grid. We used the Ground Inspection Form from the BC Ministry of Forests, Lands, and Natural Resource Operations and the Field Manual for Describing Terrestrial Ecosystems methodology (MFLNRO 2010). A visual plot is less detailed and differs in that we record all the plant species and their layer we see within an approximate 50 m radius. Habitat photos were taken at each plot. Soil data was not collected as this level of detail was not required. The data collected results in a snap-shop of the plants at each site but does not result in an exhaustive plant list for the properties as not all plants we saw were encountered at one of the nine plots.

Preliminary field data was collected by Vancouver Island University students as part of a class assignment (Thompson et al. 2013). This data was helpful in our site selection as they gave us a brief description of the site characteristics (i.e., mature, moist, or clear cut, etc) and a preliminary plant list.

A portion of parcel 11 has been reserved as park land so no plots were made in this area.

RESULTS AND DISCUSSION

The lots consist of a mix of forest ages due to past logging on the sites. The amount of area logged varies by lot, with lot 13 showing the most harvesting and lot 11 the least (Fig. 1). All recently harvested areas have been replanted and are in the pole / sapling or immature stage of forest structure except for a small area around plot 13-2 which has very small trees (< .5 m) due to a small fire that killed the young trees. The older, more mature forest is generally found as a riparian strip along the river. The remaining forest or wildlife tree patches are young second growth forest with a section of mature forest near plot 12-3. Overall, the topography of the lots was a series of benches and steep slopes leading down to the river rather than a gradual slope. The lots are south facing, which is generally a warmer and dryer aspect. Invasive species were limited to the immature forest (Scotch Broom) but some tansy ragwort was observed along one of the roads in lot 12. The burned area in lot 13 (site 13-2) had the largest diversity of invasive plants, but these plants were not in very high densities. Canada thistle, bull thistle, Scotch broom, wall lettuce, hairy cat's ear, and dandelion were found at site 13-2. We found a mix of CDF and CWH attributes throughout the parcels but no site or parcel was clearly CDF or CWH. This site is most likely in the transition zone between the two BEC zones. The majority of the field plots are the CDFmm 01 (Douglas-fir / dull Oregon grape) and the CWHxm1 03 (Douglas-fir - western hemlock / salal) plant community types. Plot 12-3 is most likely the western red cedar – Douglas-fir / Kindbergia (CDFmm 05) plant community.

Figure 1. Field plots (yellow thumb-tacks), track (green line), and approximate lot boundary (pink line) at the Couverdon lots 11, 12, and 13 along the Nanaimo River in Nanaimo, B.C. using Google Earth imagery.

Lot 11 includes a strip of land that has been reserved as park land that follows the lot boundary (not shown). The riparian strip of older forest along the river is included in this reserve. Plot 11-1 was the lowest elevation site at 149 m. This immature forest was located in the southern portion of the lot (Fig. 2). This plot is most leaning towards CDF due to the low elevation, presence of grand fir, bigleaf maple, limited hemlock (only one hemlock observed), and herb species composition (i.e., snowberry). A low density of Scotch broom was found at the site. The scotch broom should die out as it becomes overshadowed by the growing canopy cover. The moss layer was patchy and consisted of tree, Oregon beaked, and electrified cat's tail moss.

A. B.

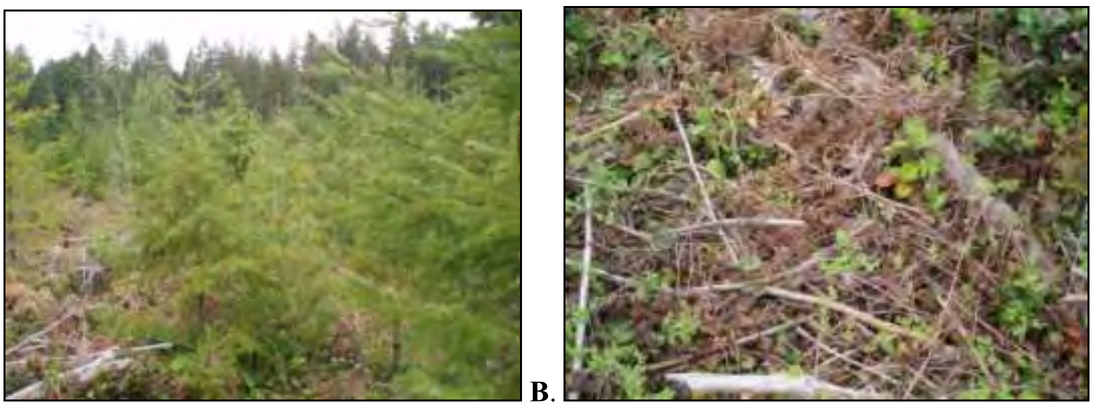


Figure 2. Plot 11-1. **A**) Douglas-fir and western red-cedar trees in the pole/sapling stage in an immature forest with a Scotch broom plant in the background. **B**) Understory herbs and shrubs at 11-1. Note trailing snowberry, salal, dull Oregon grape, and bracken ferns.

Plot 11-2 was located on a bench at 161 m in elevation and is in a young forest (Fig 3). This field plot could be in the transition zone between the two BEC zones as there are characteristics of the two sites. The presence of grand fir, electrified cat's tail moss, and snowberry would lean towards CDF while there were CWH indicators (twinflower, prince's pine, and low oceanspray abundance) present. Western hemlock was found at a low density. The main mosses observed here were electrified cat's tail, Oregon beaked, and step moss.

A.  B. 

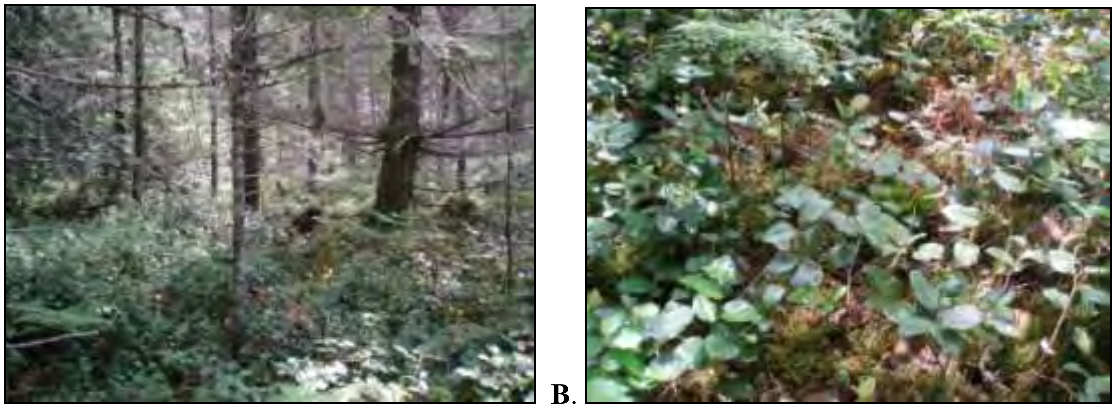
Figure 3. Plot 11-2. **A**) Dense salal understory with Douglas-fir trees in a young forest. **B**) Salal understory with snowberry and twinflower.

Plot 11-3 was on a higher elevation bench at 184 m. This young forest had a similar plant species composition as 11-2, but lacked western hemlock trees (Fig 4). This site appears to be more CWH due to the lack of tree diversity (Douglas-fir only) and low oceanspray abundance although there are still some CDF influences (trumpet honeysuckle). Step moss was the most abundant moss at this site, followed by Oregon beaked, lanky, and then electrified cat's tail moss. Other plant species to note that we observed at this site include: evergreen huckleberry, trailing blackberry, Prince's pine, and rattlesnake plantain.

A.  B. 

Figure 4. Plot 11-3. **A**) Douglas-fir trees with dense salal understory and oceanspray. **B**) Salal, snowberry, and trailing blackberry, with step and lanky moss in the understory.

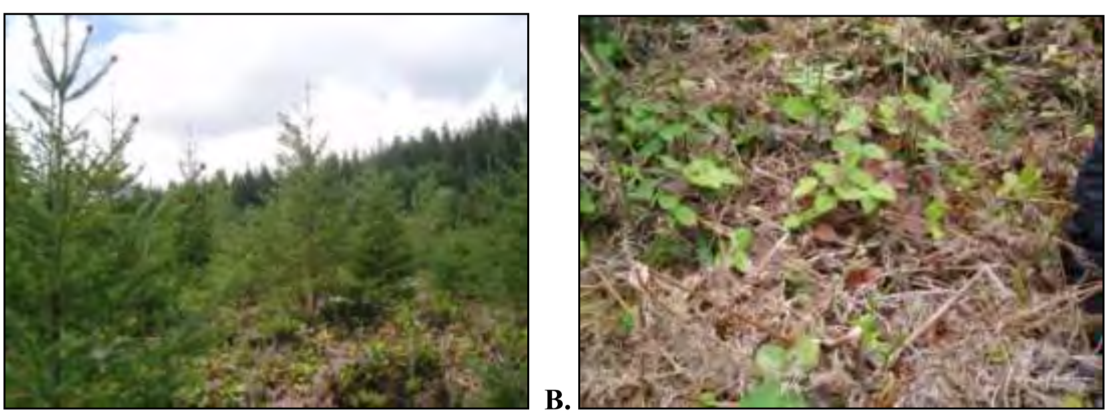
Lot 12 is to the east of Lot 11 (Fig 1). Plot 12-1 is on an upper bench in the northeastern portion of the lot at 174 m. This site appears to be more CWH than CDF due to the presence of lanky moss. However, we did not observe any western hemlock (Fig 5). Additionally, this is a moister site than the previous sites due to the higher frequency of western red cedar but still within the zonal site series. CDF characteristics were still observed with the presence of trailing blackberry and snowberry. Other interesting plants observed were: shore pine, evergreen huckleberry, and rattlesnake plantain. The moss layer was a mix of lanky, Oregon beaked, and step moss.



A. B.

Figure 5. Plot 12-1. **A**) Douglas-fir trees with dense salal understory. **B**) Salal, lanky moss, and bracken fern understory.

Plot 12-2 was located in an immature forest in the southern portion of the lot (Fig. 1). The plot is at 152 m in elevation (Fig. 6). Due to the herb and shrub layer, this site is more similar to CDF (trailing blackberry, snowberry, and western flowering dogwood) than CWH. No hemlock trees were observed. The Oregon beaked moss layer was moderately well developed. On route to Plot 12-2, we crossed a dense patch of kinnikinnick at a lower elevation which suggests CWH. This patch of kinnikinnick was at the edge of the bench closest to the steep slope that leads down to the river.



A. B.

Figure 6. Plot 12-2. **A**) Young Douglas-fir trees in an immature forest with a pacific dogwood tree flowering in the background. **B**) Salal and fireweed understory with a mix of living and dead bracken ferns.

Plot 12-3 is in a moist section with mature forest structure and is at 169 m (Fig. 7). This plot was on a bench with a gentle slope overlooking the immature forest with site 12-2. This plot seems more characteristic of CDF due to the presence of dogwood, bigleaf maple, and lack of hemlock. The moss layer was poorly developed in this site and when present, was Oregon beaked moss. The abundance of sword ferns indicates that this site is quite rich and productive. Other interesting plants observed were: wild ginger, stream violet, red columbine, Indian hellebore and maidenhair fern. A small stream was observed to the north east of the plot. This site could be western red cedar – Douglas-fir / Kindbergia (CDFmm 05) plant community.

A.

B.

Figure 7. Plot 12-3. **A**) Sword fern understory with a large Douglas-fir and several western red-cedar trees. **B**) Sword and maiden hair fern with vanilla leaf and decomposing maple leaves.

Lot 13 has the largest area of immature forest (Fig. 1). This lot was the most disturbed, had the most invasive plants, and was more similar to CWH than CDF but all sites had indicator species from the two BEC zones. Our first plot, 13-1 was along a steep slope that goes down to the Nanaimo River (Fig. 8). This site had mature forest characteristics and was at 165 m in elevation. Multi-canopy layers were present as the mature Douglas-fir trees were interspersed with younger Douglas-fir trees. This site seemed to be more CWH due to the presence of kinnikinnick but there was also no hemlock noticed. There was some common snowberry and trumpet honeysuckle present indicating some CDF overlap. This site had a nice, well developed moss layer of electrified cat’s tail moss and Oregon beaked moss.

A.  B. 

Figure 8. Plot 13-1. **A**) Steep slope with Dougla-fir trees of various ages and oceanspray. **B**) Scattered salal with kinnickinnick, dull oregon grape and snowberry in the understory.

The next two plots are in immature forests. The first plot (13-2) was on the bench just above 13-1 at 162 m (Fig 1). This plot was burned after re-planting and the fire had killed all the replanted trees so this site appears to have been left to regenerate naturally (Fig. 9). Here we found the most introduced plants (Scotch broom, hairy cat's ear, bull thistle, Canada thistle, wall lettuce, and dandelion). Young Douglas-fir trees were regenerating at the site (< .5 m tall) as part of a natural regeneration process. This site shows a mix of CDF and CWH indicator plant species but maybe leaning towards CDF due to the shrub/herb composition (trailing blackberry, oceanspray, and snowberry). The dominate moss was lanky moss which suggests CWH.

A.  B. 

Figure 9. Plot 13-2. **A**) Burned cutblock with flowering Scotch broom with a salal and bracken fern understory. Note lack of young trees as in the other replanted sites. **B**) Trailing blackberry, Canada thistle, and fireweed are a few of the species observed in the understory at plot 13-2.

Plot 13-3 was in the northern portion of the lot at 185 m. This was our highest elevation site and was near the upper slope of the hill. This immature forest was quite dry and was more similar to CWH due to the hairy manzanita, western hemlock, and lanky moss present (Fig. 10). There were also some CDF indicators such as trailing blackberry, trailing snowberry, and trumpet honeysuckle as well.

A.  **B**. 

Figure 10. Plot 13-3. **A**) Young Douglas-fir, western red cedar, and willow in the immature forest. **B**) Understory of salal, trailing blackberry, and trailing snowberry in the immature forest at plot 13-3.

Differentiating between the CWH and the CDF can be difficult to distinquish in the transition zone between the two BEC zones as there can be significant overlap in species composition. Other difficulties in classifying these lots can be due to the replanting of these forests as we do not know what species were planted for the second or third growth forests. There is a good diversity of plants within the herb and shrub layer. There is also a good diversity of tree species found within the lots. Coarse woody debris is not very abundant in the clear cuts or in the second growth forests. Over the long term, this site has the potential to be a diverse forest.

In conclusion, no site was clearly CWH or CDF based on plant species composition and abundance. This suggests that these lots are within the CWH and CDF transition zone with the lower elevation sites more CDF and the higher elevation sites more CWH. Due to the effects of climate change, sites like this may become important to the conservation of CDF as the CDF may increase in elevation with increasing temperature.

REFERENCES

BC Ministry of Forests. 1999a. The Ecology of the Coastal Douglas-fir Zone. Ecosystems of British Columbia Special Report Series #6. Ministry of Forests Research Branch. Victoria, BC. 6 pp. http://www.for.gov.bc.ca/hfd/pubs/docs/bro/bro30.pdf

BC Ministry of Forests. 1999b. The Ecology of the Coastal Western Hemlock zone. Ecosystems of British Columbia Special Report Series #6. Ministry of Forests Research Branch. Victoria, BC. 6 pp. http://www.for.gov.bc.ca/hfd/pubs/docs/Bro/bro31.pdf

BC Ministry of Forests, Lands, and Natural Resource Operations and Ministry of Environment. 2010. Field Manual for Describing Terrestrial Ecosystems. Province of BC, Victoria, BC http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25/Lmh25_ed2_%282010%29.pdf

Green, R.N. and K. Klinka. 1994. A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region. BC Ministry of Forests, Land Management Handbook Number 28. Victoria, BC

Madrone Environmental Services. 2008. Terrestrial Ecosystem Mapping of the Coastal Douglas-fir Biogeoclimatic Zone. Duncan, BC.

Thompson, K., Brugge, C., Wilson, M., and MacRae, J. 2013. Site Assessment of a Potential Park on the Nanaimo River. Class assignment for Biology 457. Vancouver Island University. Pg 40.

BASLINE BIO-INVENTORY OF THE COUVERDON PROPERTIES
Lots 11, 12, and 13 along the Nanaimo River

Prepared by:

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July 5, 2013

EXECUTIVE SUMMARY

This bio-inventory was based on background review and field investigations conducted over June of 2013. It is understood that NALT and its conservation partners may be interested in securing some or all the three properties comprising the Study Area. The field program was designed to describe general wildlife occurrence and habitat conditions at the site, as well as identify any elements of potential conservation interest. Fieldwork involved call-playback raptor surveys, breeding bird point-count surveys, conspicuous nest searches, and time-constrained searches for terrestrial amphibians. Plant community description relied heavily on fieldwork completed by Vancouver Island University students and an assessment by a CDF ecosystem specialist. Our field investigation of vegetation focused on building lists of vascular plant occurrence, including searches for rare plants.

The bio-inventory found that each of the properties comprising the Study Area possesses a number of valuable ecosystem components. The properties are strategically located adjacent to a small riverside park in an area with few protected areas. They feature a diverse mix of stand ages ranging from early-seral to mature, with isolated veteran trees and a few prominent snags. The high structural complexity found at the Subject Area supports a diverse assemblage of wildlife, particularly birds. The Subject Area occurs within an ecologically interesting transition zone between the CDFmm and CWHxm Subzones, capturing ecosystems closely resembling two Red-Listed plant communities within the CDF zone and one Blue-listed plant community in the driest CWH Subzone. In addition to the above, Lot 11 was found to support a rare plant species (Macoun's Groundsel) while Lot 13 likely supports nesting by a Blue-listed bird species (Olive-sided Flycatcher). Due to the abundance of key food plants in the Study Area, and recent occurrence records in a neighbouring area, the site was assessed as having a high potential to support the Dun Skipper, a Red-listed invertebrate related to butterflies.

Methods and Information Sources

Field Investigation

The field program for this bio-inventory was designed with two objectives in mind, namely1) to describe general wildlife occurrence and habitat conditions at the site , and 2) to identify any flora, fauna, and ecosystems of potential conservation interest. Wildlife surveys undertaken for this assessment included call-playback surveys for diurnal (day-active) and nocturnal raptors, morning point-count surveys for breeding birds, searches for nests protected under the BC Wildlife Act, and time-constrained searches for terrestrial amphibians. Opportunistic wildlife observations were recorded in field notes. The location of various field activities is given in Figure 1 below.

As plant communities of the three properties had been previously described by others, field investigation of vegetation involved building lists of vascular plant occurrence and mapping the areal extent of specialized plant communities.

Figure 1. General location of spring 2013 field activities within the Study Area.

Yellow Circle = Breeding bird point-count station

Blue Circle = Raptor call-playback station /great blue heron stand-watch

EXISTSING INFORMATION SOURCES

In the course of this assessment, a variety of existing information sources regarding plant and wildlife occurrence were reviewed, including:

- A recent Coastal Douglas-fir Assessment of the subject properties prepared by E. Barnewall (2013).
- Field plot information collected by Vancouver Island University students in the spring of 2013.
- Conservation Data Centre (CDC) Rare Element Database.
- Sensitive Ecosystems Inventory (SEI) Map Sheet 92F.010 (1:20,000 scale).
- Ministry of Environment (MoE) nest inventory information for the Northern Goshawk and Great Blue Heron (on file).
- Wildlife Tree Stewardship (WITS) database of Bald Eagle and Osprey nests.
- B.C. Ministry of Water, Land and Air Protection Status Report on Roosevelt Elk (Quayle and Brunt 2003).
- Generic Royal BC Museum guidebooks on amphibian and reptiles (Matsuda *et al.* 2006).

EXISTING CONDITIONS

Environmental Setting

The three properties comprising the Study Area encompass roughly 41 ha (99.6 acres) of forested land along the middle reaches of the Nanaimo River, about 18 km upstream of the Nanaimo River Estuary. The properties have a warm aspect, as a result of their position on the north side of the Nanaimo River. The Study Area extends from Nanaimo River Road downslope to the banks of the river. Terrain within the Study Area is quite varied, with moderately steep slopes present along the northern part of the site, and steep slopes occurring near the banks of the Nanaimo River in the south. In between, there several areas of bench land and ridges that are separated by more gently sloping terrain. There is a small but well-incised drainage occurring in the eastern part of Lot 12 that drains to the south. It has its headwaters to the south of Boulder Creek.

Elevations within the Study Area range from approximately 140 m to 190 m above sea level (ASL). As a result the properties span the upper elevational range of the Moist

Maritime Subzone of the Coastal Douglas-fir Biogeoclimatic Zone (CDFmm) and the lower elevational range of the Very Dry Maritime Subzone of the Coastal Western Hemlock Biogeoclimatic Zone (CWHxm). The CDFmm generally transitions to the CWHxm around 150 m ASL, however, it may extend beyond this (up to 380 m ASL) depending on aspect and regional climatic influences (Barnewall 2013). Both of these Subzones experience warm, dry summers and moist, mild winters (Green and Klinka 1994). Precipitation here is generally in the form of rain and snowfall is usually shallow and ephemeral, in the Shallow Snowpack Zone described by Nyberg and Janz (1990).

Typical forest stands within these subzones are dominated by Douglas-fir, with a minor to major component of Western Hemlock and minor amounts of Western Redcedar and Grand Fir. Common understorey plants of the transition zone include Salal, Dull Oregon Grape, Ocean Spray and Red Huckleberry. Vanilla Leaf, Sword Fern, and Bracken Fern are usually less prominent within these subzones (Green and Klinka 1994).

Historical land use in this part of the Nanaimo River Valley involved railroad logging, starting in the years immediately following World War 2. This method of logging was discontinued in the 1980's and replaced by truck transport of logs. After a few years of reduced forestry activity during the transition to truck logging, harvest of second-growth stands commenced in the lower part of the Nanaimo River Valley in the 1990's (Iannidinardo *et al.* 2011). After second-pass logging, a third rotation of tree crops was planted in keeping with modern forestry practices. Parts of the subject properties, and immediately adjacent parcels, appear to have been logged within the past two decades or so.

Currently, adjacent land uses in the vicinity of the Study Area are dominated by forestry. There are extensive areas of regenerating forest interspersed with patches of mid-seral and, in places, mature seral forest. A few clusters of rural residential land use occur roughly 0.6 km to the northeast and 1.8 km to the east of Lot 13. A large gravel pit is in operation about 6 km from the Study Area. Owing to this part of the valley's status as privately-managed forest land, there are few formally-designated protected areas. The Regional District of Nanaimo has an unnamed linear park around the margins of Lot 11. It protects approximately 10 ha of forest, most of it adjacent to the Nanaimo River. There is a transmission line corridor running east-west about 200 m north of the Study Area.

HABITAT VALUES AND WILDLIFE OCCURENCE

The Study Area as a whole possesses above-average habitat values. It is situated at low elevation (< 200 m), which typically supports a greater diversity of wildlife than either middle or upper elevation habitats. The site benefits from adjacency to a major river system that functions as a wildlife movement corridor for a variety of wide-ranging mammals, particularly large carnivores. It also benefits from adjacency to a linear protected area managed by the RDN, resulting in several small pockets of forest with interior forest conditions within Lots 11 and 12. While lacking permanent wetlands, the Study Area exhibits a high degree of topographical complexity, with the juxtaposition of bench lands, steep slopes, gullies, and other more gently sloping areas within a relatively small area.

The mosaic of different-aged forest patches comprising the three properties results in high structural diversity, important for supporting a diverse bird assemblage. All three properties include a significant deciduous component to complement the predominantly coniferous cover. Though far from abundant, the site includes a number of large-diameter snags and veteran trees that provide perching and denning opportunities for wildlife. Regenerating stands across the site generally provide high forage values, dampened somewhat by the proliferation of Scotch Broom in places.

The interspersion of young, mid-seral, and mature stands provide good security, travel, and thermal cover for larger mammals. As commonly occurs in harvested areas, large recumbent logs and cavity-bearing snags are in short supply, and may provide a focus for future habitat enhancement activities.

Like many areas along the rural fringes of eastern Vancouver Island, the Study Area is well used by Columbian Black-tailed Deer. Deer sign in the form of tracks, trails, browsing sign, and droppings was encountered across the site. Although they are known to inhabit areas due south of the Study Area (Quayle and Brunt 2003), no evidence of use by Roosevelt Elk was found at the site. Bear sign was detected in Lots 11 and 12, and presumably uses similar habitats in Lot 13 as well. Bears would be attracted to forage growing in regenerating forest and riparian areas in summer and early autumn and nearby roadside vegetation in the spring. Skunk Cabbage, an important black bear food plant was not found in the Study Area. Apart from bears, two other large carnivores are expected to occur in the Study Area from time to time. Cougars occur at relatively high densities throughout Vancouver Island, and cover large territories. They have been reported from the area below First Lake in recent years (C. Davies, personal communication). Grey Wolves occur at relatively low densities in the region, ranging from approximately 1 wolf / 50 km^2 to 1 wolf /150 km^2, typically along major river valleys. Wolves travel widely in search of ungulate prey, covering 20 km to 30 km/day, on average, and probably pass through the

Study Area several times per year. Scats attributable to the latter were found in Lots 11 and 12 in June of 2013 (Fig. 2).

Figure 2. Wolf scat found in lower part of Lot 12 in June of 2013.

A number of smaller mammals that have an affinity for riparian habitats (e.g. Mink, River Otter, and Raccoon) are expected to occur in the Study Area from time to time, along with others favouring upland forest (e.g. Marten, Red Squirrel, Deer Mouse, and Dusky Shrew). However, only Red Squirrel sign was observed during the 2013 fieldwork.

As indicated in Table 1, a total of 39 species of birds were documented in the Study Area. Two species of raptorial birds were detected on the site, including the Sharp-shinned Hawk and Red-tailed Hawk, but neither is expected to nest on the properties. Call-playback surveys did not elicit any territorial responses from falcons, accipiters, or owls. Similarly, no raptor nests have been reported in or near the site through the Wildlife Tree Stewardship nest database. In general, the site features a very low density of cavity-bearing snags suitable for nesting by small owls. However, riparian forest might attract use by Barred Owls, while forest patches are probably used by hunting Great Horned Owls on occasion. However, no owl castings were detected in the field.

The remainder of the Study Area's bird assemblage is dominated by forest passerines. Among the better-represented species groups were warblers (7 species), flycatchers (4 species), and sparrows (also 4 species). Despite the low density of snags, four species of woodpeckers were recorded on the properties. Two Provincially Blue-listed bird species were documented through the fieldwork; the Band-tailed Pigeon and the Olive-sided Flycatcher. The former was observed flying over Lot 12 while the latter was noted in Lot 13, and probably nests there. A documented species that is considered Regionally Important due to its association with mature forest, the Pileated Woodpecker, was seen on Lot 11.

With a southern exposure and no sizeable wetlands present on or near the properties, it was not surprising that native pond-breeding amphibians remained undetected during the June fieldwork. Forested upland habitats appear suitable for the entirely terrestrial Ensatina, but no terrestrial salamanders of any type were encountered during searches for the Blue-listed Wandering Salamander. This latter species is associated with low-elevation forests dominated by Douglas-fir or Western Hemlock where coarse woody debris is abundant on the forest floor (Matsuda *et al.* 2006). With the exception of the streamside forest in Lots 12 and 13, few parts of the subject properties were found to contain an abundance of moist downed wood.

Only two species of reptiles, both garter snakes, were noted within the Study Area. As the name suggests, the Common Garter Snake is a widely distributed species on Vancouver Island. It is usually most abundant around lakes, ponds, and rivers. The other observed snake, the Northwestern Garter Snake, is highly terrestrial and frequents meadows and forest edges throughout it range, which includes Vancouver Island and the adjacent Lower Mainland (Matsuda *et al.* 2006). A reptile which was not seen but is nevertheless likely to inhabit suitable parts of the Study Area is Northern Alligator Lizard. This small reptile can be locally abundant across eastern Vancouver Island, with favoured habitats being open rocky areas with large woody debris. It is known to occur in the nearby community of South Wellington.

Table 1. Study Area Wildlife & Sign Observations in June of 2013.

Common Name	Couverdon Properties		
	Lot 11	Lot 12	Lot 13
Mammals			
Black Bear	√	√	
Columbia Black-tailed Deer	√	√	√
Grey Wolf	√	√	
Red Squirrel		√	√
Birds			
American Goldfinch			√
American Robin	√	√	√
Band-tailed Pigeon		√	
Black-headed Grosbeak	√	√	√
Black-throated Grey Warbler	√	√	√
Cedar Waxwing			√
Chestnut-backed Chickadee	√	√	√
Chipping Sparrow	√		
Common Raven	√	√	√
Dark-eyed Junco	√	√	√
European Starling		√	√
Hairy Woodpecker	√		√
Hammond's Flycatcher	√	√	√
MacGillivray's Warbler	√		√
Northern Flicker	√	√	√
Olive-sided Flycatcher			√
Orange-crowned Warbler	√	√	√
Pacific-slope Flycatcher		√	√
Pileated Woodpecker	√		

Purple Finch		√	√
Red-breasted Nuthatch	√	√	
Red-breasted Sapsucker		√	√
Red Crossbill			√
Red-tailed Hawk	√	√	√
Rufous Hummingbird	√	√	√
Sharp-shinned Hawk	√		
Spotted Towhee	√	√	√
Swainson's Thrush		√	√
Tree Swallow			√
Townsend's Warbler	√	√	√
Turkey Vulture	√	√	√
Warbling Vireo	√	√	√
Western Tanager	√	√	√
White-crowned Sparrow	√	√	√
Willow Flycatcher	√		√
Wilson's Warbler		√	
Winter Wren		√	√
Yellow-rumped Warbler	√	√	√
Yellow Warbler		√	
Herptiles			
Common Garter Snake		√	√
Northwestern Garter Snake			√
Butterflies			
Anise Swallowtail	√	√	√
Mourning Cloak	√	√	
Oreas Comma		√	
Slivery Blue	√	√	√

Four species of butterflies were recorded within the subject properties, three of which are widespread on Vancouver Island (i.e. Anise Swallowtail, Mourning Cloak and Silvery Blue). The fourth, the Oreas Anglewing, is considered uncommon because populations are usually small and individuals are seldom seen (Guppy and Sheppard, 2012). It was observed in Lots 11 and 12 in June of 2013. Due to the frequent appearance of food plants at the site (i.e. Spreading Dogbane), and recent CDC occurrence records less than 3 km to the west of the site, the subject properties are considered to have a high potential to support the recently Red-listed Dun Skipper.

Figure 3. An uncommon Oreas Anglewing butterfly seen within Lot 12.

PLANT OCCURRENCE

Overall, the Study Area was found to support a wide variety of native plants, and a few non-native plants. As indicated in Table 2, nearly 100 species of vascular plants were identified on the subject properties, including 12 species of trees, 33 species of shrubs, and 54 non-woody species. Three shrubs and 8 herbaceous plants were included among the non-native plants. For the most part, plants occurring on the site are typical forest species however one provincially Blue-listed plant, Macoun's Groundsel (*Senecio macounii*), was recorded in the southern part of Lot 11 (Fig. 4). This plant is also noted in the Conservation Data Centre Rare Element database as occurring in 1992 near the confluence of Boulder Creek and the Nanaimo River, about 800 m to the east of its Lot 11 location. In addition to the lone threatened herbaceous plant, the Study Area includes one Yellow-listed tree

(Trembling Aspen) and three Yellow-listed shrubs that appear infrequently in the Nanaimo region (Hairy Manzanita, Silverback Luina, and Spreading Dogbane). A number of interesting wildflower species were in bloom during the 2013 fieldwork. Wild Ginger was detected in the central part of Lot 12, while Common Red Paintbrush and Small-leaved Montia were seen within the riparian forest of Lot 12. Tiger Lily and Trillium was observed in several scattered locations across Lots 11, 12, and 13.

Table 2. Plants Observed at the Couverdon Nanaimo River Properties in 2013.

Common Name	**Couverdon Properties**		
	Lot 11	**Lot 12**	**Lot 13**
Trees			
Arbutus	√	√	√
Big Leaf Maple	√	√	√
Bitter Cherry	√	√	√
Black Cottonwood	√	√	√
Douglas-fir	√	√	√
Grand Fir	√	√	√
Lodgepole Pine	√	√	√
Red Alder	√	√	√
Trembling Aspen			√
Western Flowering Dogwood	√	√	√
Western Hemlock	√	√	√
Western Redcedar	√	√	√
Shrubs			
Baldhip Rose	√	√	√
Black Cap	√	√	√
Black Twinberry		√	√
Cascara	√		

Common Snowberry		√	√
Douglas Maple	√	√	√
Dull Oregon Grape	√	√	√
Evergreen Blackberry	√	√	
Falsebox	√	√	√
Hairy Honeysuckle	√		
Hairy Manzanita	√		√
Himalayan Blackberry	√		√
Kinnickinnick	√	√	√
Ninebark		√	√
Nootka Rose	√	√	√
Ocean Spray	√	√	√
Pacific Hardhack		√	√
Purple Peavine	√	√	√
Red Elderberry	√		
Red Huckleberry	√	√	√
Salal	√	√	√
Salmonberry	√	√	√
Saskatoon	√	√	√
Scotch Broom	√	√	√
Scouler's Willow	√	√	√
Sitka Willow		√	
Spreading Dogbane	√	√	√
Tall Oregon Grape	√	√	√
Thimbleberry	√	√	√
Trailing Blackberry	√	√	√
Trailing Snowberry	√	√	√
Twinflower	√	√	√

Western Trumpet Honeysuckle	√	√	√
(Table 2 continued)	**Couverdon Properties**		
Common Name	**Lot 11**	**Lot 12**	**Lot 13**
Herbs & Ferns			
American Brooklime	√	√	√
Big-leaved Sandwort		√	
Blue Wildrye	√	√	√
Bracken Fern	√	√	√
Broad-leaved Starflower	√	√	√
Bronze Sedge		√	
Bull Thistle	√	√	√
Canada Thistle	√	√	√
Cleavers	√		√
Coastal Strawberry	√	√	√
Common Red Paintbrush		√	
Common Vetch	√	√	√
Cow Parsnip	√		
Creeping Buttercup	√	√	√
Deer Fern	√		
Early Blue Violet		√	
Fireweed	√	√	√
Foxglove	√		
Fringecup	√	√	
Green Spleenwort	√		
Hairy Cat's-ear	√	√	√
Herb-robert	√	√	√
Lady Fern	√	√	√
Large-leaved Avens		√	

Maidenhair Fern	√	√	
Many-flowered Wood-rush	√	√	√
One-sided Wintergreen	√	√	√
Oxeye Daisy	√	√	√
Pacific Bleeding-heart	√		
Pathfinder			√
Pearly Everlasting	√	√	√
Prince's Pine	√	√	√
Queen's Cup		√	
Rattlesnake Plantain	√	√	√
Red Columbine		√	
Scouler's Groundsel	√		
Sheep Sorrel	√	√	√
Silverback Luina		√	
Small-flowered Buttercup	√	√	√
Small-leaved Montia		√	
Spike Bentgrass	√	√	√
Spiny Wood Fern	√	√	
Stream Violet		√	
Sweet Vernalgrass	√	√	√
Sword Fern	√	√	√
Tansy Ragwort	√	√	√
Tiger Lily	√	√	√
Trillium	√	√	√
Vanilla Leaf	√	√	√
Wall Lettuce	√	√	√
Western Meadowrue	√	√	√
Western Saxifrage		√	
White-flowered Hawkweed	√	√	√

Wild Ginger		√	
Yarrow	√		

Figure 4. Macoun's Groundsel (*Senecio macounii*), a provincially Blue-listed plant, was observed in the southern part of Lot 11 in 2013.

The locations of a number of mature trees, primarily large diameter Douglas-firs but also a few cedars, hemlocks and pines, were recorded during the fieldwork. These are shown, along with sizeable snags and other site features in Figure 5 below. A total of five large firs were noted within Lot 11, seven in Lot 12, and six in Lot 13. Other individual trees of note included a large diameter Shore Pine in Lot 12 as well as a large twin-stem cedar, large hemlock and Trembling Aspen in Lot 13.

A total of 12 dead and dying trees, or snags, with diameters exceeding 20 cm were recorded during the fieldwork. These were distributed unevenly across the Study Area. Fir snags were scattered around the central part of Lot 11 and the north-central part of Lot 12, while several Shore Pine snags were found in the central parts of Lot 12 and Lot 13.

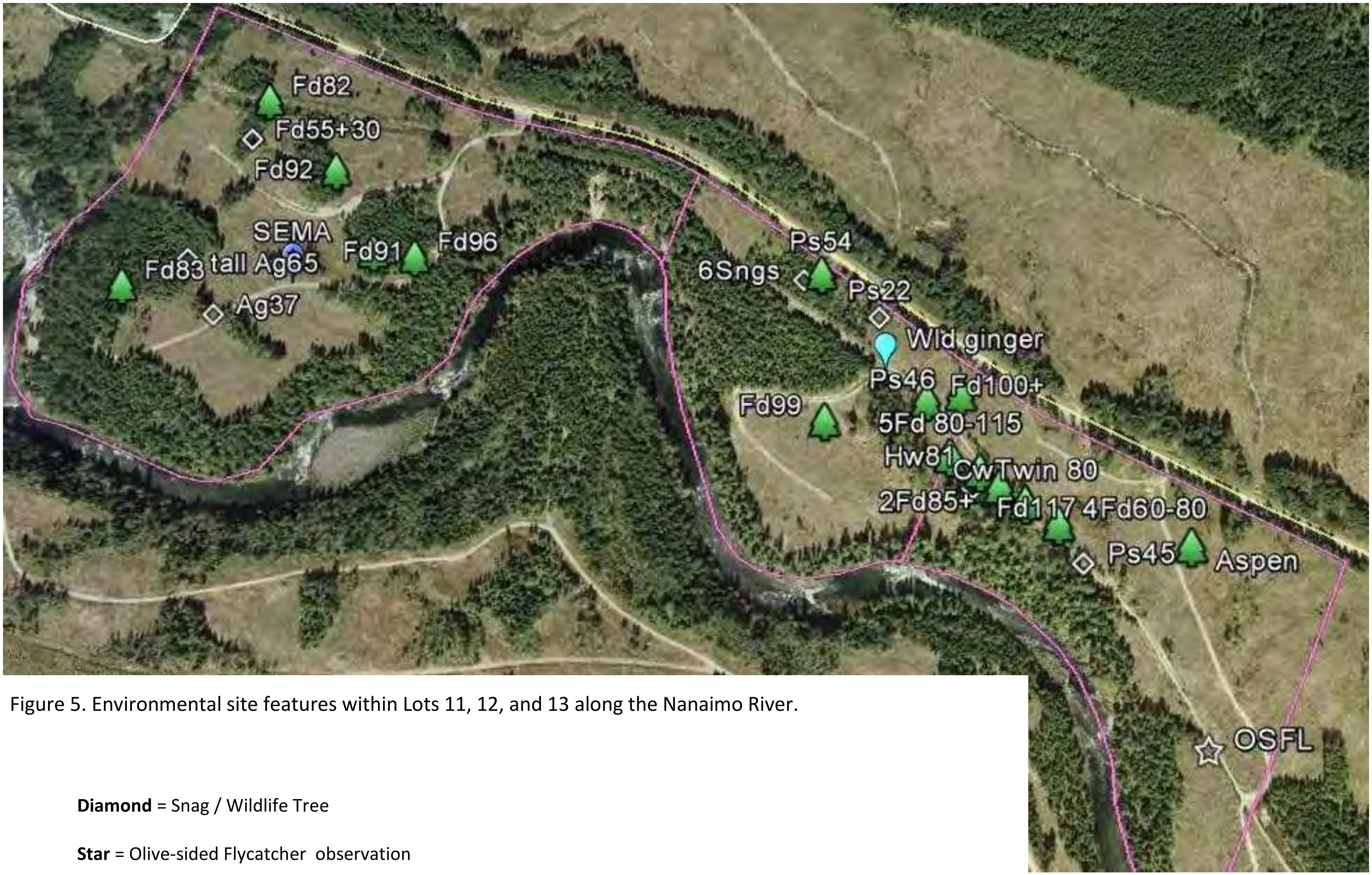


Figure 5. Environmental site features within Lots 11, 12, and 13 along the Nanaimo River.

Diamond = Snag / Wildlife Tree

Star = Olive-sided Flycatcher observation

PLANT COMMUNITIES

A review of Sensitive Ecosystem Inventory (SEI) Map Sheet 92F.010 shows that the subject properties include portions of two SEI Polygons. The first, Polygon N0120, is a kilometers-long, narrow riparian unit that encompasses the high-bench floodplain of the Nanaimo River main stem. It includes sparsely vegetated plant communities, shrub-dominated communities, and young riparian forest. Lot 12 includes roughly 500 lineal metres of SEI Polygon N0120, while Lot 13 includes about 600 lineal meters of this polygon. The second SEI unit, Polygon N0790D –R2, is a remnant of one of four streamside forest units in close proximity to the Study Area. Two of these, Polygons N0790A and B, are included in a new Regional District of Nanaimo Park. It should be noted that recent re-digitizing revealed that SEI Polygon N0790D is currently only about one-third its size in 1997, underlining the threats to mature forest throughout the Nanaimo River Valley and the southeast Vancouver Island generally. SEI fragment N0790D-R2 is comprised of mature riparian forest approaching 1.2 ha in total area, located mostly within Lot 12 with only a small area in Lot 13.

Broad scale Biogeoclimatic Zone Mapping prepared by the Ministry of Forests (Neuzdorfer *et al.* 1994) suggests that the Study Area is entirely within the Dry Maritime Subzone of the Coastal Western Hemlock Zone (CWHxm), occurring about 7 km west of the boundary with the CWHxm Subzone of the Moist Maritime Subzone of the Coastal Douglas Fir Zone (CDFmm). However, a recent CDF assessment of the Study Area by Barnewall (2013), supported by a recent re-evaluation of the Coastal Douglas Fir Zone distribution by Madrone Consulting, determined that the Study Area is more accurately considered a transition zone between the CDFmm and CWHhxm. Characteristic plants of both subzones can be found across the Study Area, with the lowest parts tending towards typical CDFmm plant communities and the upper parts tending towards characteristic CWHxm plant communities. The southern exposure of the Study Area may help explain the intrusion of CDF Zone characteristics into what would normally be considered the CWHxm Subzone. Given the projected warming of the climate in the coming decades, there is potential for the CDF Zone to push even further up the Nanaimo River Valley.

Field reconnaissance found that, for the most part, site soils possessed average nutrient levels that were neither very dry nor excessively moist. As a result, most of the Study Area supports forest communities that approximate either the zonal CDFmm/01 (lower areas) or the CWHxm/03 (for higher areas). Mid-seral stages of these ecosystems have a tree canopy that is dominated by Douglas-fir with an infrequent occurrence of Western Hemlock, Grand Fir and Western Redcedar. The forest understory is typically dominated by Salal with a minor component of Twinflower, Dull Oregon Grape, and Bracken Fern (Fig. 6).

Small areas in the central part of Lot 12 and southwest part of Lot 13 have moderately rich and moist soils that support a plant community resembling the CDFmm/05 ecosystem type. This ecosystem type features a canopy of fir and cedar trees with an understory dominated by Sword Fern (Fig. 7). Maidenhair Fern and Vanilla Leaf were also found on the forest floor of this ecosystem type.

Figure 6. Typical understory in mature Douglas-fir-dominated stands in the Study Area.

Figure 7. Sword Fern dominated understory of a mature Western Redcedar- Douglas-fir / Kindbergia plant community.

From a conservation perspective, all of the above ecosystem types are considered significant (Table 3). The CDFmm/01, also termed the Fd-Dull Oregon Grape community, is provincially Red-listed, with the highest priority for protection under the Conservation Framework. The CDFmm/05 community, termed the CwFd – Kindbergia community, is also Red-listed, with only a slightly lower priority for protection under the Conservation Framework. The CWHxm/03, sometimes referred to as the FdHw-Salal ecosystem type, is provincially Blue-listed with the same Conservation Framework priority as the CDFmm/05.

Table 3. Summary of ecosystem associations represented within the Study Area.

Plant Community (Site Association Code)	Locations	Successional Stages Represented	CDC Listing	Conservation Framework Priority
Fd – Dull Oregon Grape (CDFmm/01)	Lots 11, 12, & 13	Mid-seral and Mature	Red	Highest
CwFd - Kindbergia (CDFmm1/05)	Lots 12 & 13	Mature	Red	Secondary
FdHw - Salal (CWHxm1/03)	Lots 11, 12, & 13	Mid-seral	Blue	Secondary

Scattered among the zonal forest ecosystems of Lots 11 and 12 are four small areas of rock outcropping. These areas are too small to appear on SEI maps, the largest measuring about 100 m long by 15 m wide. Rock outcrops support a semi-open canopy of Douglas-fir trees 15 – 35 cm in diameter. The understorey is comprised mostly of Salal, Snowberry, and Bracken Fern growing through a heavy cover of mosses, primarily Step Moss (Fig. 8). There are often patches of Oregon Grape, Baldhip Rose, Ocean Spray, and juvenile Arbutus in the shrub stratum of these rock outcrops. Twinflower, Prince's Pine, and grasses frequently appear above the moss layer.

Sizeable areas of regenerating forest less than 20 years in age are found within each of Lots 11, 12, and 13. Lot 13 has the most extensive coverage by regenerating forest, accounting for roughly 75 % of that property. Lots 11 and 12 each have more than 50% coverage by early seral forest. Although detailed silvaculture prescriptions were unavailable, it appears that most cut-over areas were replanted heavily to Douglas-fir., sometimes with a minor component of Shore Pine and Western Redcedar (Fig. 9). Natural in-fill by deciduous trees (i.e. Big Leaf Maple, Red Alder, Black Cottonwood, and Douglas Maple) and native shrubs (eg. Ocean Spray, Salal, Saskatoon, and willows) has resulted in a very dense shrub layer in these areas. Cover by invasive Scotch Broom is particularly heavy along old road networks across the site, but should decline as young stands move into the mid-seral stage of forest succession. Herb cover is highly variable in regenerating stands, but Bracken Fern is commonly encountered there.

The spatial distribution of plant communities is given in Figure 10 below.

Figure 8. Small areas of mossy rock outcrop in Lots 11 and 12 typically support Snowberry, Salal, Twinflower, Prince's Pine, and grasses.

Figure 9. Regenerating stands support young firs, cedars, and pines. They contain a diverse mix of mostly native shrubs and non-woody vegetation.

Figure 10. Plant communities within Lots 11, 12, and 13 along the Nanaimo River.

Orange = Dry Rock Outcrop Plant Community

Pink = CwFd – Kindbergia Plant Community

CONCLUSION

Each of the properties comprising the Study Area possesses a number of valuable ecosystem components. The properties are strategically located adjacent to a small riverside park in an area with few protected areas. They feature a diverse mix of stand ages ranging from early-seral to mature, with isolated veteran trees and a few prominent snags. The high structural complexity found at the Subject Area supports a diverse assemblage of wildlife, particularly birds. The Subject Area occurs within an ecologically interesting transition zone between the CDFmm and CWHxm Subzones, capturing ecosystems closely resembling two Red-Listed plant communities within the CDF zone and one Blue-listed plant community in the CWH zone. In addition to the above, Lot 11 was found to support a rare plant species (Macoun's Groundsel) while Lot 13 likely supports nesting by a Blue-listed bird species (Olive-sided Flycatcher). Due to the abundance of key food plants in the Study Area, and recent occurrence records in neighbouring areas, the site possesses a high potential to support the Dun Skipper, a Red-listed invertebrate species related to butterflies.

References

Barnewall, E. 2013. *Coastal Douglas-fir Assessment of Couverdon Properties Lots 11,12, and 13, along the Nanaimo River, in Nanaimo, BC.* Report prepared for Nanaimo and Area Land Trust. 9pp.

Cannings, S.G., L.R. Ramsay, D.F. Fraser, and M. Fraker. 1999. *Rare Amphibians, Reptiles, and Mammals of British Columbia.* Resources Inventory Branch, BC Ministry of Environment, Lands, & Parks, Victoria, BC. 198pp.

Fraser, D.L., W.L. Harper, S.G. Cannings, and J.M. Cooper.1999. *Rare Birds of British Columbia.* Wildlife Branch & Resources Inventory Branch, Ministry of Environment, Lands and Parks, Victoria, B.C., 244pp.

Green, R.N. and K. Klinka. 1994. *A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region*, B.C. Ministry of Forests, Burnaby. 285pp.

Guppy C. and J. Shepard: 2013. *Polygonia Oreas silenus*. In Klinkenberg, Brian. (Editor) 2012. *E-Fauna BC: Electronic Atlas of the Fauna of British Columbia* [efauna.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. [Accessed: 7/2/2013]

Iannidinardo, D., K. Epps, and M. Kennah. 2011 *Forest Resource Management*. In. Nanaimo River Stewardship Baseline Report. Nanaimo and Area Land Trust. 140pp.

Matsuda, B., D.M. Green, and R.W. Campbell. 2006. *Amphibians and Reptiles of British Columbia.* Royal B.C. Museum, Victoria, B.C. 266pp.

Nuszdorfer, F.c., K.L. Nuszdorfer, A.M. Scagel, K. Klinka, T. Lewis, and R.N. Green. 1994. *Biogeoclimatic Units of the Vancouver Forest Region; Map Sheet 5 of 6 – Southern*

Vancouver Island and Sunshine Coast. Province of British Columbia. Ministry of Forests Research Branch, Scale 1: 250,000.

Nyberg, J.B. and D.W. Janz. (eds) 1990. *Deer and Elk Habitats in Coastal Forests of Southern British Columbia.* Special Report Series 5, B.C. Ministry of Forests, Research Branch, Victoria. 310 pp.

Quayle, J.F., and K. R. Brunt. 2003. *Status of Roosevelt Elk in British Columbia* . Wildlife Branch & Resources Inventory Branch, Min. of Environment, Lands and Parks, Victoria, B.C., Wildlf. Bulletin No. B-106. 31pp.

AGRICULTURE

MAYTA RYN

TALES FROM THE RIVER……

Ian Jones and his family have recently bought a farm on Thatcher Road and will be farming on the floodplain of the Nanaimo River. Ian was raised in a family that was active in farming as a way of life and subsidized their farm losses with outside incomes. In contrast, Ian farms for a living. After taking a two-year course in Agricultural Technology, he started looking for a farm. It is not easy for a young person to become a full time farmer in British Columbia. Ian started with a home on a half-acre in the Cedar area and leased nearby acreage in order to farm. He was making his living farming, but the larger acreages were priced above what they would return as agricultural income. Finally, after twenty years of making a living farming and building up his equity in smaller acreages, he found 36 acres that was priced as a working farm and included a house that was large enough for his growing family, the buildings that he needed to store his equipment, animals and crops, and land capable of providing the basis for a mixed farm producing hay, beef, chickens and berries. He now owns one of the best pieces of farmland in the Nanaimo area and has realized his dream.

OVERVIEW

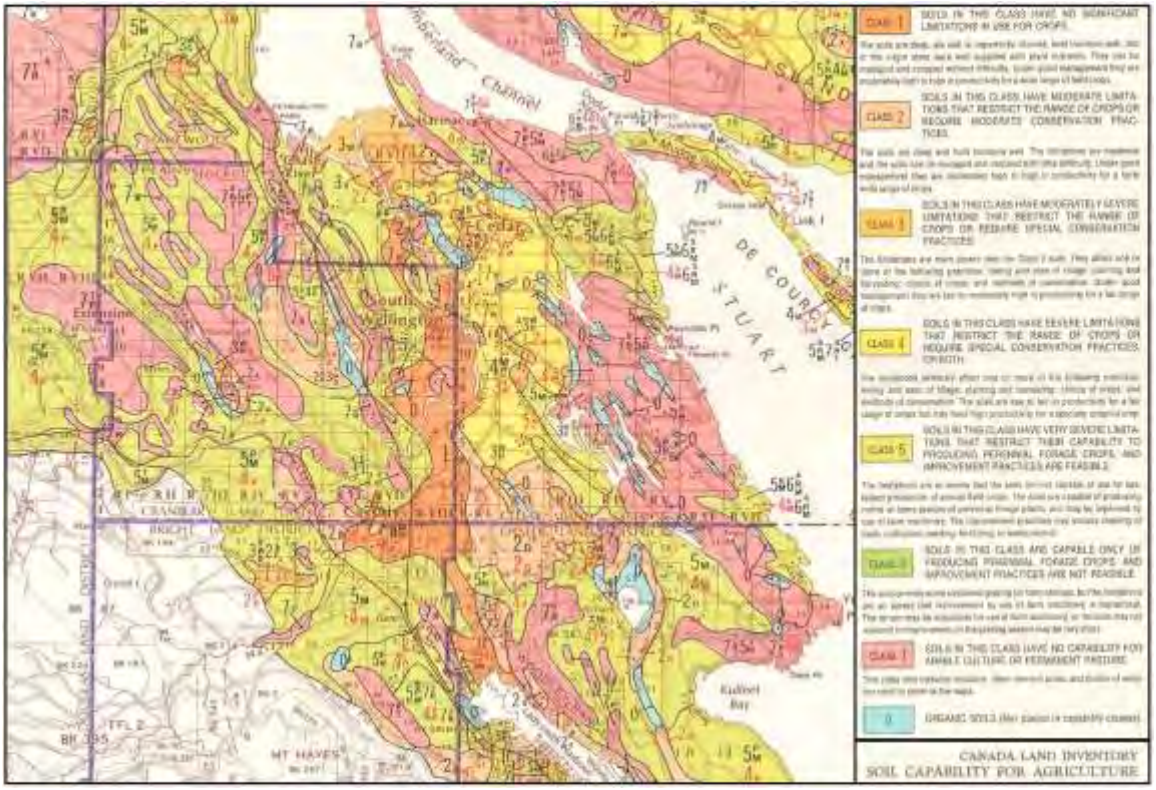
The lower portion of the Nanaimo River is located in the Cedar area of the Regional District of Nanaimo (RDN). This area was developed for farming in response to the needs of the industrial City of Nanaimo. The families who were brought out to mine the coal in Nanaimo needed food and in those times, by necessity, food was produced locally.

In the late 1800s and early 1900s, a farmer could make a good living supplying the citizens of Nanaimo with their milk, fruit, and produce. Some of the best farms were developed on the floodplain and estuary of the Nanaimo River. The floodplain still has a number of very productive farms and the agricultural land in the estuary is divided between resident landowning farmers, and land leased to farmers by the Snuneymuxw First Nations.

After the floodplain and estuary, the next best agricultural land was developed by draining marshes. In contrast, the forest soils on the uplands had to be heavily enriched with manure and fertilizer to be productive.

Looking at Map No. 1, you can see the floodplain of the Nanaimo River has Class One soil which is the highest classification, while most of the rest of Electoral Area A has lower quality soil of Class Four or Seven. The Class One alluvial soil along the Nanaimo River is not only rich in nutrients, it is also unique to the area and rare on Vancouver Island. The soil allows a farmer to extend the growing season because the water from the winter rains drain away in the early Spring, instead of being trapped by a layer of impervious clay.

Most agricultural areas along the Nanaimo River are subject to flooding, but the area where the farmer in "Our Nanaimo River Story" is farming is protected by dikes that were built in 1962 to manage the Harmac water system.



Map No 1: Soil Classification Map for the lower Nanaimo River.

From 1974-76 most of the agricultural land in British Columbia was put into an Agricultural Land Reserve (ALR) with the intention of restricting development in order to preserve it for agricultural purposes. With the globalization of food production and the pressures of urbanization, increasing amounts of agricultural land are being withdrawn from the ALR[9]. However, the lower portion of the Nanaimo River is still rural in character and most of its agricultural land remains in the ALR and is being actively farmed or remains available for farming. In fact, over 50% of the Cedar area is in the ALR.

Electoral Area A (Figure 2), which includes the lower portion of the Nanaimo River, has just completed a new Official Community Plan (OCP) that stresses the value of agriculture to the community and the desire to retain and not develop agricultural lands within the ALR. Here are the relevant sections of the OCP:

[9] Editors Note: since 1996 there have been six applications to remove land from the agricultural land reserve in Electoral Area 'A', of which three have been approved, for a total of about 66 ha of land. Information provided by Roger Cheetham to the Regional District of Nanaimo, March 23, 2009.

Electoral Area A Official Community Plan

5.0 Creating a Local Food System

Electoral Area 'A' has deep agricultural roots and strongly desires to maintain, enhance, and promote the Plan Area as an agricultural community. Plan Area residents wish to support agriculture and become leaders in local food production as stated in the Community Vision. Significant changes are required to achieve this vision.

POLICIES

2. The Regional District supports the BC Land Reserve Commission's mandate of preserving and encouraging the development of agricultural and forest lands.

3. The Regional District encourages the retention of large land holdings within the ALR … to ensure the economic viability of farming

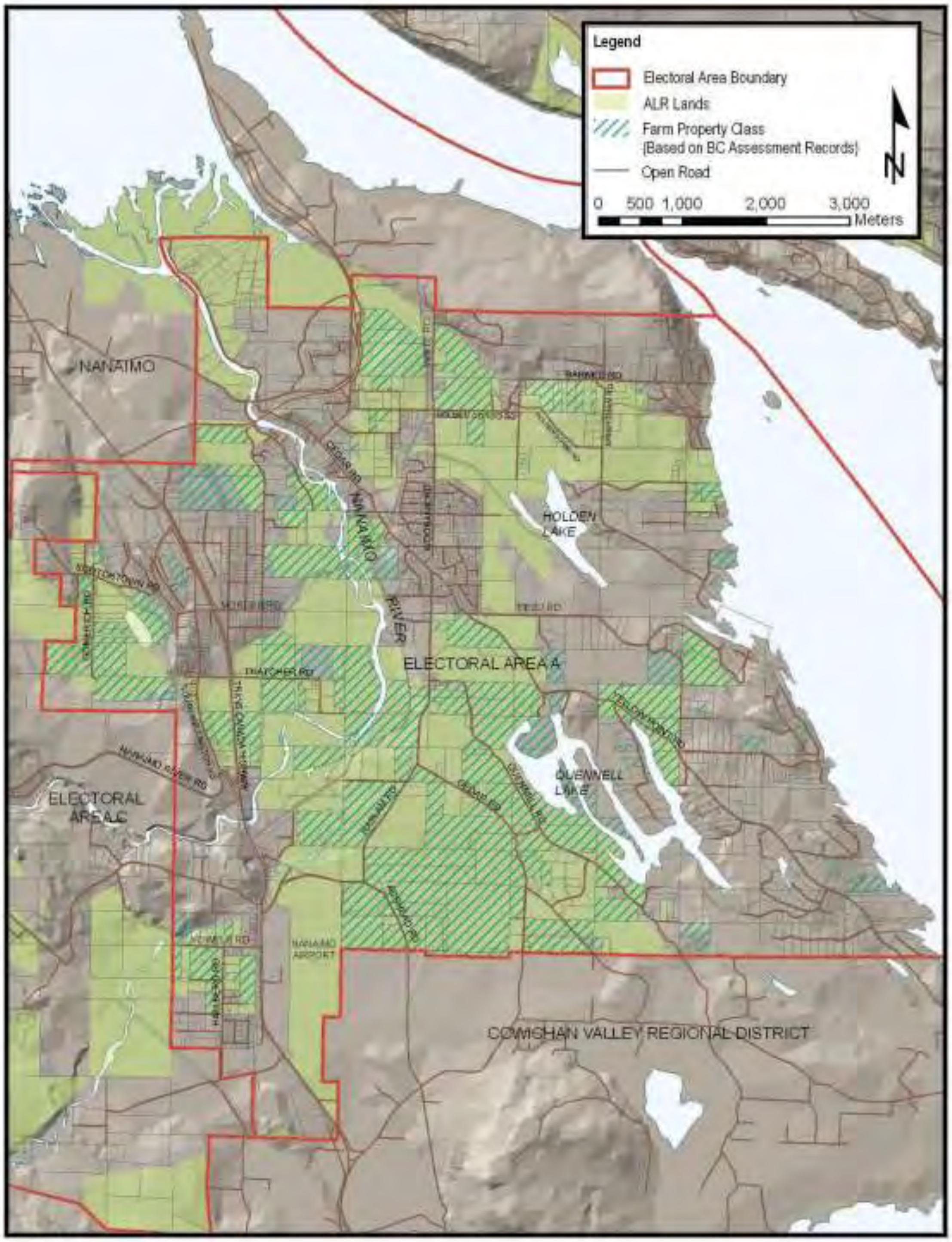
STAKEHOLDERS

- Farmers
- Residential land owners and developers
- First Nations
- Recreational enthusiasts
- Fish and wildlife
- Agricultural Land Commission
- Regional District of Nanaimo
- City of Nanaimo
- Conservation organisations
- Consumers of locally produced food

The lower portion of the Nanaimo River is increasingly attractive to residential property owners and developers. Having the agricultural land within the ALR slows, but does not stop development. While the Electoral Area A OCP supports retention of agricultural lands, the RDN and local residents have no jurisdiction to enforce this vision. Decisions to remove lands from the ALR, and make them available for development, are made by the provincial Agricultural Land Commission(ALC). Once removed from the ALR, lands are then subject to RDN bylaws affecting zoning and subdivision.

The Nanaimo River is an outdoor haven for recreational enthusiasts, but not all recreational enthusiasts are respectful of agricultural interests, and the incidents of conflict escalate with increasing public use in the area. Local farmers have expressed concern over noise, and the destruction of their fencing from ATV use. Also, there is the potential for the spread of disease that could affect crops and livestock. Incidences of conflict are likely to increase with increased recreational use of agricultural lands. Recently when maps of potential recreational trails were published in the Area A OCP, there were misunderstandings between recreationists, who then believed that the trails were already open to the public, and land owners who had not been consulted or advised in regards to potential trails.

Farmers committed to caring for natural areas on their properties are not offered incentives to offset the financial burden associated with protecting or restoring important wildlife and plant habitats. Respecting riparian areas along the Nanaimo River takes productive agricultural land out of a farm without compensating the farmer. In fact, farm property taxes are based on the use of the land and, where land is taken out for a riparian area, the farmer not only loses income generated by that land, but also suffers a tax increase because the land is no longer being farmed. In addition, farmers also come in conflict with wildlife. Black-tailed Deer and Canadian Geese can do a lot of damage to crops and the increasing urbanization of this area and the values that accompany urbanization, make it very difficult for farmers to control wildlife on their farms.


Legend
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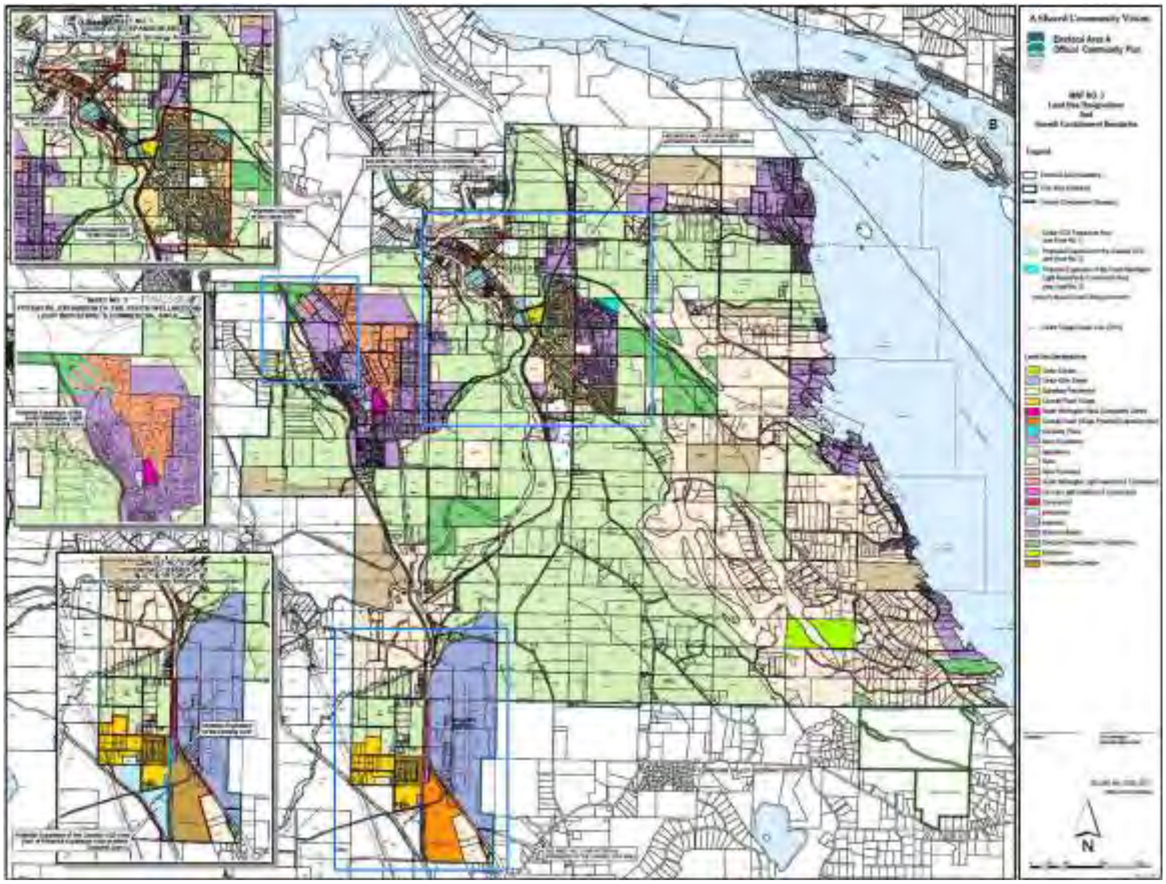
QUENNELL LAKE
ELECTORAL AREA C
NANAIMO AIRPORT
COWICHAN VALLEY REGIONAL DISTRICT



RISKS AND IMPACTS

The biggest negative impacts to agriculture along the Nanaimo River have been urbanization and globalization, and this trend is likely to increase.

The Cedar area started out as a rural farming community developed to feed the residents of the City of Nanaimo. The first push for urbanization came with Harmac and the demand for residential development close to this workplace. This sparked the growth in the 1950's of the village centre with three general stores and a bakery, surrounded by residential lots serviced by a community water system. Marsh land around York Lake that had been drained for produce farming came out of production and was surrounded by commercial and residential lots. Once established, the community water system grew and more residential lots were serviced.

Between 1950 and the present, growth has been slow as Nanaimo looked north for development. However, Nanaimo is increasingly looking south and several large developments are being planned for this area which could have certain impacts on agricultural land in the area. There is concern about the amount of groundwater available for continued residential development, it's not limitless, and it is needed for agriculture. Also, once services are extended, there is incentive to continue development which brings pressure to remove land from the ALR.

The new OCP sets Cedar Village within an Urban Containment Boundary directing growth within the boundary and restricting growth outside.

The other big negative impact on agriculture in this area has been globalization. In the early 1900s, a farmer made a decent living producing milk, meat, fruit and produce for the local market. Now the citizens of Nanaimo buy inexpensive produce from California, Chile and other parts of the world that is produced through large scale agriculture, making it difficult for Cedar farmers to compete. While land remains in the Agricultural Land Reserve, it is increasingly farmed as an estate rather than a productive working farm.

Increased awareness of the impacts of food from afar are turning people's attention towards locally produced food and farmer's markets are flourishing in the region, notably the Cedar Farmer's Market at the Crow and Gate Pub. Hopefully this trend will continue and increase the opportunities for local farmers to make a living from farming.

OPPORTUNITIES

The citizens and governmental bodies of the Regional District of Nanaimo and the Province of British Columbia need to do more to preserve and encourage agriculture within their jurisdictions. First of all, the Provincial Government needs to support the Agricultural Land Commission in its mandate. Hopefully, the recent review of the Agricultural Land Commission will provide the vision and financial support for preserving farmland throughout B.C. Secondly, the Nanaimo Regional District needs to get more active in developing and supporting an agricultural plan for the district. An Agricultural Advisory Committee has been formed and, along with consultants and regional district staff, is proceeding with the development of an agriculture plan for the region. The process will involve establishing an inventory of agriculture and farming activities and the issues that need to be addressed in order to achieve a vibrant industry, and then developing strategies/actions to ensure agricultural planning goals are met. Lastly, the citizens need to show their support for local farming by buying food produced locally whenever possible and by supporting the OCP's vision of preserving agricultural land.

INFORMATION GAPS

The citizens and the governments of the Regional District of Nanaimo, the Province of British Columbia, and Canada as a whole need to know more about where their food comes from and how it is produced. Citizens will only be interested in buying locally if they understand the value of food produced by local small scale farms, as well as the consequences of relying on food produced at factory farms in Canada and throughout the World. Governments will only support agriculture through legislation if they understand the benefits that local farms bring to their goals of sustainability, community health, and prosperity. Education, increased marketing of local produce, and community commitment are needed to make local agriculture along the Nanaimo River viable

REFERENCES

Official Community Plan for Electoral Area A published on The Regional District of Nanaimo website.

Forest Resource Management

Domenico Iannidinardo, Ken Epps & Morgan Kennah

Forest resource management in and around the Nanaimo River watershed

HISTORY OF FOREST DEVELOPMENT

The forest land within the Nanaimo River watershed was originally owned by the E & N Railway and acquired by the Victoria Lumber Company and Comox Logging & Railway Company respectively. Victoria Lumber and Manufacturing Company (predecessor to Island Timberlands) established a separate logging division in 1941 and joined forces with Comox Logging Company (predecessor to TimberWest) in 1945 to commence railroad logging in the watershed on their respective ownerships. The rail cars would then travel to their respective log dumps at Ladysmith and Chemainus harbours.

Figure 1: E&N Land Grant illustration (1).

Railway logging was discontinued in the Jump Creek drainage in 1969 and the Nanaimo Lakes area in the mid-eighties. There were short periods of no activity including the transition to off-highway log trucks, then soon after that, further change to highway log trucks.

Harvesting in the lower Nanaimo River watershed dates back to 1900, but was limited in extent until post-war railway logging began. This transportation innovation for the region facilitated initial harvesting into the upper watershed. Harvesting has since been fairly constant, with an increased rate occurring from the mid-sixties to the mid-eighties. Beginning in the 1990s, harvesting of second growth stands and planting third rotation crops was commonplace. Today, two major forest companies and many Forest Professionals maintain a strong and cooperative working relationship in managing this spectacular resource.

OVERVIEW

Forest management involves consideration of how forests meet the social, economic and ecological objectives established by the landowners and society. Forest management requires an understanding and application of a wide range of tools, skills and techniques based on knowledge of complex and dynamic ecosystem functions. Forest value is most clearly quantified by the valuation of the timber resource; it is further qualified, however, by a range of intrinsic values and ecosystem services that cannot be as clearly defined in monetary terms.

Management of the forest resource maintains past, present and future significance to the Nanaimo River watershed. Most of the land ownership in this watershed originated from the Esquimalt & Nanaimo (E&N) Railway lands granted to coal barons of the late 1800s as payment to build a mainline railway up Vancouver Island from Victoria (Figure 1). Settlement of Vancouver Island began to occur as the provincial government had intended by the transaction. As the E&N line progressed north, it became clear that most of the land in this large tract had higher values for its timber than coal. Because the E&N Railway was focused on mineral values it began slowly selling or leasing parts of the railway lands to logging companies in the early 1900s. It was after World War II that railway branch lines headed west into the watershed, bringing loggers deep into the valley. The railway supported log transport – a significant change in the forest industry during the twentieth century (Figure 2).

Figure 2: Comox Logging & Railway Co. crew photograph with timber locomotive.

Figure 3 provides a visual depiction of the Nanaimo River watershed, detailing lakes within the area and land ownership boundaries between the private managed forest land areas and other land use categories. Areas delineated as private managed forest land are actively managed for their forest value, either by Island Timberlands or TimberWest, comprising about 85% of the 84,000 hectare watershed. Forest cover is renewable over time, with regeneration cycles lasting on average from 50 to 90 years for the Nanaimo River region. Actively managed by Forest Professionals[10], the relatively dry, western hemlock ecosystem complexes that dominate the area are dynamic, renewable, and common within the greater landscape of central Vancouver Island.

How trees grow is the dominant predictor of forestry. Foresters use their understanding of growth rates and various factors such as weather, slope, aspect, soil types, and climate variability to project thousands of individual stands throughout the Nanaimo River watershed over many decades. This process helps maintain a sustainable average annual cut and minimizes disturbance to human and ecological stakeholders by dispersing harvesting throughout the watershed. Consider a modern logging truck with its typical forty cubic meter (m^3) load of timber. Depending on site location in the watershed, growth rates range from 2 m^3 per hectare (ha) per year (yr) to 12 m^3/ha/yr. These growth rates confirm that the opportunity for forest resource management within the Nanaimo River watershed is in one of the most highly productive forests in Canada and underscores it as the principal industrial resource in the watershed for the foreseeable future.

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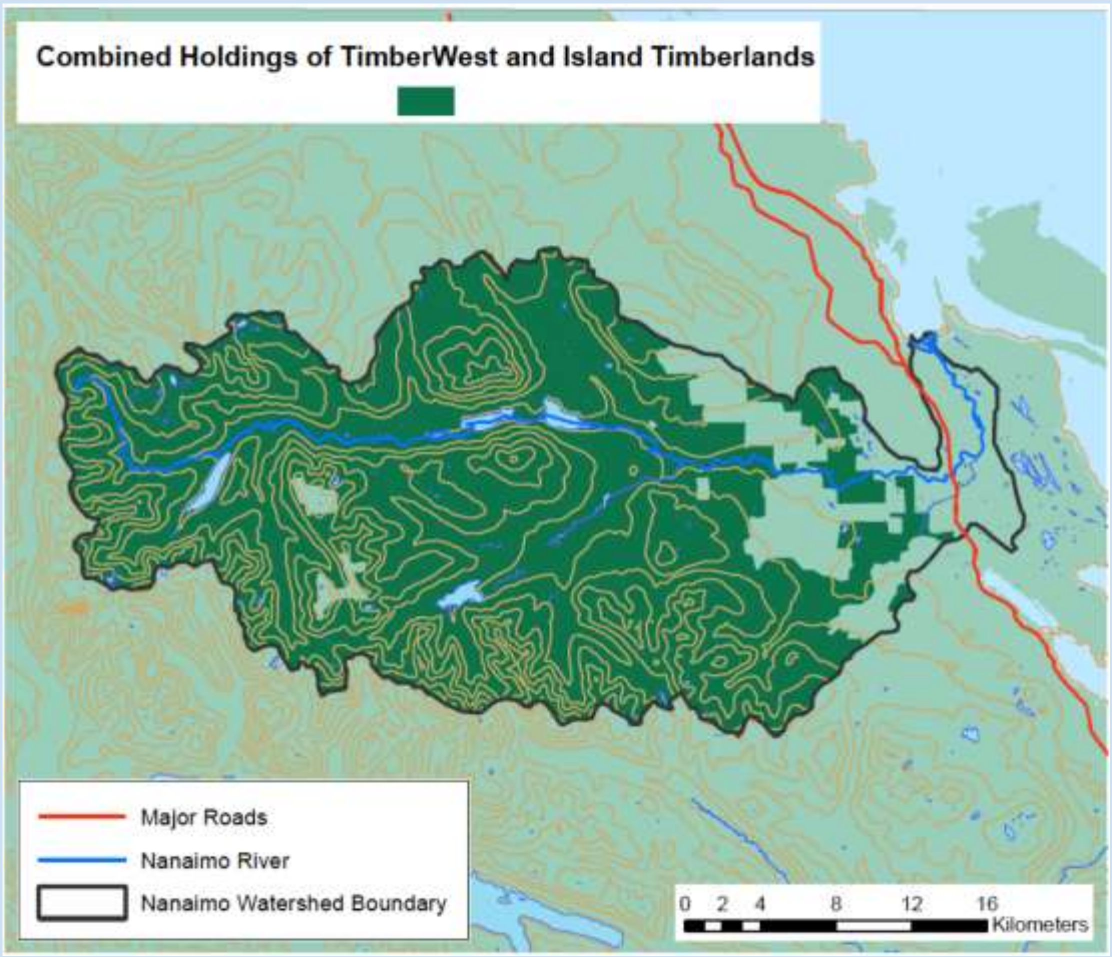
[10] Members of the Association of BC Forest Professionals are Registered Professional Foresters (RPF) or Registered Forest Technologists (RFT). Details at: www.abcfp.ca

Figure 3: Private managed forest land of TimberWest and Island Timberlands within the Nanaimo River watershed.



Forest resource management is dependent on a multitude of factors, of which economics of stand management are important. Timber and wood product customers' desires and export/import dynamics (from regional to global in destination), foreign exchange rates, and the broader investment climate all play a role. The two major forest companies in the Nanaimo River watershed are certified by third-party organizations for their environmental and safety management, above and beyond regional, provincial and federal legislative requirements. The Private Forest Landowners Association (PFLA) is a not for profit society representing the owners of 96 percent of Private Managed Forest land across BC, promoting responsible forest stewardship on BC's private forest lands. As PFLA members, Island Timberlands and TimberWest are committed to protecting the key public environmental values of fish, water, reforestation, soils and critical wildlife habitat (2) as part of creating the optimal mix of products.

The provincial government and the PFLA have worked together to develop an innovative regulatory model for BC's private forest lands that maintains environmental values through a cost-effective administrative and enforcement structure. The Private Managed Forest Land Council is a government agency established to oversee the Managed Forest Program. It annually confirms that landowners are attaining their management commitment, including ongoing audits of practices. Attracting more land into managed forest is an efficient way for government to increase forest stewardship while providing incentives for landowners to manage land to high environmental and economic standards.

REFORESTATION AND SILVICULTURE

Before trees are harvested, Forest Professionals develop plans for the reforestation of each area. Most areas are planted, but some may be naturally regenerated with seed from adjacent stands if the conditions are favourable. Where planting is proposed, the tree species selected for planting need to be ecologically suited to the site, and then the Forester must determine the age and size of seedling best suited to the area considering site conditions such as potential for brush competition and ungulate browse damage. Seedlings are ordered from nurseries that specialize in growing trees under specific reforestation schedules to ensure they are ready for planting once timber harvesting is complete.

The companies provide the seed to each nursery. Early reforestation efforts included the collection of tree cones from wild stands of trees from similar elevations to provide the seeds for the nursery. Today, much of the seed comes from seed orchards where very good quality trees are used as the source for the seed. Based on field testing, the use of this high quality seed improves tree growth, thereby helping to re-establish harvested areas sooner and provide higher timber yields than would be attained otherwise.

Once an area has been harvested and any necessary site preparation (e.g., removing debris accumulations or competing brush) is completed, skilled planting crews are hired to plant the seedlings previously ordered and grown in the nursery. Planters are instructed which species to plant, where to plant them, and at what density (spacing) across a harvest area. At this stage, company representatives monitor planting operations closely to ensure the reforestation plan begins properly.

Foresters' work continues long after an area is planted. There may be a need to provide some additional browse protection for the seedlings, or have brushing carried out in parts of some plantations to reduce competing vegetation. Moreover, plantations and other forest areas in the watershed are also monitored for risks that may arise at any time in the harvest cycle. Wildfire, for instance, is one risk that requires careful preparation and supervision. Monitoring also occurs for insects and disease that can occasionally impact new plantations and older forests. And, in certain cases, stand tending activities include applying nitrogen fertilizer to supplement growth rates, either at the time of planting or around seven years prior to harvest.

STAKEHOLDERS

In addition to the land owners/managers, there is a wide array of stakeholders that can influence the management of the forest value, beyond the forest management entity itself. In turn, these stakeholders may be affected in some way by the management of the forest resource. Stakeholders include, but are not limited to:

- Local to global, motorized and non-motorized recreational enthusiasts (e.g., hikers, bikers, skiers, campers, all-terrain vehicle users, hunters, and fishers);
- Research scientists;
- Non-timber forest product harvesters (e.g., bough-cutting or salal harvesting for decoration, mushrooms, berries, etc...);
- Drinking water purveyors (from small household systems up to the full scale of City of Nanaimo);
- Wildlife managers (e.g., government, as designated authority on behalf of endangered species and associated critical habitat);
- Land trespassers (associated with illegal garbage disposal, property theft and vandalism – to list a few);
- Professional practitioners (e.g., foresters, biologists, engineers, and geoscientists);
- Employees, contractors, consultants, suppliers;
- First Nations;
- Local community residents; and
- Community interest groups (e.g., watershed enhancement, fish & game clubs, breeding bird counters).

Each of these stakeholder groups has a set of objectives that may be equivalent, complementary, conflicting and/or mutually exclusive. Each stakeholder's objectives may have a varying impact on forest resource management in the area of concern, which depending on one's perspective, may be purely positive, negative, or present a trade-off. For instance, non-motorized recreationalists may present an income stream to the land manager for use of their property; however, this group of recreationalists may cause detrimental impact on the forest ecosystem (e.g. unwanted trail creation reducing reforested area, trash deposition, risk of wildfires, and invasive plant species introduction).

The most accountable stakeholder group, both affecting the forest value and being affected in response, is the land owner and land manager. As private forest land owners and managers, the companies hold the overarching responsibility of ensuring a balance of values is implemented into resource planning. As with any landowner, each forest company in the Nanaimo River watershed is better able to consider and support the interests of other stakeholders or neighbours when it is successful at fulfilling its basic operating objectives.

RISKS AND IMPACTS

Previous land policy decisions and broader market conditions have had the greatest net effect on management of the forest value. Trees grow at predictable rates over long periods. Legislative initiatives usually do not. Most agree that any policy or practice implemented in the forests of the Nanaimo River watershed should be informed by the best science. Forest managers need the freedom to learn about the land and adapt their practices to meet ever changing forest conditions, the economic operating climate and the broader market (3).

Going forward, forest management needs to continue to have the respect of its neighbours and legislators just as much as it needs the respect of its customers. Recently harvested areas need time before the planted seedlings will turn the area green again. (This cycle of sustainable forestry has already happened at least once in the Nanaimo River watershed.) Foresters working on these lands must not only continue to operate at the highest professional level, but communicate that with direct neighbours in the "urban interface" and indirect neighbours in our legislatures representing the broader public. Maintaining legislation that allows flexibility and accountability will ultimately ensure the best certified natural resources are provided to our many customers. Moreover, allowing innovation will encourage landowners to respond to increasing demands for non-timber forest resources.

Both companies depend on sales of timber to generate a return on their investment. Customers range from the local to the national and international. Sales to a specific market will vary depending on current market values, which change considerably over time. Having the flexibility to pursue various markets creates opportunity to find the best market value for the product. Receiving globally competitive values allows operations to remain viable, with payments to contractors, employees, suppliers and the government (taxes) continuing to contribute to the local economy.

Pressures for alternate land uses can change the amount of forest land available for forestry purposes. These "non-forestry" use areas can include: special management for drinking water storage facilities, habitat reserves, recreational use, roads, power lines, mineral extraction, housing and other uses competing for specific areas of land. These changes are often in response to the needs of the local community and/or government and require considerable planning and a co-ordinated effort to implement.

OPPORTUNITIES

Adaptive management means accepting that there is more to learn and incorporating these opportunities for improvement into your business. Both major forest companies operating within the Nanaimo River watershed work closely with a variety of research groups to generate new data that informs how forestry is done.

For example, both companies participate with in-kind (staff resources) and financial contributions towards the Marmot Recovery Foundation (4). Vancouver Island marmot colonies share this home in provincial ecological reserves as well as appropriate habitats on private managed forest land. Additionally, goshawks and marbled murrelets are birds that call parts of the Nanaimo River watershed home. To better understand these important species, participation in research efforts is ongoing with government agencies and other groups. As resident stakeholders in our management, learning more about how such species are affected by forestry activities continues to inform improved operational decisions and, ultimately, better stewardship.

Enhancing and securing forestry in the Nanaimo River watershed needs good caretaking by the landowner and the broader public that benefits from its resources. Although timber is a private resource, many of the other resources associated with the land are public. For instance, water, fish and wildlife belong to everyone. Educating those who access these resources over private land about the importance of conservation is important. Improper use of our land by some members of some user groups has resulted in millions of dollars spent by the forest companies to fight human-caused wildfires and invasive plant outbreaks such as scotch broom. By voluntarily allowing access to company-sponsored campsites, the forest companies are encouraging a way to allow people to enjoy private forest lands responsibly. Ongoing coordination with schools and community organizations is another way to raise appreciation of the multitude of values on these forest lands.

INFORMATION GAPS

Trees, and the forests they create, are the dominant features on the landscape because they are resilient. Forests can tolerate great ranges in weather patterns, unlike annual crops that do not have the luxury of tolerating an occasional extreme year. However, more effort is being directed to understanding how global climate variability may require new foresight in planning future forests. This is a priority for Forest Professionals as responsible managers of the forest value.

A changing climate requires Forest Professionals to consider that tree growing conditions in the future may be different than those experienced today. Trees species selection for planting may change. Forest fires may become more common. Winter storms may be more severe. Using computer models run through our geographic information systems allows testing of scenarios to show when and where practices might need to change on the landscape. Computer modeling can also help show where rare species may reside or invasive plants could spread in the watershed. All of this requires continuous learning and adaptive planning to maintain the best possible stewardship of private managed forests in the Nanaimo River watershed – stewardship that is in the interest of the forest companies and the public.

REFERENCES

Literature Cited

1. Taylor, W. A. 1975. A History of The Esquimalt and Nanaimo Railway Land Grants, The Railway Belt and The Peace River Block. Crown Land Registry Services, Victoria.

2. PFLA. 2011. PFLA PFLA: Public Values. Accessed June 22, 2011 from: http://www.pfla.bc.ca/environment/.

3. Cashore, B., G. Hoberg, M. Howlett, J. Raynor, and J. Wilson. 2001. *In Search of Sustainability: British Columbia Forest Policy in the 1990s.* UBC Press, Vancouver, 61-93.

4. Marmot Recovery Foundation. www.marmots .org

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- Island Timberlands: Morgan Kennah, Manager, Sustainable Timberlands and Community Affairs – MKennah@IslandTimberlands.com
- Private Forest Landowners Association (PFLA): Rod Bealing, Executive Director – rod.bealing@pfla.bc.ca.

RECREATION

MATTHEW KELLOW & OTHMANE RAISSOUNI CHERIF D 'OUAZZANE

INTRODUCTION

This chapter touches on and outlines some of the recreational values that occur within the Nanaimo River watershed.

This chapter:

- Highlights and explores many of the recreational values of the Nanaimo River watershed.
- Discusses the importance of the Nanaimo River's recreational values from the perspective of those individuals who have knowledge about those values.
- Outlines the positive and negative impacts of recreation on the river and explores perceived threats to recreation through stakeholder questionnaire.
- Provides a snap shot into the unique opinions of recreational users by the way of field research.

The field research specifically targeted swimmers in an effort to better understand this popular recreational pursuit.

HISTORY OF RECREATION IN THE NANAIMO RIVER WATERSHED

Recreational activities have occurred in the Nanaimo River and surrounding watershed for as long as humans have frequented the area. Although most information on recreation in the area is anecdotal, or widely dispersed, some observations are possible. For example, it is clear that the first settlers to the area have been swimming in the river since their arrival. A small ski hill operated on Green Mountain from 1963 until 1985 (1) and people have been white water canoeing and kayaking on the river since the early 1970's (2). Morden Colliery Historic Provincial Park was established in 1972 to protect what remains of the area's rich coal mining history and now serves as a location for visitors to hike and access the river (3). It is also clear that recreational hunting and fishing have been taking place within the watershed since humans have been in the area, as related by residents recounting stories of themselves or family members hunting game within the watershed or taking fish from the river.

CHAPTER STRUCTURE

This chapter identifies and highlights the different recreational activities and their associated values that take place within the Nanaimo River watershed. The research consisted of participant interviews and a survey delivered in the field.

The interviews were used to capture the diverse perspectives of individual study participants who could speak to their associated recreational value. These recreational activities were identified through a process of brainstorming within the NALT Baseline Sub-Committee and a list of contacts was generated for identifying potential participants in the study. Potential participants were then sent an email from NALT staff stating the goals of the project and further information explaining that a representative from NALT would contact them to request participation in the study. NALT representatives then contacted potential study participants, by email, phone, or personal interview and administered the stakeholder survey (Appendix 1). The completed surveys were then returned and themes identified. The themes where then grouped together and are presented in this chapter under the heading of Stakeholder Interviews.

The fieldwork portion of the research consisted of three days spent in the field at different locations along the Nanaimo River. The purpose of the fieldwork was to locate and document actual recreational river users to discover how many people were at the river at a given time on a given day, what recreational activities these individuals were participating in, and to better understand the recreational values of the Nanaimo River. In this case, the researchers travelled to one of 18 different access points along the Nanaimo River between First Lake and the Cedar Bridge to locate river users and invite them to fill out a short survey (Appendix 2). Once at a specific location researchers would travel from the parking lot to the river and invite all river users encountered to participate in the research. The goals of the research were explained to potential survey respondents and a consent letter was offered to those interested in reading more about research. The survey was administered in the field and normally took under 2 minutes to complete. The data gathered from the completed surveys was then imputed into statistical software for analysis. The results from the fieldwork are presented in the section titled *Nanaimo River Field Work Results.*

STAKEHOLDER INTERVIEW/QUESTIONNAIRE

Within the Nanaimo River watershed recreational pursuits are diverse. Recreationalists are participating in a variety of different activities, with different frequencies of use, and at different times during the year. The stakeholder interviews were an opportunity to gather information from individuals who represented a specific recreational value. The original list of stakeholders who were contacted for inclusion in the research was lengthy. Many of those contacted were not interested in the project and multiple invitations for inclusion were made in attempt to include as many different voices as possible. That being said, the recreational values presented here are in no way complete and some recreational activities that take place within the Nanaimo River watershed are not represented in this document. In the following section each recreational value, where information was collected, is highlighted and explored individually.

COMMERCIAL CAMPGROUNDS

Sunset View from the Café Deck at Living Forest Oceanside Campground and RV

Overview: camping is a popular recreational pursuit within the Nanaimo River watershed, and three commercial campgrounds are situated along the Nanaimo River. One of those campgrounds, Living Forest Oceanside Campground and RV, is located on the lower reaches of the Nanaimo River within the estuary. David Littlejohn is the owner of Living Forest Campground and in this section he provides the perspective of a campground business owner along the Nanaimo River. David is also a longtime resident of the Nanaimo River having lived there since 1971.

Living Forest Campground relies on tourists for its business so tourism is another interest directly connected to the value of camping that David identified. David explained that Living Forests Campground is a location where outdoor-based activities take place including recreation, recreational vehicles (RVs), camping, kayaking, swimming, and exploring.

Importance: David believes that the business of Living Forest Campground is very important to the Nanaimo River and the greater city of Nanaimo. He explained that Living Forest

Campground grosses approximately $1,200,000 annually, and he estimates that the local economy of Nanaimo benefits from roughly $5,000,000 contributed from tourists to the campground. David went on to say that Living Forest Campground is one of the few destination-based businesses in Nanaimo, and as a result the city benefits from the very nature of his product.

Positive and negative impacts: David thought that within the Nanaimo River Estuary a slowly building long-term trend was an increase in the protection of the estuary. This included the cleaning up of the estuary and as a result of a cleaner estuary an increase in biodiversity would occur. Because the campground is situated along the Nanaimo River Estuary David also believes that the "campground has the added responsibility to keep the estuary beautiful and pristine". David also explained that although the permit for log booming was recently extended for 20 years, he believes this activity would eventually be moved to a different location.

David stated those who benefit from recreational values include: fishermen, hunters, kayakers, swimmers, naturalists, and his customers who participate in this activity. He believes the group who most negatively affects the value of recreation is that of the industrial users (forestry). Dave explained that forestry including clearcut logging and land development had the biggest impacts on the value of recreation within the Nanaimo River watershed. He further explained that logging in the watershed resulting in forestry companies selling off their private lands for large scale development and this action had the biggest negative impact on the value of recreation.

David went on to explain that lead shot used by hunters within the estuary was still a concern, and that log booming within the estuary had negative consequences on the river and was the single largest threat.

Opportunities: David explained that as much publicly owned land along the river was needed to secure and enhance the value. He also stated that the provincial government should consider swapping crown land for private land that is currently owned by the two forestry companies within the Nanaimo River watershed for the purpose of increasing and ensuring public access to the river.

David identified the development of recreational property along the river as the biggest future threat to the river. David believed through the development of residential properties public access to the river would be reduced. The last thing he wanted to have included in our interview was the fear that access to the river was reduced if the steeper canyon sections were to become a park. He explained that parks might want to put up fences and restrict access to the river because of safety concerns and he says this as a potential negative if parks became involved on the river.

RECREATIONAL WHITE WATER KAYAKING AND CANOEING

"The very second I slipped my kayak into the Nanaimo River I knew I was where I was supposed to be. It was January, the river was numbingly cold, it`s banks were still lined with snow and my breath mingled with the misty surface of the river. I took my first wobbly, unbalanced stroke, timidly pulling myself into the river`s current. I took another, this time stronger and before I knew it I learned to tame the current. The face of the Nanaimo River has changed many times since that first wintery day. Now, I continue down the river watching the seasons change, the water rise and fall and friends float by. I have gone in search of other rivers now too; along the way always remembering those first few strokes on the Nanaimo River".

Jessie Paloposki, July 20,2011

Overview: Recreational white water kayaking and canoeing are popular pursuits along different sections of the Nanaimo River. People have been running the Nanaimo River's rapids since the 1970's and on any given weekend when the water is high kayakers and canoeists are on the river recreating. Don Cohen, professor in the Sport Health and Physical Education (SHAPE) program at Vancouver Island University (VIU), has been a long time resident of Nanaimo and has probably spent over a 1000 days on the river in kayaks, canoes and rafts. Don provided the perspective of a recreational white water kayaking/canoeing enthusiast for this section of the document.

The Nanaimo River has a lower section from the Island Highway Bridge down river to the Cedar Bridge that is suitable for beginner kayakers and canoeists. The most popular run is the Mile 16 Bridge to House Rock (White Rapids Rd.) take out and this can be run either by kayak or canoe with different options for available take out locations to shorten the run depending on skill level, water level, or objectives. The Upper Nanaimo River has a creek boating section (very steep gradient for expert kayakers and C1's only) that is becoming more popular.

Importance: According to Don, interest in recreational paddling has increased as the popularity of white water kayaking has increased. There would not be recreational white water kayaking, canoeing, or rafting on the Nanaimo River without access to the river. Recreational paddlers make up a portion of all the recreational users within the watershed; however, these people are a dedicated group and use the river throughout the year.

Positive and negative impacts: According to Don the people who most benefit from white water recreation on the Nanaimo River are the paddlers themselves which include, individuals, recreational paddling clubs (University of Victoria Kayak Club), informal groups, and schools such as VIU. Don believes the groups who most negatively impact the river are commercial industrial water users, municipal water allocation, logging companies, gravel extraction, and the sale of land for private housing developments that potentially reduce access to the river through private property. Don stated that in the past logging practices on private timber holdings has resulted in negative impacts on riparian habitat, water quality, and resulted in higher river temperatures. He further stated that logging close to the river's bands resulted in blow down and debris hazards in the river and had other negative impacts on fish and wildlife. Lastly, Don stated that the sale of private timber holdings for future real estate development could potentially reduce access to the river and increase water allocation from the river that results in lower flows and shortens the paddling season.

ROCK CLIMBING

Overview: Rock climbing is a popular activity that takes place at two established climbing sites above the Nanaimo River. Greg Sorenson is a long time Nanaimo area resident who has owned an outdoor guiding company, taught outdoor skills, helped develop the Nanaimo River climbing sites and now helps in maintaining them and further site development. Additionally, Greg is an area representative with the Climber's Access Society of BC.

"It's all about Atmosphere! The Nanaimo River Climbing areas are picture perfect, serene, another world with Nature's creative side being displayed front and center".

Gregory Sorenson, July 1, 2011

The Nanaimo River climbing site is made up of two different locations called the Sunny Side and the Dark Side that sit opposite each other and are split by the Nanaimo River. The Sunny Side, located off Nanaimo River road, is comprised of conglomerate rock, has five climbing areas with upwards of fifty routes. Most of the climbing routes are easy to moderate in difficulty. Trails have been built and are maintained by local climbers to improve access and reduce environmental impacts to the site. The Dark Side, located off Spruston Road, is comprised of Sandstone, has three climbing areas with more than forty routes. Most of the routes are intermediate to advanced in difficulty.

Importance: The Nanaimo River climbing sites are the busiest climbing locations in the central Vancouver Island area due to the diversity of routes, different styles of routes, ease of access, and the beautiful scenery as the climbing sites sit just above the river. As highlighted by Greg, the Nanaimo River is the second oldest climbing spot in Nanaimo with approximately 4000 climbing days per year. The site has become more popular over the last 17 years as the sport of rock climbing has grown in popularity as a result of the introduction of fixed protection to improve safety.

Positive and negative *impacts*: According to Greg the groups who benefit from the Nanaimo River climbing site are all the recreational rock climbers who use the site, plus users such as VIU's Outdoor Recreation Program, local search and rescue groups, Scouts Canada, climbing outfitters, climbing guides, and those who access the river through the established climbing trails.

Greg believes the groups who have the largest negative impact on the climbing area are the irresponsible people who use the site to party or polluters who leave garbage in the area. These users negatively impact the private land owners and thus threaten the rock climbing opportunities as access could become an issue in the future.

Opportunities: Greg stated improved and continued public access was necessary to secure and enhance the recreational opportunities of the Nanaimo River climbing site. He was not aware of any current efforts to improve access to the climbing site. In closing Greg stated that rock climbing will always be a fringe activity. Although it has increased in popularity over the years, it will become an activity for the masses. He thought this important because rock climbing is generally poorly understood in terms of the inherent risks and environmental impacts. Greg's final thought was that people really need to understand the sport to accurately understand the needs and values of rock climbers.

HUNTING AND FISHING

Overview: Hunting and Fishing in the Nanaimo River watershed is probably one of the oldest recreational pursuits to take place in this geographic region. As logging roads were constructed and access improved up the watershed hunters and fishermen have been enjoying these places. Wayne Hamilton, Nanaimo Fish and Game Committee Chair and Board Director of the Nanaimo River Hatchery provided the stakeholder information on the following section.

Wayne describes how hunting, fishing, camping, and trapping are all very important activities that take place within the Nanaimo River watershed. According to Wayne, in the past these recreational opportunities were much more numerous than they are today. That is to say both the opportunities to catch fish and hunt game have been reduced because of restrictions on access but also the availability of fish and game. Wayne explained the Nanaimo River watershed has been a major hunting area for elk, deer, grouse, cougar and bear for as long as he could remember. Until wolves decimated the deer population, this watershed was a major producer of protein for Nanaimo area residents.

Positive and negative impacts: Wayne explains that the individuals who take part in the activities of hunting and fishing benefit from using the watershed for these purposes. These same people also enjoy camping in the area too. Wayne believes that the logging companies have the most impact on the recreational value of hunting and fishing by seriously restricting or not permitting access to areas that have those values. He believes that logging companies will further restrict public access in the future.

Opportunities: Wayne explains that to improve the opportunities for hunting and fishing within the Nanaimo River watershed, access through land owned by forestry companies will have to be improved. Currently the Nanaimo Fish and Game Club is working with TimberWest to create a system that will improve access and the recreational opportunities on their private property.

WALKING/NATURE VIEWING/HIKING

Overview: Many of the Nanaimo River's recreational users go to the river and surrounding watershed to explore, walk their dog, view wildlife, practice photography, hike, snowshoe, cross country ski, sunbathe, pan gold, climb peaks, and other non motorized pursuits. Jessica Wolf, a local biologist and nature interpreter, has spent a considerable amount of time at the Nanaimo River pursuing some of the activities listed above. A 10-year resident in the Nanaimo Region, Jessica enjoys hiking in the watershed during all seasons, photographing nature, and harvesting wild mushrooms and plants for food. She is concerned about the health of the river and currently volunteers with NALT on the Nanaimo River project. Jessica completed a Nanaimo River questionnaire and her comments are presented here to offer her perspective on these diverse recreational activities.

Positive and negative impacts: Jessica believes that one of the biggest threats to recreational uses of the watershed is the fact that virtually all of the land along the river is in private ownership. Some private land owners post no trespassing signs to prevent river access via their property. Jessica explains that one forest company who owns a significant portion of the upper watershed is in the process of removing a sizable portion of their lands from a forestry designation and selling this property for residential development. This trend will negatively affect access to the river and the possibility of creating a contiguous trail system along the river.

While Jessica wants to ensure people have access to the river, she is also concerned about the impact recreational users can have on local species. For instance, dogs can chase and impact the survival of deer or nesting birds, and people can displace elk from their feeding grounds. Jessica has noticed that locations with heavy recreational use have experienced accelerated soil erosion and trampling of vegetation. This is particularly damaging to sensitive wildflower meadows with shallow soils. Jessica is also concerned that the lack of toilet facilities in high use areas next to the river could potentially introduce disease and impact water quality.

Additionally, Jessica notes that there is conflict between different recreational user groups. For example, hikers/swimmers who value quiet nature experiences are disturbed by the loudness of dirt bikes and ATVs and their ecological impact. Even within the same recreational user group values can be different. Jessica notes that some people who swim at the river leave a mess while others pack out all their trash.

Jessica further states that recreational users have a large impact on private landowners. Recreational users typically trespass on private property to access the river. Some of these users will camp, party, cut down trees, start fires, and leave their garbage behind for private landowners to deal with. The issue of liability is also of concern when individuals are recreating on private land.

"I seek the river as a place of rejuvenation, solace, inspiration and joy – of connection to my place in nature".

Jessica Wolf, June 14, 2011

Opportunities: Jessica provides a series of suggestions as to improve this recreational value. Her personal vision is a network of protected wildlife corridors and public trail systems throughout the watershed. The Cowichan River and Englishman River provide local models of collaboration between stakeholders which resulted in protection of significant riparian corridors. Jessica further states that important recreational opportunities in the Nanaimo River watershed need to be identified and mapped, and future acquisition priorities determined. This action would ensure recreational areas are not in areas that will impact sensitive ecosystems and wildlife habitats. Interpretive signage can be of use to highlight and raise awareness about sensitive ecosystem features (like frog/salamander breeding pools, wildflower moss meadows). Jessica believes that the current legal process of removing lands from forestry and rezoning with no public input should be changed as this is impacting the ability to protect recreational corridors in the upper watershed.

Lastly this section concludes with Jessica's own words describing her hesitancy with the creation of a park along the Nanaimo River. "Although I want to see river access secured and wildlife habitat protected, I'm concerned by what happens when you make it into a park. It gets overrun with too many people, and this can lead to significant ecological impact. To date I enjoy that I can find places to be alone in nature at the river. "

EDUCATIONAL VALUES ASSOCIATED WITH RECREATING ON THE NANAIMO RIVER

Overview: Chapter author Matthew Kellow completed this section on the educational values of recreation on the Nanaimo River based on his personal experience and opinions. Matthew works at Vancouver Island University (VIU) as an Outdoor Recreation Technician where he leads outdoor experiences and teaches outdoor related skills to students.

The value of the Nanaimo River as an educational location to teach white water kayaking and rafting skills is unique to South Vancouver Island. VIU frequently uses the river as a location to teach and run field based courses. Specifically, the Outdoor Recreation Program uses the lower reaches of the river to teach introductory river kayaking and as a location to offer sea kayaking programs. The Outdoor Recreation Program uses the middle section of the river to offer a series of white water kayak lessons. This same program runs day-long guided rafting trips on the middle section of river, and uses this same section to offer a spring raft guides training course. The Outdoor Recreation Program has also used the upper watershed for hiking trips and as an access point for the Labour Day Lake/Moriarty Mountain area too.

The Sport Health and Physical Education (SHAPE) program offers course that utilize the lower and middle sections of the Nanaimo River. SHAPE courses that use the river are: SHAPE 118, 142, 190, and 370. All of these courses have student in rafts and kayaks in some form of skills acquisition and leadership training education.

In the past, Thompson Rivers University (TRU) has used the middle section of the Nanaimo River to run some of its Kayak 2 course on. Raven Rescue has used sections of the Nanaimo River to run swiftwater training on. Other kayak schools on Vancouver Island have also used the Nanaimo River as a location to teach white water kayaking.

"I have so many special memories of working with students on the river. Some of my favorite memories include watching bald eagles feed on spawning salmon or the exquisite beauty of running the river in the fall season with the deciduous trees in all their majestic colours displayed along the river's edge illuminating the path down river as the sun begins to set".

Matt Kellow, May 22, 2011

Importance: The Nanaimo River is very important to the value of education through recreation because of its close proximity to the city of Nanaimo and VIU. Most of the river's sections are relatively easily accessed, and the difficulty of the river is perfect for the kinds of experiences educators are using the river to provide. The pool and drop nature of the river makes it unique to southern Vancouver Island. Other local rivers, such as the Chemainus and the Cowichan can be used as locations to stage water based educational programs. However, the Chemainus has less water volume than the Nanaimo and has one short usable section suitable for educational purposes, and although the Cowichan is recognized as a Canadian Heritage River, the sharp bedrock nature of the river bottom makes it more hazardous for students and equipment.

VIU's use of the river has increased over the last 10 years as the SHAPE program and the Outdoor Recreation Program have grown. TRU now visits the river, and river use for educational purposes would be even higher if access and liability were not such large barriers.

Positive and negative impacts: The group who most benefits from the value of education are the students who participate in course that take place on the Nanaimo River. To a much lesser extent the Forestry Companies benefit, because as river users, institutions such as VIU, are an extra set of eyes and ears on their private forestry properties. VIU also pays TimberWest annually for the privilege of using their property to access the river. I don't think anybody is negatively impacted by the use of the Nanaimo River as an educational setting.

The forestry companies have the biggest impacts on this value. The risk of losing access is of real concern as VIU's Outdoor Recreation Program has tens of thousands of dollars invested in kayaks, rafts, and associated equipment to offer students outdoor recreational courses. The risk of forestry companies selling some of their holdings for residential land development is also another impact that will ultimately reduce VIU's ability to access the river. Once the land becomes the property of a developer and ultimately a private residence is constructed on the river, VIU most likely will not be able to access the sections currently used for educational purposes.

Opportunities: Frequent and usable access to the river has to become part of any future residential development. But the most preferred option would be the creation of a class A Provincial Park or another Regional Park. This is an opportunity, but I don't believe anybody is working on it presently. The creation of a river park such as Nahatlatch River Provincial Park, Adams River Provincial Park, or Cowichan River Provincial Park would be the best thing to protect the educational opportunities of the Nanaimo River. A municipal or regional park would be another choice. A park would serve to protect the educational opportunities along the river through improved and long term access and the protection of natural environment. A park would also ensure other values such as public recreation could continue.

FIELD WORK RESULTS

Purpose

Summertime swimming in the Nanaimo River

The purpose of the field work was to locate, document and interview river users to discover how many people were at the river at a given time on a given day, what recreational activities these individuals were participating in, and to better understand the recreational values of the Nanaimo River from the perspective of those at the river. In particular, the fieldwork provided researchers an opportunity to talk to swimmers, one of the most popular activities, and one of the most difficult to accurately represent through stakeholder interviews as presented earlier in this chapter.

The field days consisted of three separate excursions to the river. Two trips were on Saturdays during June and July, 2011 and another trip was made late afternoon midweek during July 2011. To conduct field work researchers travelled to one of 18 different identified access points along the Nanaimo River between First Lake and the Cedar Bridge to locate river users and invite them to fill out a short survey (Appendix 2). A total of 71 surveys were collected over three field days and almost all river users encountered were willing to complete the survey. Sampling was not random and therefore the results should be considered as informative but not necessarily statistically representative of all user groups. However, the results do offer a unique glimpse into a diverse set of recreational users who were encounter over the three days of fieldwork.

Field Work Limitations

The fieldwork portion of the research presented a number of challenges that limited the scope of the results. During the first fieldwork day researchers spent the day travelling Nanaimo River Road and stopping at areas that had cars and attempted to locate and speak with recreational river users. This strategy let us encounter users who were white water canoeing, hiking, camping, or just sitting in their cars enjoying the view. However, much time and effort was expended finding these people and after six hours of fieldwork only 7 surveys were completed. On the next two fieldwork days a different strategy was adopted where researchers intentionally selected a sunny hot day, split up, and went to different locations that would be populated by swimmers. This technique increased our sample size and got us talking to more people.

The very nature of some of the recreational pursuits taking place in the Nanaimo River watershed makes finding these people through fieldwork techniques very difficult. Therefore, a limitation of the research is that the field work essentially targeted those who could be accessed easily in high numbers, such as swimmers, to the exclusion of watershed users who were difficult to find; or who simply were not there because their given recreational activity does not take place during the months of June and July (for example, hunting).

Results

Results are presented below in relation to the questions contained in the survey. For each survey question a graph or table is provided and a short description of the results follows each figure. A final section at the end of the chapter offers some conclusions as to what was discovered during the fieldwork.

Profile of Study Participants

Table 1 shows that a small majority of respondents were male (58%). The greatest number of respondents (41%) fell between the ages of 20 – 29 years old, with the under 19 year old group representing 20% of the sample population. The other age categories were similar in size except for the 30 – 39 years old representing only 4.2% of the sample.

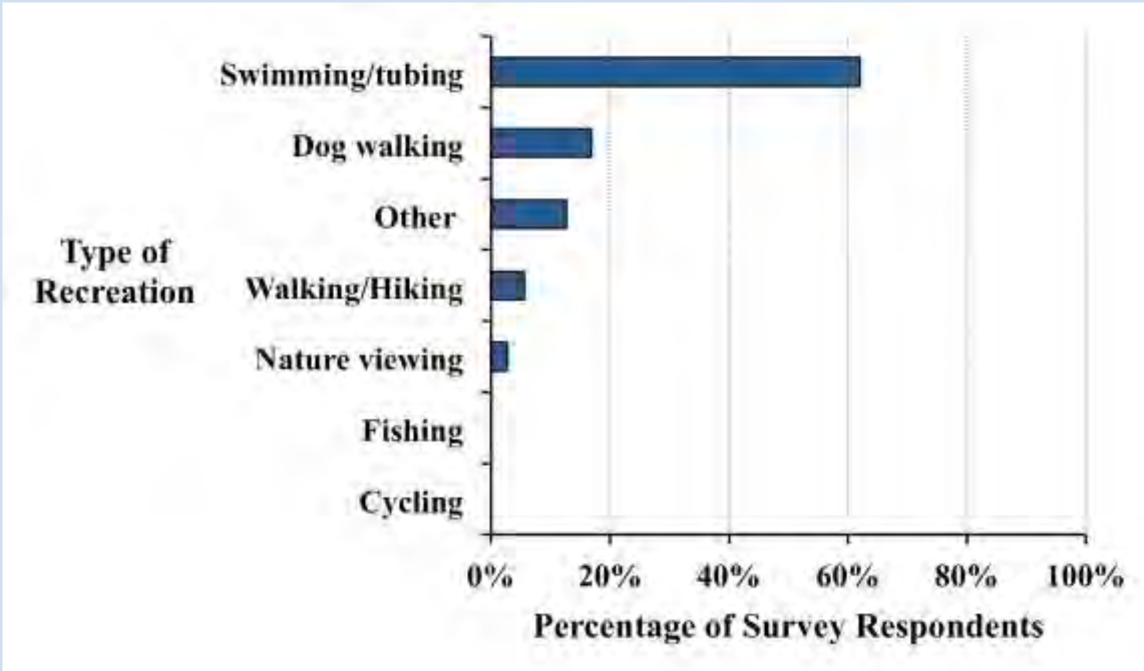
Table 1: Summary profile of respondents (n=71).

Attribute (n=71)	Number	%
Gender		
Female	30	42.0
Male	41	58.0
Age		
< 19	14	19.8
20-29	29	40.8
30-39	3	4.2
40-49	10	14.1
50-59	9	12.7
> 60	6	8.5

Reasons for Visiting the Nanaimo River

Figure 1 demonstrates that the majority of river users were at the river to swim (63.4 %). Although tubing was listed with swimming as a similar activity no river users were encountered tubing. The second most popular reason for visiting the river was dog walking (16.9 %). The category represented by "other" (12.7 %) was made up of white water canoeing (2.8 %), and individuals who were conducting a dance party at the river (9.9 %). A number of river users pointed out that they were at the river to swim but enjoyed both walking and the ability to view nature while at the river and selected multiple reasons for coming to the river.

Figure 1: Recreational activities taking place at the Nanaimo River



River Use Levels

Results from this question demonstrate that 46 % of those surveyed reported using the river more than 12 times during the summer months (Figure 2). The other response categories had relatively even distributions ranging from 7 % through to 15 %. Many of the respondents claimed they frequent the river more than 20 times in a single month. These people were often local residents who lived in close proximity to the river and potentially visited the river up to three times in a single day.

Figure 2: Recreational use level over the summer.

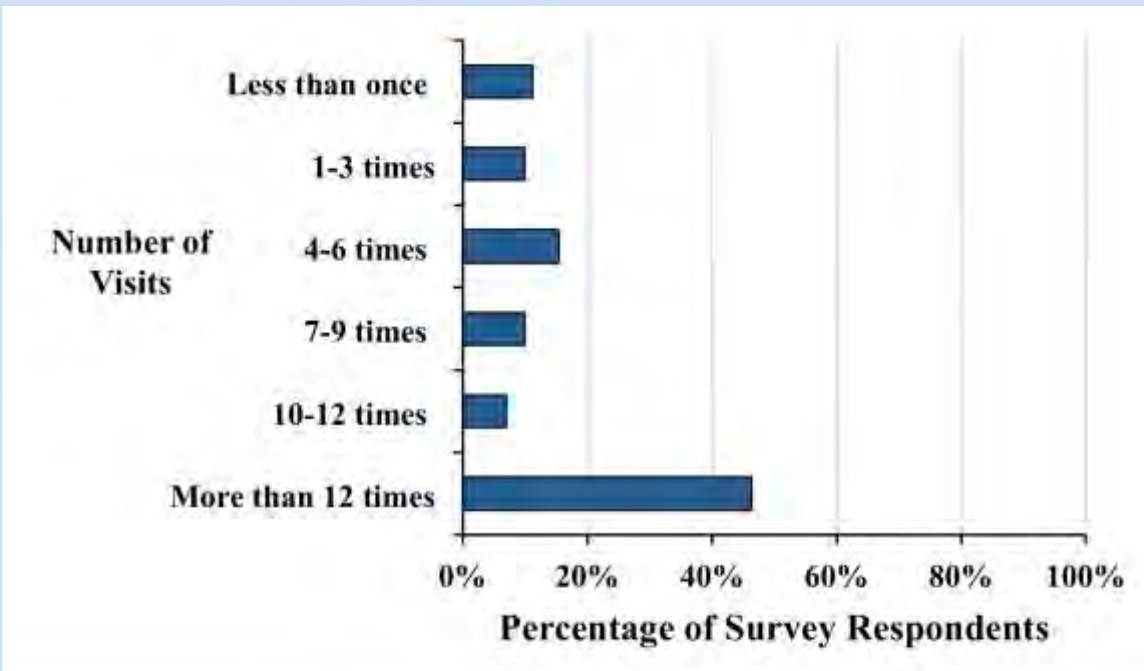


Figure 3 displays the recreational use level for the rest of the year and excludes the months June through August. The bulk of survey respondents (52 %) reported to be using the river less than once a month for recreational purposes outside of the summer months. Another 25 % reported using the river one to three times a month. A small group (8 %) of respondents reported using the river more than 12 times in a single month and this group appeared to be made up mainly of local residents.

Figure 3: Recreational use in seasons other than summer.

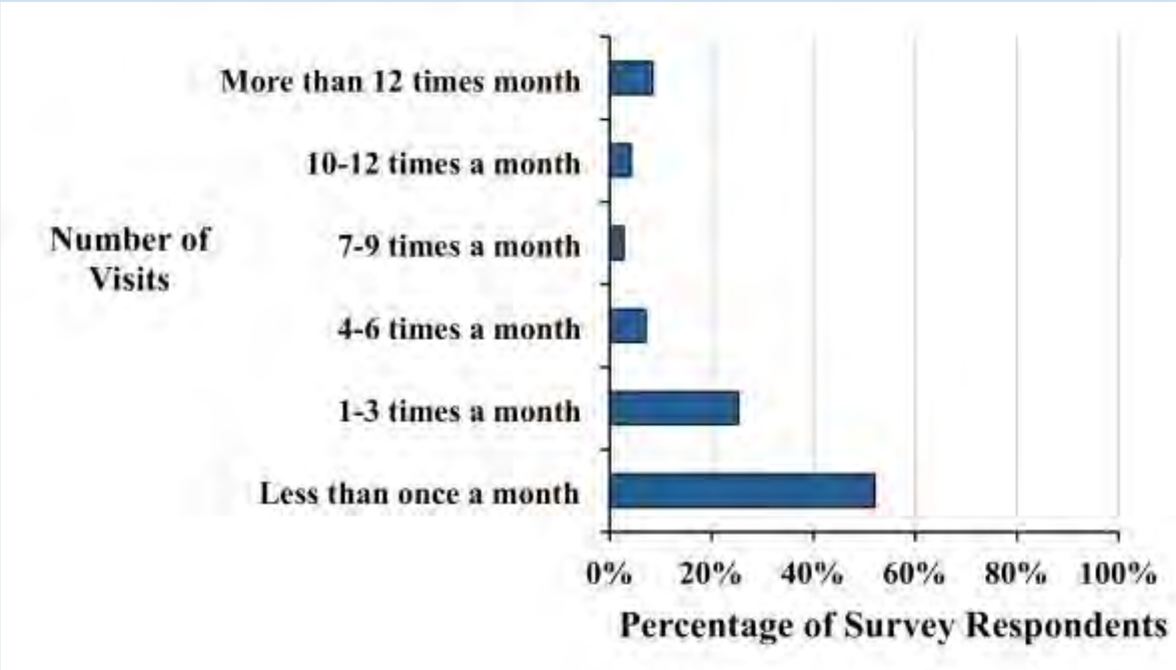
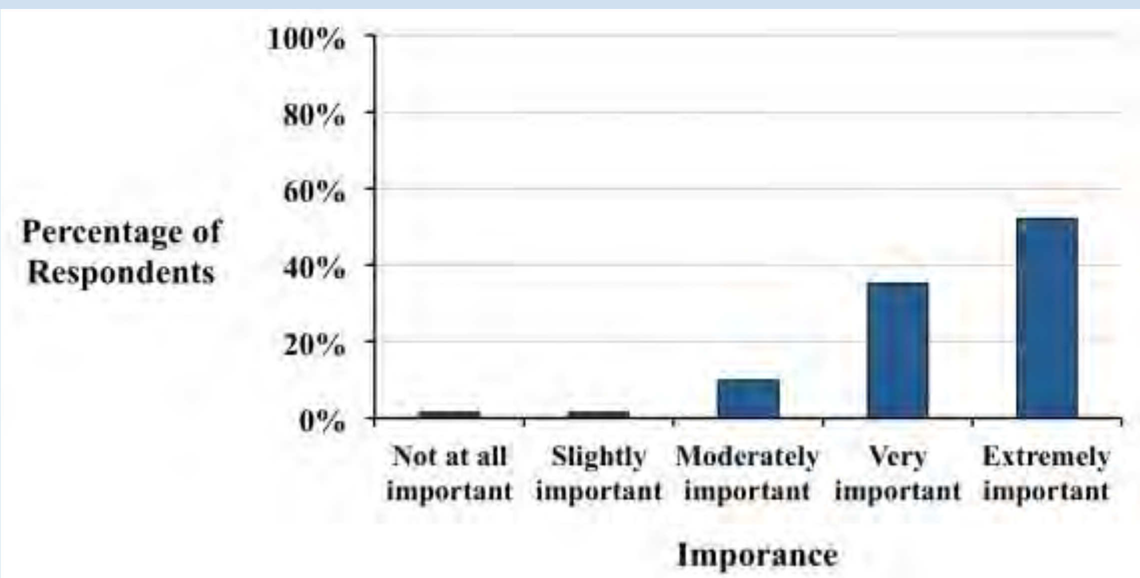


Figure 4: Importance of recreational opportunities within the Nanaimo River watershed



The Importance of Recreating within the Nanaimo River Watershed

Survey participants were asked to identify how important it was to them to be able to enjoy recreational opportunities within the Nanaimo River watershed. Results from this question (Figure 4) demonstrate that it was extremely important (52 %) or very important (35 %) for respondents to enjoy recreation on the river. Another way to express this result is to say that 87% of respondents stated that was very or extremely important for them to enjoy recreational opportunities within the Nanaimo River watershed.

Concern and Challenges for Recreation on the Nanaimo River

Figure 5: Concerns and challenges to recreation on Nanaimo River

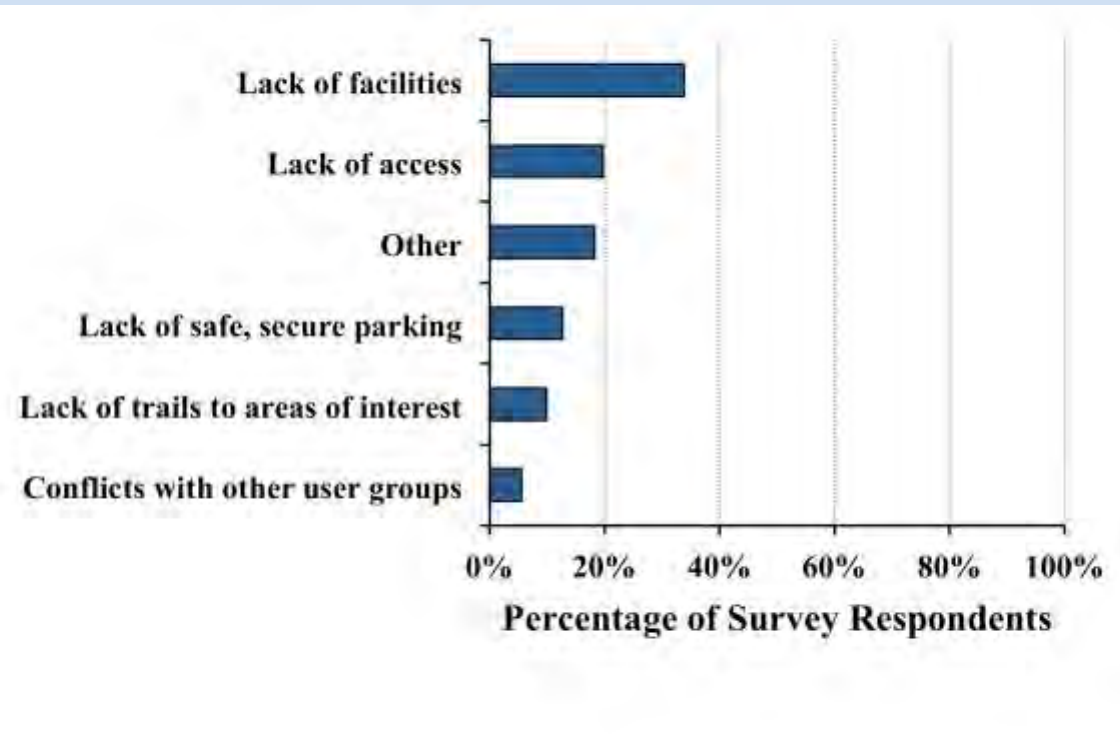
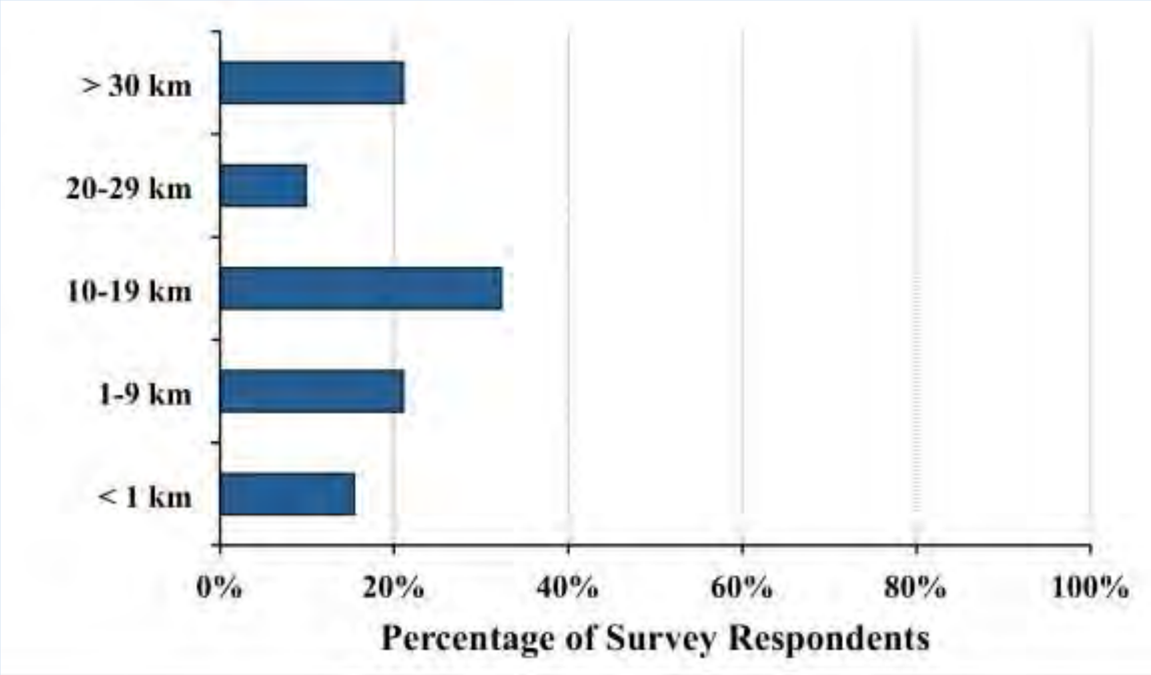


Figure 5 describes the greatest concerns and challenges to the ability of respondents to enjoy recreation on the Nanaimo River. Survey participants responded (34 %) that the lack of facilities was the great concern/challenge to their ability to enjoy recreation on the river. Lack of facilities includes items such as washrooms, garbage cans or picnic benches. 20 % of respondents stated that lack of access to the river from private land ownership was a concern/challenge. Eighteen percent reported that something "other" was a concern or challenge to their recreational enjoyment (usually garbage).

Participant Residential Proximity to the Nanaimo River

Survey Participants were asked how close they live to the Nanaimo River. The survey found that that a small majority (32.3%) live between 10 and 19 km from the river (Figure 6). There was a fairly even spread between all the categories and this demonstrates that Nanaimo River residents and those who live over 30 kilometers from the river are frequenting the river.

Figure 6: Distance travelled to recreate on the Nanaimo River.



The final question on the survey asked participants to share any other comments, questions, or concerns about the Nanaimo River. Those responses were grouped together into similar themes and are summarized in the section below:

- Respondents stated that they don't want the recreational locations to become developed; they don't want to see any changes on the river through comments such as "Leave this place the way it is now" and "Don't make a park on the river".
- Participants shared some of their feelings and amazement regarding the area with comments such as "it's beautiful" and "best place on earth".
- Visitors who were experiencing the Nanaimo River for the first time expressed that they would be returning to the river in the future to explore other locations.

- Many of the participants raised the issue of lack of cleanliness due to human use and the need for garbage and recycling receptacles.
- Some respondents expressed a belief that visitors and tourist at the river cause damage and that local people should be the only ones able to enjoy the river. These river users provided comments such as “leave us alone” and “no more tourists/strangers”.
- Other respondents stated that the river should have more public access. They claimed that the “no trespassing signs” and the locked gates deterred them from accessing the river and provide comments such as “the forestry company restricts access”.
- Many of the river users who participated in the research expressed disapproval of what they perceived as a high occurrence of drinking and partying. A number of families claimed this situation was uncomfortable because of the noise and profanity. Other river users, who were not part of a family group at the river, believed the partying was the major source of garbage and broken bottles at the river.
- Some swimmers thought diving boards would be a good idea.
- Respondents raised the issue of unsafe parking and the unavailability of parking areas. There was also a common theme that parking should be free and if new parks were created this would result in pay parking.
- River users expressed a desire for more picnic tables and washrooms.
- Participants also requested more trails to other areas as well as trails for non-motorized vehicles such as “bikes”.

CONCLUSIONS

The fieldwork component of this chapter provided an opportunity to speak directly to individuals who were using the river for recreational purposes. As stated above, the limited number of days in the field, the time of year the survey was administered, and the non-random nature of selecting participants mean that the survey results should be treated more as a scoping exercise than a statistically robust sample. Nevertheless, researchers did collect 71 completed surveys and had the opportunity to speak with and listen to many more people at the river.

What did emerge from the research was an understanding that river users are diverse and varied with all age groups and genders well represented in the sample. Recreational users at the river between 20 – 29 years of age were most represented in the sample at 40.8%. Swimming (62%) was the most common reason for participants to visit the river. River users also claimed to be frequenting the river a lot during the summer months with 46% stating they come more than 12 times during a single month. Within the sample group the opposite occurred during the rest of the year (September through to May) with 52% of the respondents claiming to frequent the river less than once a month during this time. River users did place a high level of importance on their ability to recreate within the Nanaimo River watershed as 87% of the sample stated this ability to enjoy the river was “very important” (35%) or “extremely important” (52%). Further, 34% respondents identified the greatest concern/challenge to their ability to enjoy recreation on the Nanaimo River was the lack of facilities.

Clearly, those using the river for the first time all the way through to the people who literally spend their summer on the river, love the river. This sentiment emerged repeatedly. At different times during the river field work there would be a line up or small crowd of people waiting to fill in a survey or who just wanted to talk about the river. Those from outside the city of Nanaimo and local residents alike are obviously passionate about the river.

RECOMMENDATIONS FOR FUTURE RESEARCH

Not all recreational users are represented in this research. Future efforts should be made to collect information from groups such as the four wheel drive and all terrain vehicle (ATVs) enthusiasts.

During the summer and fall, TimberWest operates a gate located at First Lake that collects information from those passing through the gate. The collected information may be of use to better understanding recreational uses within the upper Nanaimo River watershed. This information resides with the Ministry of Environment.

A similar study undertaken by the Regional District of Nanaimo (or larger entity) with adequate funding and potentially a large crew of people working the river could generate an expanded data set that would better answer the research questions.

Lastly, with a bit more work population estimates could be generated for recreational users or for specific recreational activities. These numbers would be useful for tracking long term trends and would offer a deeper level of statistical analysis than what was provide in this document.

References

Literature Cited

1. Nanaimo Information Forum. (2011). *Nanaimo Information.* Retrieved July/12, 2011, from www.nanaimoinformation.com/forum/showthread.php?-Green-Mountain-Ski-Hill&p=54080

2. Canoe Sport British Columbia. (1974). *British Columbia canoe routes* (1st ed.). New Westminster: Nunaga Publishing Company LTD.

3. BC Parks. *Morden Colliery Historic Provincial Park.* Retrieved July/12, 2011, from www.env.gov.bc.ca/bcparks/explore/parkpgs/morden/

Stakeholders Interviewed

Cohen, D. (2011).

Hamilton, W. (2011).

Kellow, M. (2011).

Littlejohn, D. (2011).

Sorenson, G. (2011).

Wolf, J. (2011).

APPENDIX ONE – RDN WATER BUDGET APPENDICES A, C and D

APPENDIX A – GLOSSARY OF TERMS

Alluvial	Applying to the environments, actions, and products of rivers or streams
Aquifer	Any water-saturated body of geological material from which enough water can be drawn at a reasonable cost for the purpose required. An aquifer is only a relative term determined largely by economics and is best illustrated by extreme examples. An aquifer in an arid prairie area required to supply water to a single farm may be adequate if it can supply 1 m^3/day. This would not be considered an aquifer by any industry looking for cooling water on the order of 10,000 m^3/day. A common usage of the term aquifer is to indicate the water-bearing material in any area from which water is most easily extracted.
Aquifer management unit	A hydraulically-connected groundwater system that is defined to facilitate management of the groundwater resources (quality and quantity) at an appropriate scale.
Aquitard	A water-saturated sediment or rock whose permeability is so low it cannot transmit any useful amount of water. An aquitard allows some measure of leakage between the aquifer intervals it separates.
Bedrock	The solid rock that underlies unconsolidated surficial sediments.
Block-Faulted	High-angle faulting in which blocks of the crust move vertically up or down relative to each other. Often occurs in areas undergoing horizontal extension.
Bedrock aquifer	A bedrock unit that has the ability to transmit significant volumes of water to a well completed within it. Typical examples include sandstone and siltstone or significantly fractured intervals.
Channel	An eroded depression in the soil or bedrock surface within which alluvial deposits accumulate (i.e. gravel, sands, silt, clay).
Contaminant	A substance that is present in an environmental medium in excess of natural baseline concentration.
Contemporaneous	Formed or existing at the same time.
Cumulative Effects	The changes to the environment caused by all past, present, and reasonably foreseeable future human activities.
Evapotranspiration	The process by which water is discharged to the atmosphere as a result of evaporation

	from the soil and surface-water bodies and transpiration by plants. Transpiration is the process by which water passes through living organisms, primarily plants, into the atmosphere.
Fault	A break in material in which material on one side of the break has moved relative to that on the other side. In the Foothills and Rocky Mountain Front Ranges Thrust faulting is the most common – Thrust faults are low angle faults in which older material may be 'thrust over' younger material.
Fluvial	Produced by the action of a stream or river.
Geometric mean	A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing transmissivity estimates, which may vary over 10 orders of magnitude. A geometric mean is a log (base 10) transformation of data to enable meaningful statistical evaluations.
Groundwater	All water beneath the surface of the ground whether in liquid or solid state.
Hydraulic Conductivity	The rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time.
Hydraulic Gradient	In an aquifer, the rate of change of total head per unit distance of flow at a given location and direction. It has both horizontal and vertical components.
Hydrogeology	The science that relates geology, fluid movement (i.e. water) and geochemistry to understand water residing under the earth's surface. Groundwater as used here includes all water in the zone of saturation beneath the earth's surface, except water chemically combined in minerals.
Infiltration	The flow or movement of precipitation or surface water through the ground surface into the subsurface. Infiltration is the main factor in recharge of groundwater reserves.
Instream Flow Needs	The amount of water required in a river to sustain a healthy aquatic ecosystem, and/or meet human needs such as recreation, navigation, waste assimilation or aesthetics.
km	kilometre
Lacustrine	Fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits
m	metres

mm	millimetres
m^2/day	metres squared per day
m^3	cubic metres
m^3/day	cubic metres per day
Monitoring Well	A constructed controlled point of access to an aquifer which allows groundwater observations. Small diameter observation wells are often called piezometers.
Overburden	Any loose material which overlies bedrock (often used as a synonym for Quaternary sediments and/or surficial deposits) or any barren material, consolidated or loose, that overlies an ore body.
Permeability	A physical property of the porous medium providing an indication of how easily water will flow through the material. Has dimensions $Length^2$. When measured in cm^2, the value of permeability is very small, therefore more practical units are commonly used - Darcy (D) or millidarcy (mD). One darcy is equivalent to $9.86923 \times 10{-}9$ cm^2.
Receptor	Components within an ecosystem that react to, or are influenced by, stressors.
Recharge	The infiltration of water into the soil zone, unsaturated zone and ultimately the saturated zone. This term is commonly combined with other terms to indicate some specific mode of recharge such as recharge well, recharge area, or artificial recharge.
Significant Aquifer	A permeable water-bearing horizon of sufficient thickness and lateral extent that can yield useable quantities of water. An aquifer in excess of 5 m thick, 100 m or more in width and extending a lateral distance of 500 m or more may be considered a significant aquifer.
Stratigraphy	The geological science concerned with the study of sedimentary rocks in terms of time and space.
Stress	Physical, chemical and biological factors that are either unnatural events or activities, or natural to the system but applied at an excessive or deficient level, which adversely affect the receiving ecosystem. Stressors cause significance changes in the ecological components, patterns and processes in natural systems.

Strike	The strike line of a bed, fault, or other planar feature is a line representing the intersection of that feature with a horizontal plane.
Subcrop	An occurrence of the strata directly beneath an unconformity (e.g., base of unconsolidated materials constituting a weathering surface).
Surficial Deposits	See Overburden
Sustainable	A characteristic of an ecosystem that allows it to maintain its structure, functions and integrity over time and/or recover from disasters without human intervention.
Thalweg	The line defining the lowest points along the length of a river bed or valley. Also the line defining the central (long) axis of a buried channel or valley.
Thrust Faulting	A shallow dipping fault in which the hanging wall moves up relative to the footwall. It is caused by horizontal compression. This results in placing older rock over younger rock.
Till	A sediment deposited directly by a glacier that is unsorted and consisting of any grain size ranging from clay to boulders.
Total Dissolved Solids	Concentration of all substances dissolved in water (solids remaining after evaporation of a water sample).
Transmissivity	The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient; a measure of the ease with which groundwater can move through the aquifer: **Apparent Transmissivity**: the value determined from a summary of aquifer test data, usually involving only two water-level readings; **Effective Transmissivity**: the value determined from late pumping and/or late recovery water-level data from an aquifer test; and **Aquifer Transmissivity**: the value determined by multiplying the hydraulic conductivity of an aquifer by the thickness of the aquifer.
Trend	The relationship between a series of data points (e.g. Mann Kendall test for trend).
Water Management	A framework to enable water planning, allocation and Framework management of water resources

Water Management Plan	A plan that provides guidance for water management and sets out clear and strategic directions for how water should be managed.
Watershed	The geographic area of land that drains water to a shared destination. The boundary is determined topographically by ridges, or high elevation points. Water flows downhill, so mountains and ridge tops define watershed boundaries.
Water Well	A hole in the ground for the purpose of obtaining groundwater; "work type" as defined by AEW includes test hole, chemistry, deepened, well inventory, federal well survey, reconditioned, reconstructed, new, old well-test.
Yield	A regional analysis term referring to the rate a properly completed water well could be pumped, if fully penetrating the aquifer: **Apparent Yield**: based mainly on apparent transmissivity, and **Long-Term Yield**: based on effective transmissivity.
AMSL	Above mean sea level
BGP	Base of Groundwater Protection
DEM	Digital Elevation Model
NPWL	Non-pumping water level, also often referred to as static water level
TDS	Total Dissolved Solids

APPENDIX C

WATERLINE GEODATABASE DEVELOPEMENT
MAJOR COMPILED/INTERPRETED HYDROGEOLOGY AND HYDROLOGY GIS MAPS AND DATASETS

LIST OF MAPS - APPENDIX C

WATERLINE GEODATABASE DEVELOPMENT AND WATER BUDGET ASSESSMENT

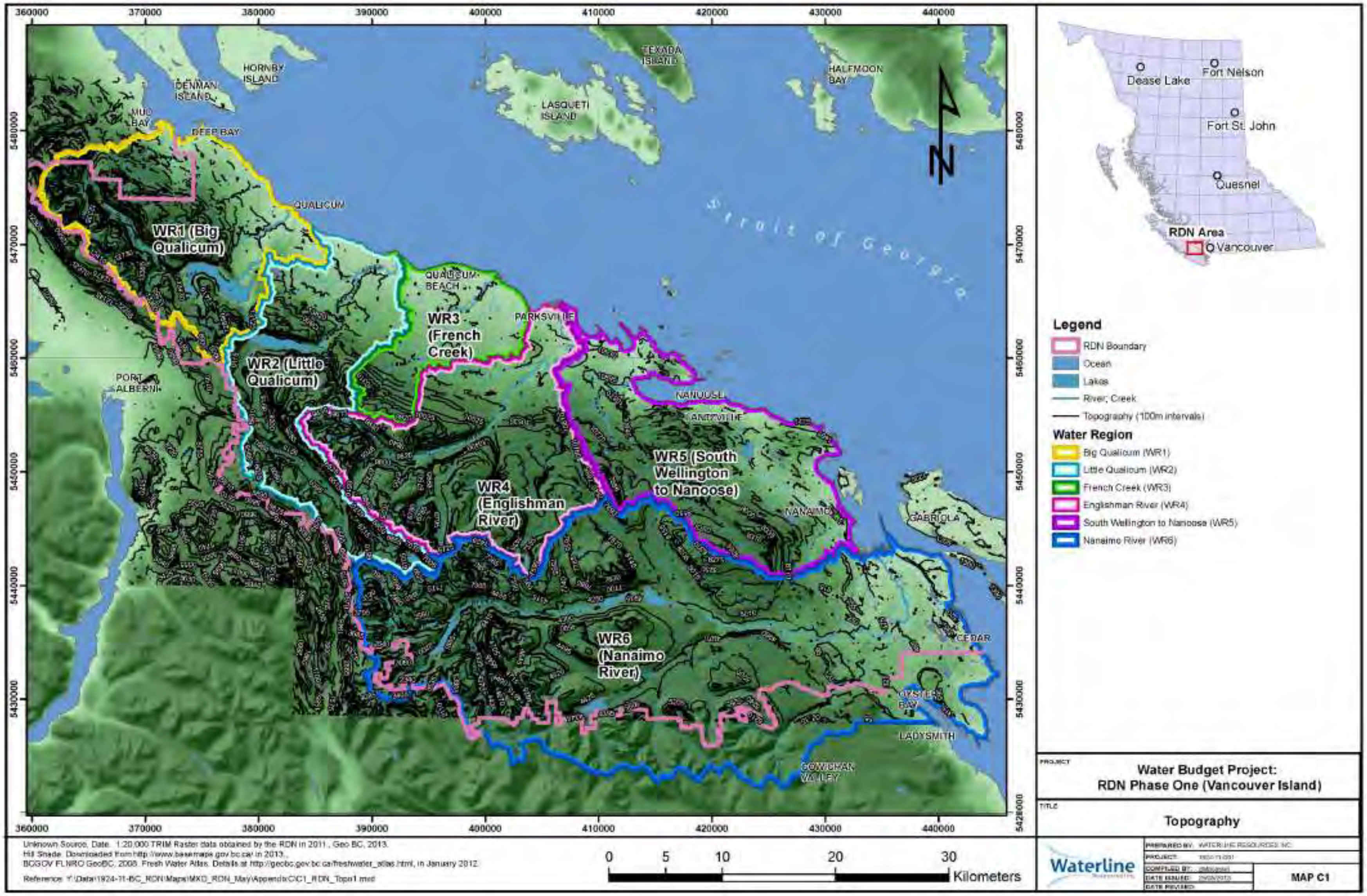
The first task for the RDN Phase One Water Budget project was to assemble all available groundwater, surface water, geological and time series data into a GIS. Many of the publicly available datasets can be brought directly into ArcGIS for mapping and analysis. Others require extensive processing, including the thirty thousand raw driller's descriptions that were refined in an iterative capture process using a data refining application, down to 10 material classes (e.g. sand/gravel, silt/clay, till, etc.). The boreholes and geology were brought into a 3D geological modelling application in order to establish a coherent picture of subsurface hydrogeology (aquifers & aquitards) which forms the conceptual model for each water region and aquifer within each region. The output from the 3D model include a bedrock subsurface topography, water table and piezometric surfaces, geometry and thickness of bedrock of overburden aquifers (confined and unconfined), and potential interconnections with surface water bodies. The results of this processing, refinement and analysis of all the source data form the conceptual model and allows for establishing the inputs for the water budget calculations.

In order to bring a consistent structure to the large amount of data involved in the RDN Water Budget project, Waterline developed a custom ArcHydro Groundwater data model and geodatabase. Once constructed, the data model helped to organize, structure, visualize, and analyze multidimensional groundwater and environmental data. This includes aquifers and wells/boreholes, 3D geological and hydrogeological models, time series information, and various other multi-disciplinary datasets.

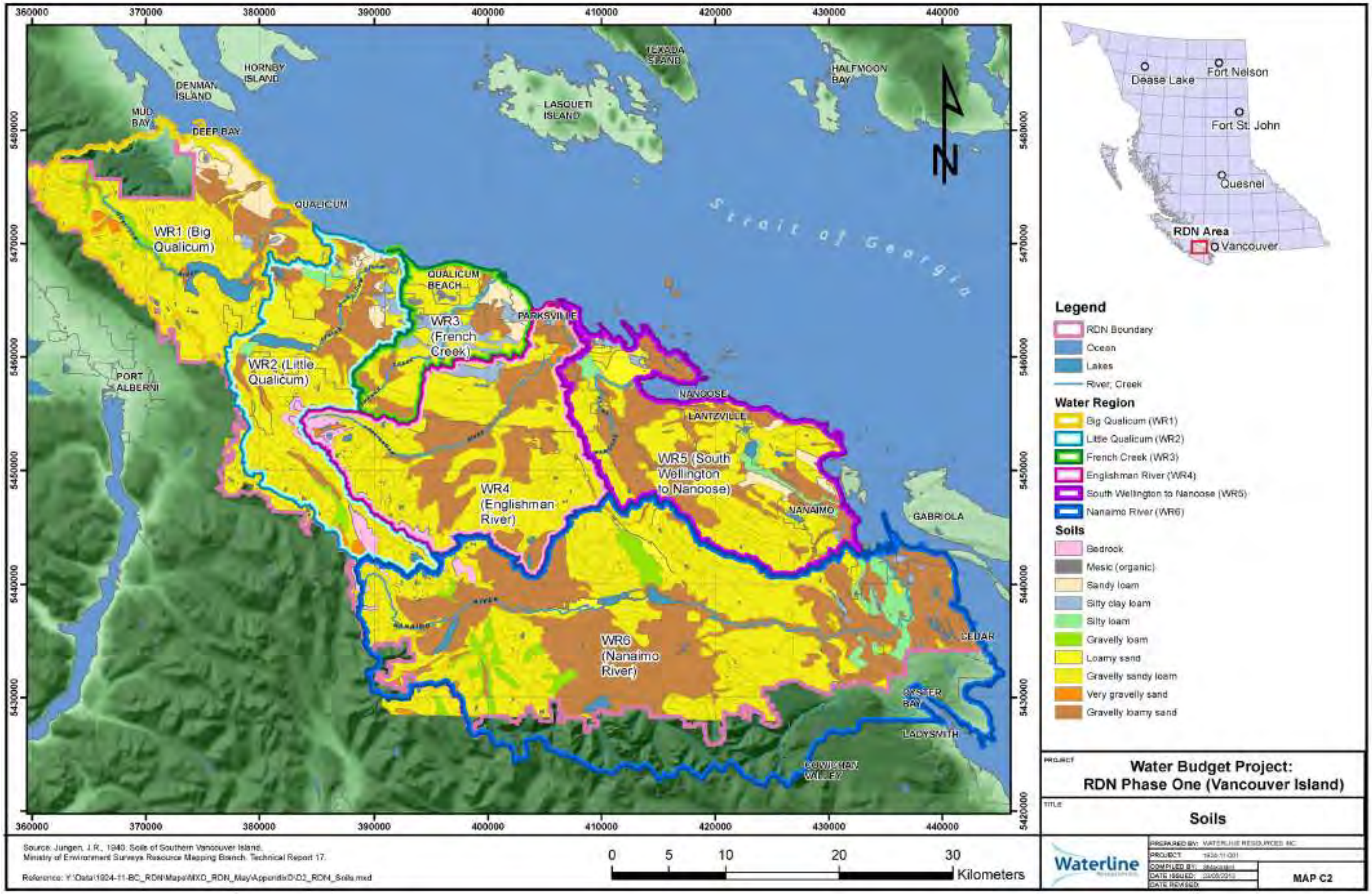
A set of scripts and tools are available for ArcGIS that are designed specifically to work with the ArcHydro Groundwater data model. The groundwater model developed for the Water Budget is a companion to an ArcGIS Surface Water data model (ArcHydro). Although some surface water information is included in the ARC Hydro Geodatabase, the main focus was on groundwater related information in order to facilitate the aquifer water budget and stress analysis. Additional surface water components can be added to the geodatabase as needed in the future. The ArcHydro geodatabase developed for the RDN Water Budget can be used directly by GIS staff at the RDN, or the database schema can be imported to a relational database management system (e.g. SQL Server, ArcSDE) for further development.

In conjunction with other geological software (i.e.: Leapfrog Hydro) Waterline was able to manipulate these data to produce visualizations, maps, graphs and cross-sections as well as develop 3D conceptual hydrogeological models of key aquifers within the RDN. These dataset and models could at some point in the future be used as input to numerical groundwater flow modeling programs such as MODFLOW or FEFLOW, which will be required if the RDN wish to move to a full Tier 1 or Tier 2 watershed analysis (OMNR 2012). The GSC is currently modelling the Nanaimo Lowlands aquifers in the area and is using Leapfrog Hydro for the conceptual Model input.

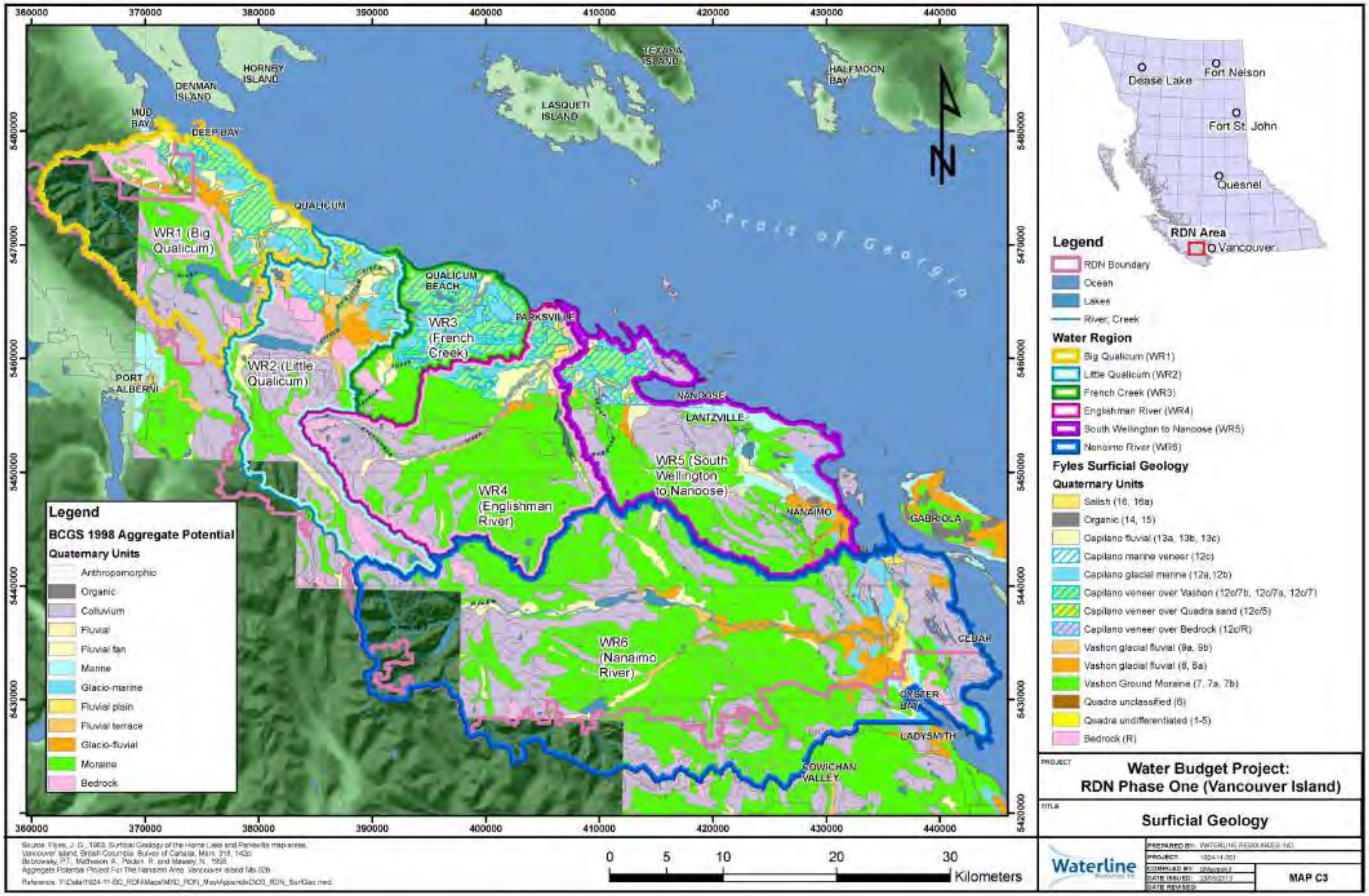
As there are 100’s of combinations of maps and cross-sections that could now be produced from the geodatabase and the 3D Model, it is not reasonable, nor is it within the present scope of work to present more than several key visualizations as was provided in the body of this report. The Phase One Water Budget report provides only key maps used to explain the approach to the aquifer and surface water budgets. The sample maps provided in this appendix are presented for illustration purposes to show some of the various layers and other datasets that were considered in Waterline’s water budget assessment. More data exist in the ArcGIS Geodatabase which will be provided to the RDN. The intent of Waterline’s work in developing the geodatbase system was that the RDN would be able to use the database to develop a secure user website (similar to the RDN Water Map) which could serve the data publicly. The maps herein are samples provided for illustration purposes only of some (not all) of the data available in the ArcGIS database developed by Waterline, for use by the RDN.



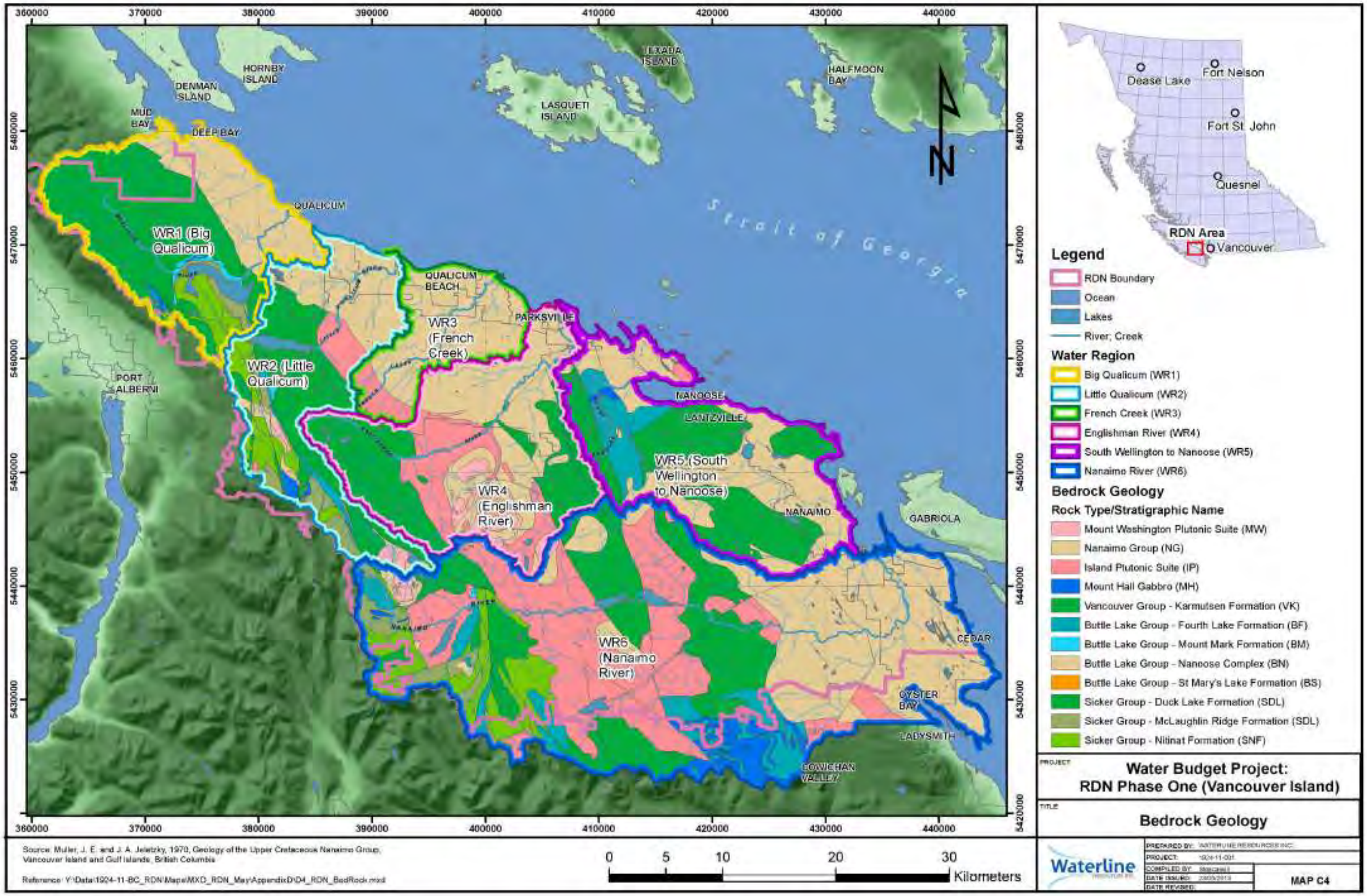
Map C1: Topography - The topography layer was developed from 1:20,000 TRIM data provided by the RDN. The elevation data was a critical dataset in the development of the 3D geomodel for the RDN as it was the surface layer onto which all surface and subsurface data was geo-referenced. Waterline evaluated some discontinuous LIDAR data that was available from various communities across the RDN but selected the 1:20,00 Trim data since it provided full coverage across the study area. The sample provided here is for illustration purposes only as it is not possible to show labeled contours over such a large area.



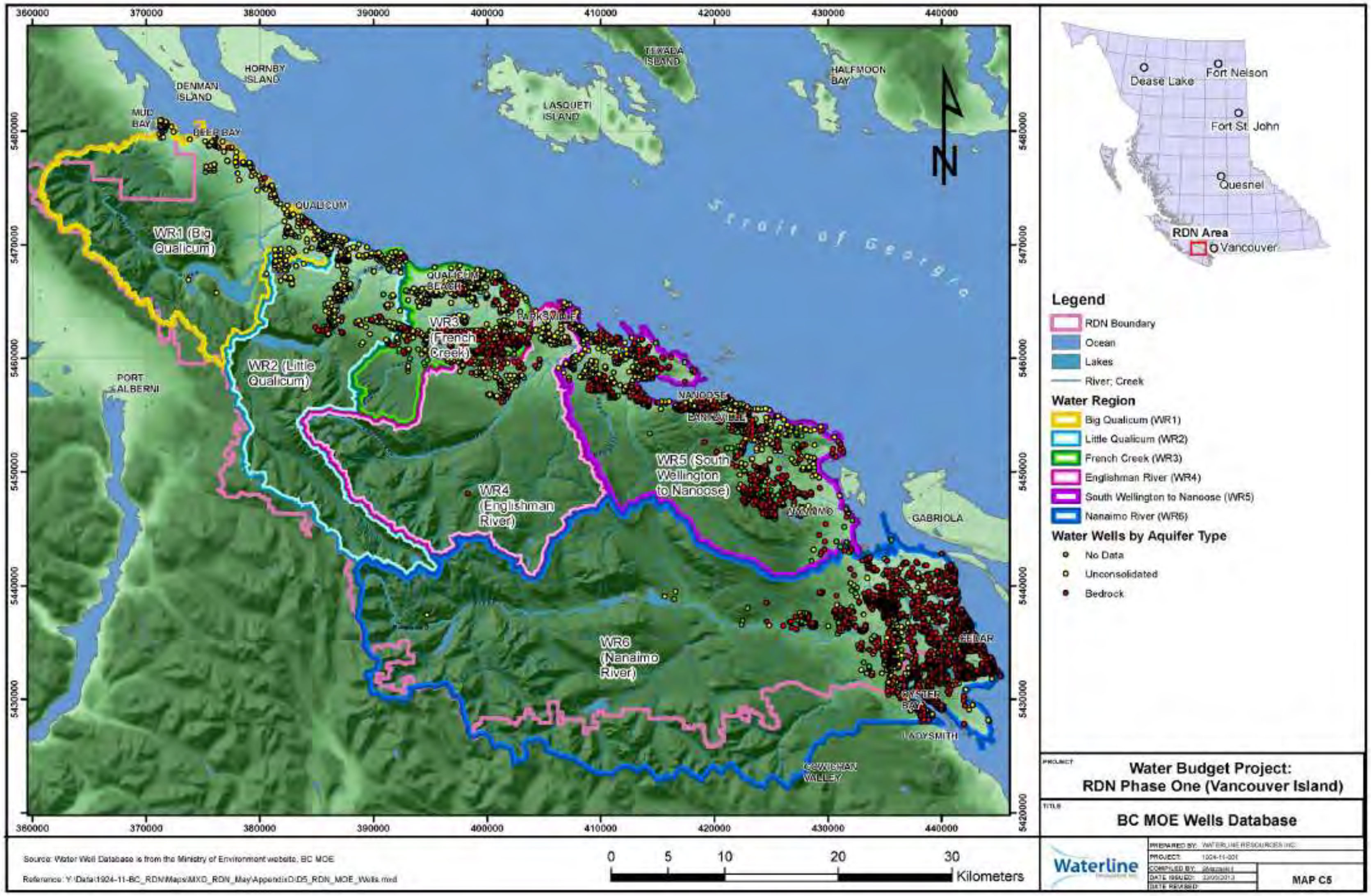
Map C2: Soils - The soils layer was source from the Ministry of Environment (see reference on Map) and was important in mapping potentially significant recharge areas when combined with NRCAN Remote Sensing Data (see Maps C11, C12, and C3) The soils data was integrated with borehole lithology, 1:20,000 Trim elevation mapping, surficial geology mapping, and remote sensing data to assess infiltration and recharge characteristics within each water region across the RDN.



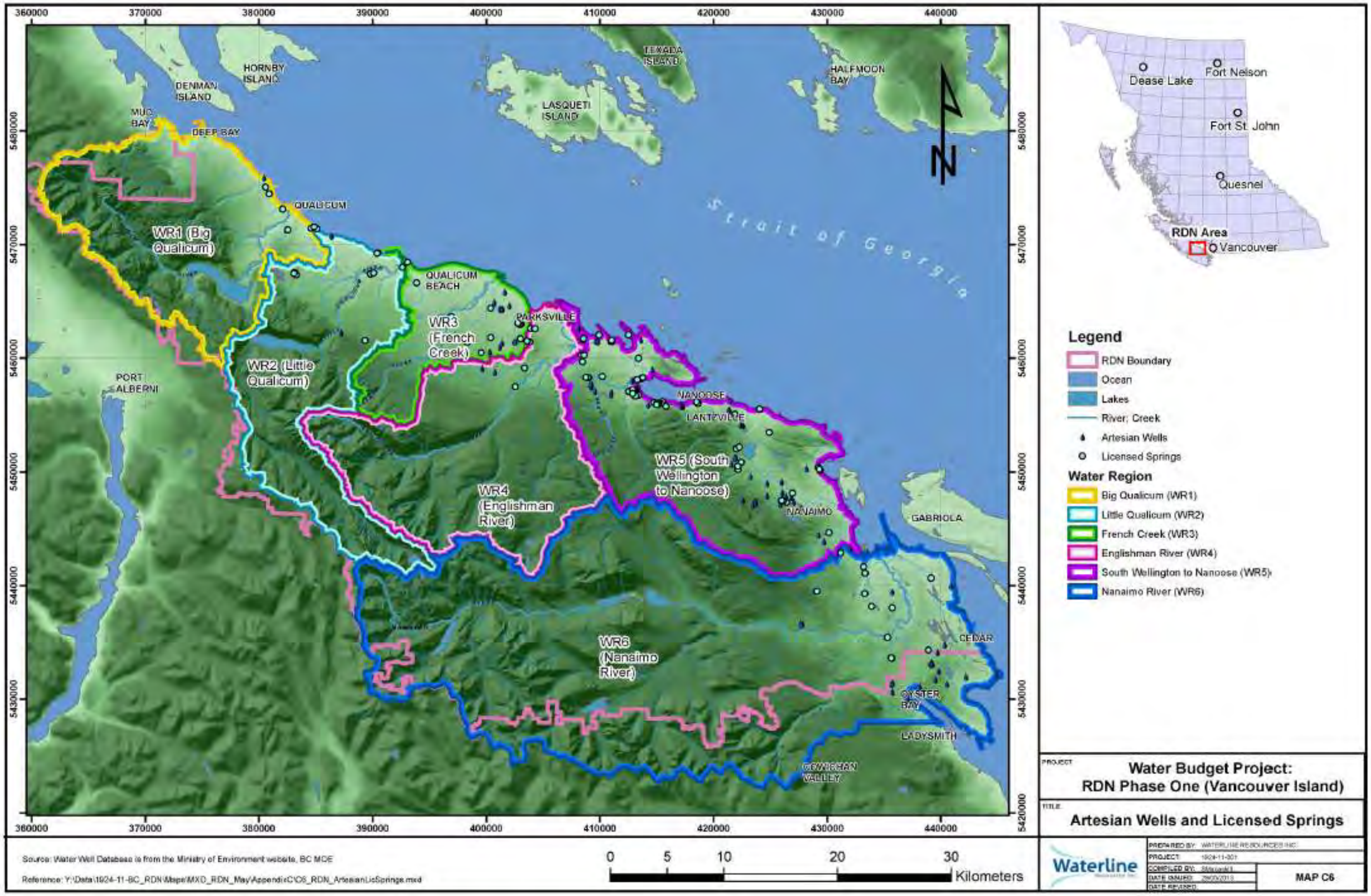
Map C3: Surficial Geology - The surficial geology layer was taken from Fyles (1963) and, where absent, was filled in with the Aggregate Resource Mapping series. This data was integrated with borehole lithology, 1:20,000 Trim elevation mapping, and soils mapping to correlate glacial deposits and develop conceptual geology and hydrogeology of the various unconsolidated aquifers across the RDN. The data was a key part of the assessment of groundwater-surface water interactions for the various creeks and rivers across the RDN. NRCAN in Victoria is currently re-mapping this map sheet and expect to have an updated version within the next year or so.



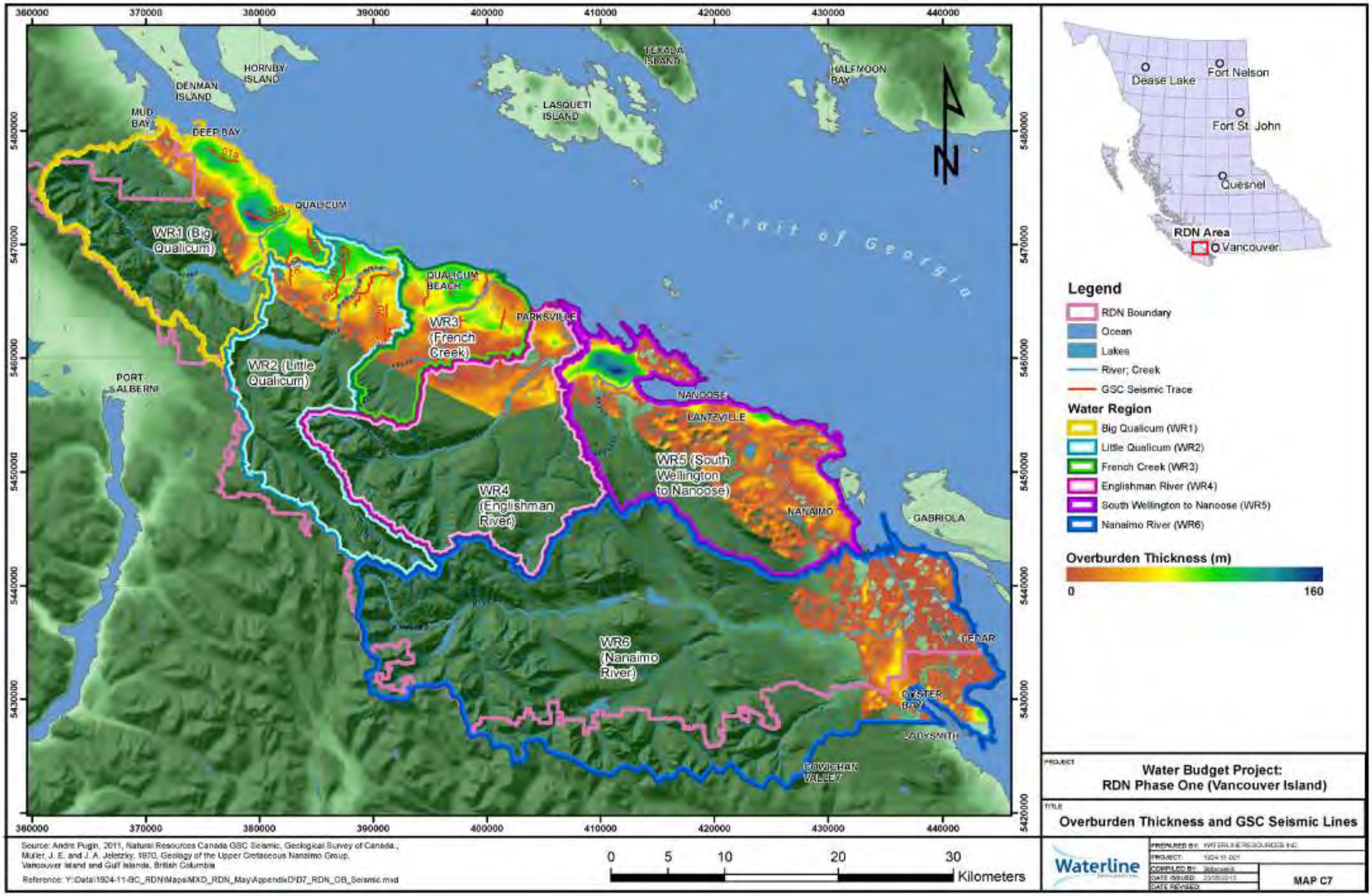
Map C4: Bedrock Geology - Bedrock geology layers were downloaded from the Geo BC website and compiled into Waterline's ARC GIS Geodatabase. This information was integrated with borehole lithology, along with GSC seismic data (unpublished) to develop a bedrock surface topography map, and overburden thickness isopach map (see Map C7). The data was also integrated with mapped aquifer information to develop conceptual models of the hydrogeology of each bedrock aquifer previously mapped within the RDN.



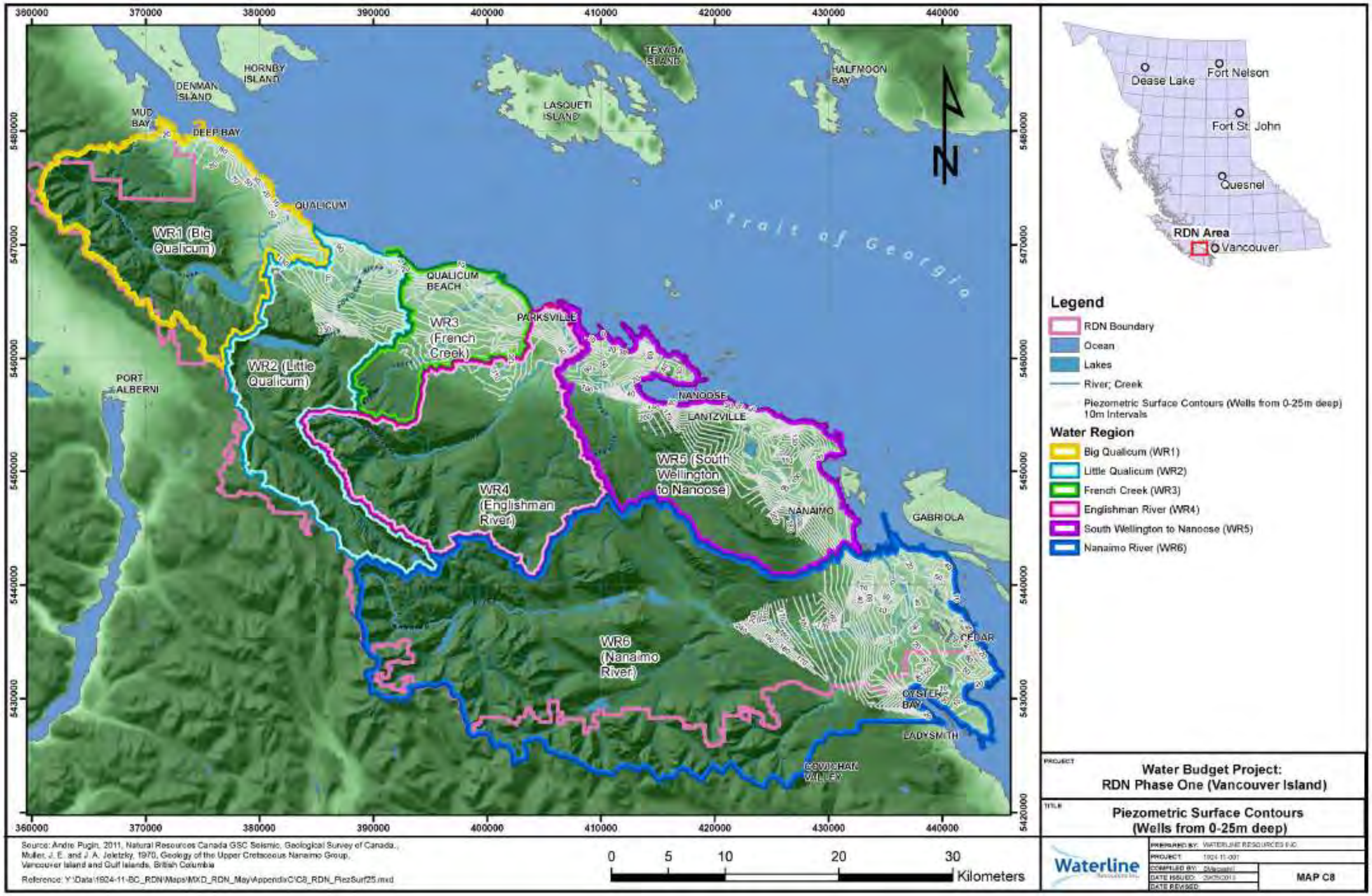
Map C5: BCMOE Wells Database -



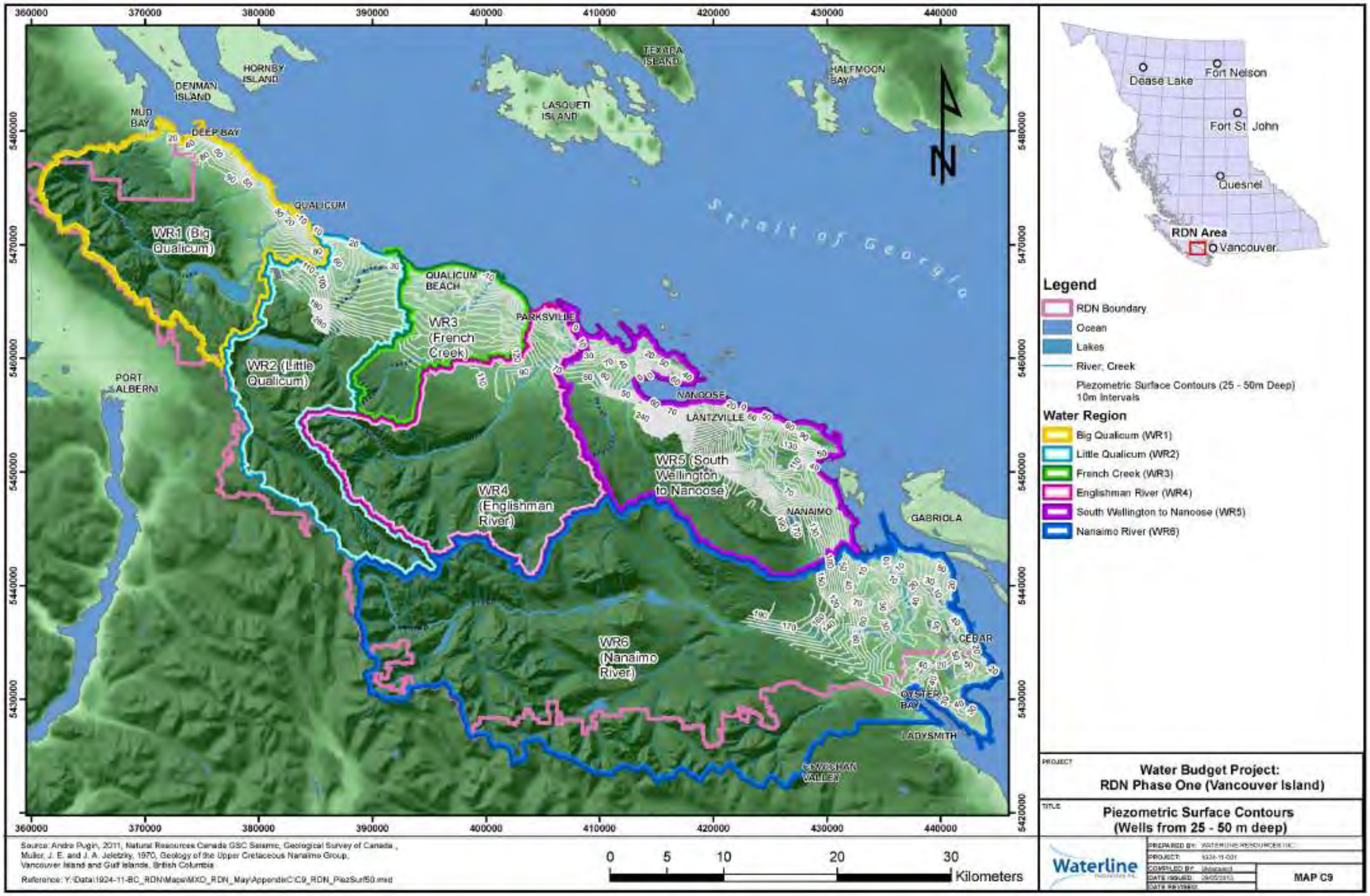
Map C6: Artesian Wells & Licensed Springs - BC MOE WELLS database was searched for flowing artesian wells, geo-referenced and plotted. The location of licensed springs was obtained from the Water Resource Atlas database. These data are useful in assessing aquifers which hare under artesian pressure and discharge zones within each water region.



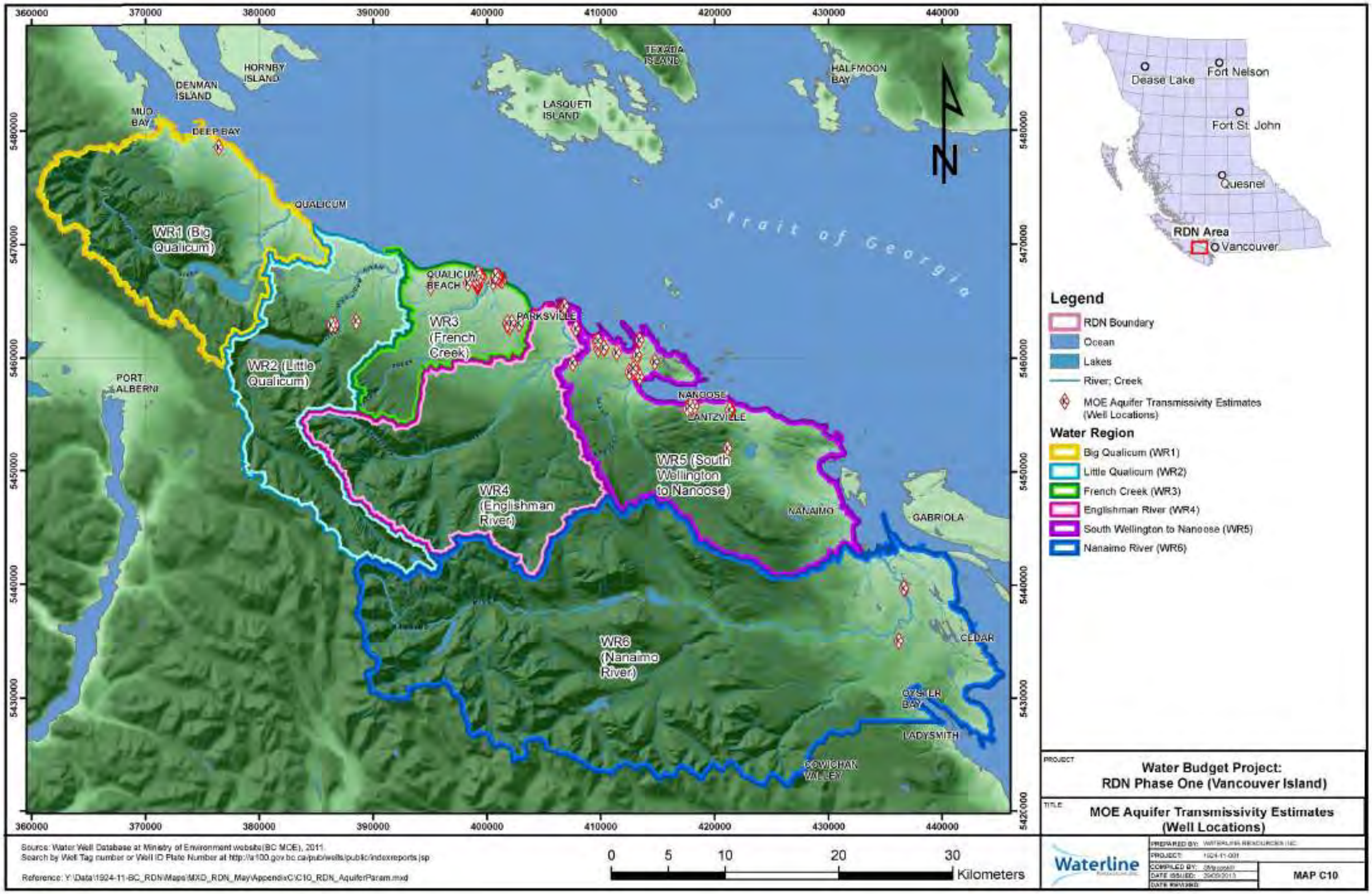
Map C7: Overburden Thickness Contours - Overburden thickness mapping was completed by integrating surface topography data (Map C1), borehole data (C5), GSC seismic data, and bedrock outcrop data (C4). The data was compiled and refined within Waterline's Geodatabase system and contoured in ARC GIS. The GSC Seismic lines define the area of the GSC's Nanaimo Lowland study.



Map C8: Piezometric Surface Contours (Wells from 0-25 M Deep) - A piezometric surface contour map was developed using a sorting routine in the Waterline Geodatabase to identify all the wells completed between 0-25 m below ground. The measured water level at the time of drilling was then used to produce the contour map shown as Map C8 in order to get a general sense of the shallow groundwater flow direction. Ideally, current water level data from similar hydrostratigraphic zones should be used for this analysis. However, no current water level data is available in one database and would have been difficult to reconcile existing data to MOE well ID for inclusion in this analysis. It should be noted that at the regional scale of the Phase 1 water budget assessment this analysis provides a rough indication of the direction of shallow groundwater and hydraulic gradient which are required for aquifer water budget estimates. The data indicates that all shallow groundwater essentially mimic topography and flows to the ocean which is expected. Hydraulic gradient estimates taken from the 0-25 m deep contours were applied to water budget estimates for shallow aquifers (Capilano, Kame Deltas, Salish, and where appropriate Quadra and bedrock aquifers). A typical calculation is shown below in Appendix D.

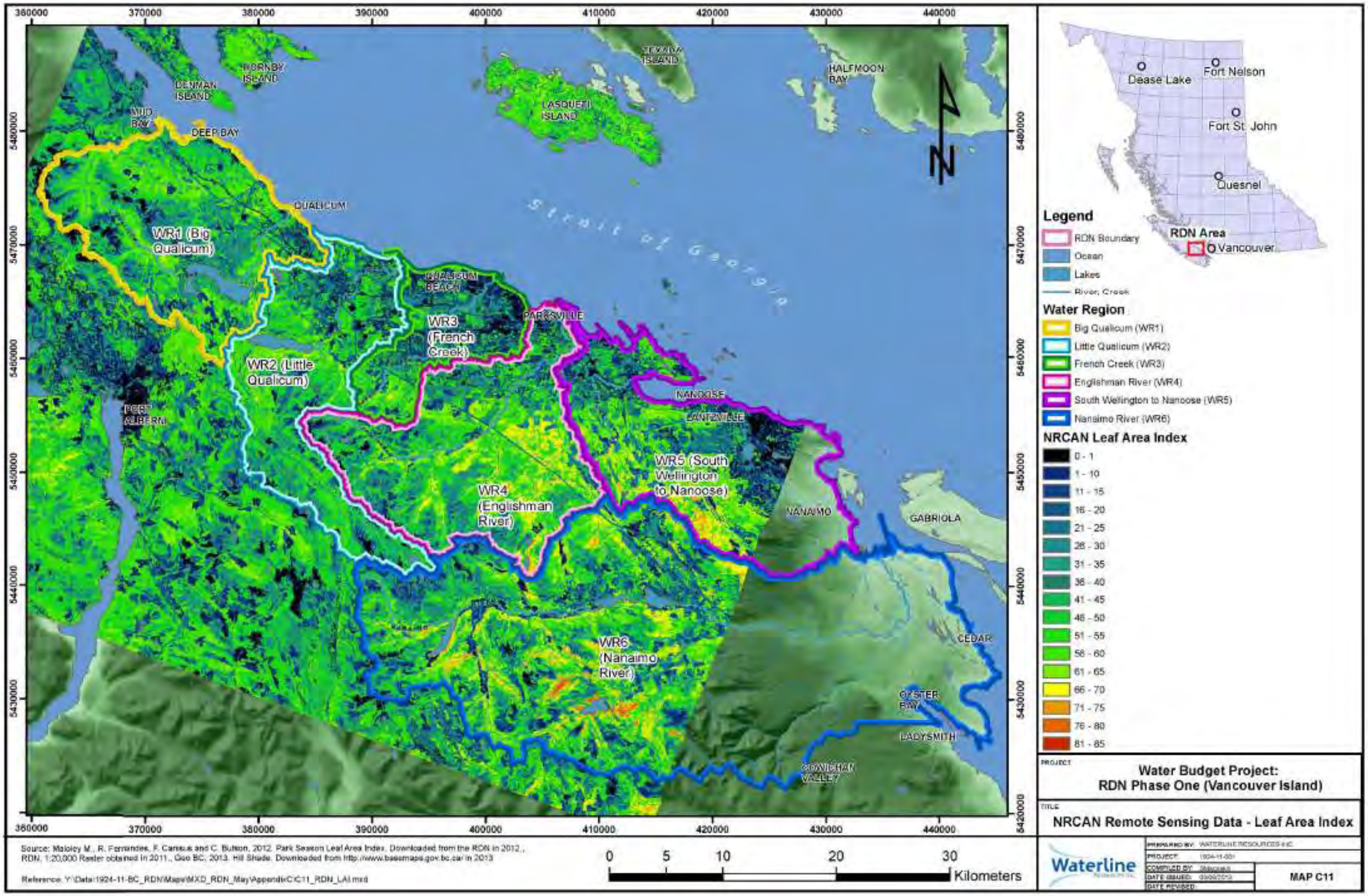


Map C9: Piezometric Surface Contours (Wells from 25-50 M Deep) - A piezometric surface contour map was developed using a sorting routine in the Waterline Geodatabase to identify all the wells completed between 25-50 m below ground. The measured water level at the time of drilling was then used to produce the contour map shown as Map C8 in order to get a general sense of the shallow groundwater flow direction. Ideally, current water level data from similar hydrostratigraphic zones should be used for this analysis. Hydraulic gradient estimates taken from the 25-50 m deep contours were applied to water budget estimates for deep aquifers across the RDN (Quadra, Vashon, and bedrock aquifers). A typical calculation is shown below in Appendix D.

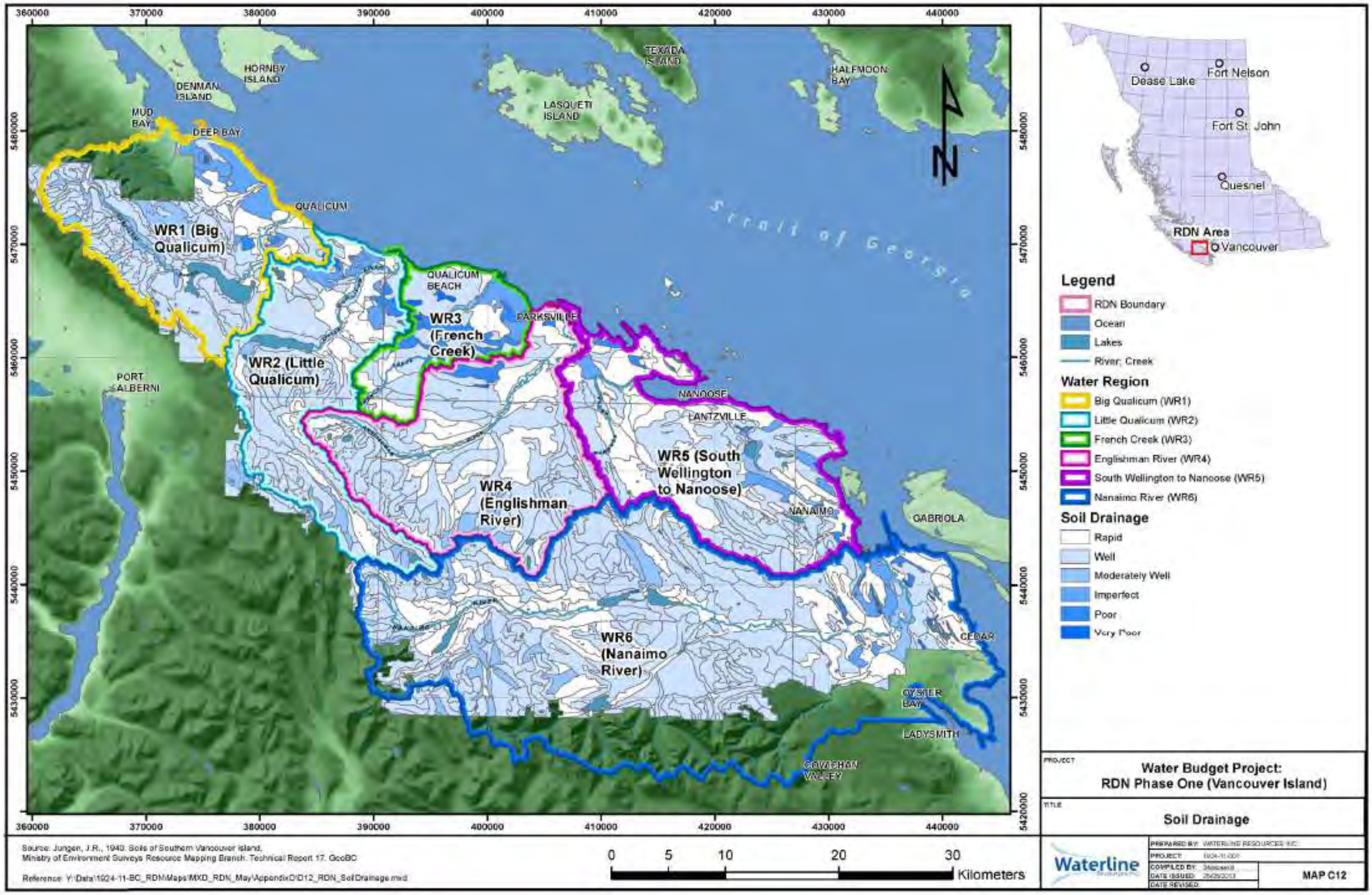


Map C10: MOE Aquifer Transmissivity Estimates (Well Locations) - Fundamental parameters that allow and assessment of groundwater permeability of an aquifer (transmissivity, hydraulic conductivity) or storage properties (storativity, specific yield) are needed to complete aquifer water budgets.

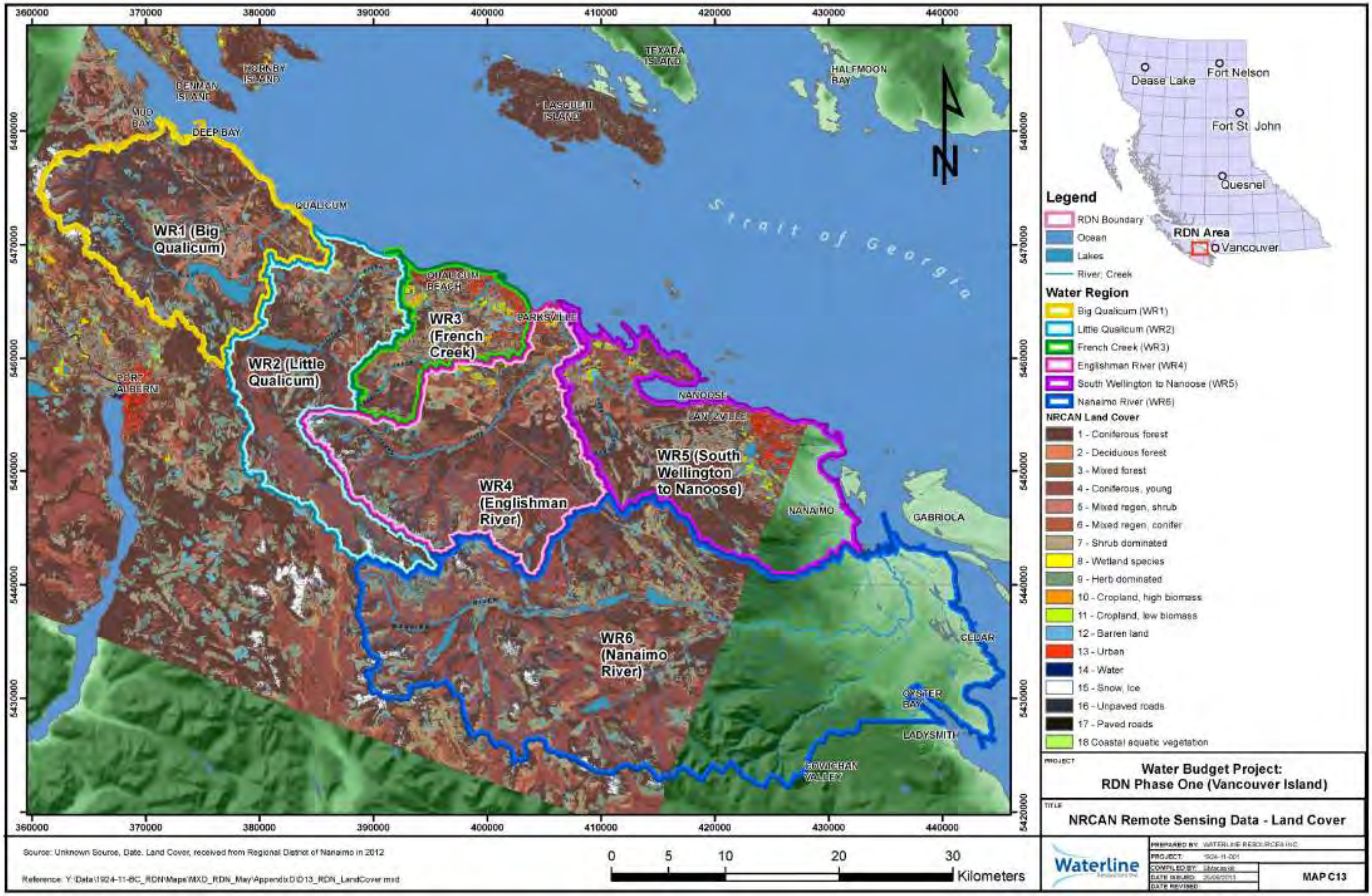
BC MOE undertook to evaluate over 100 historical pumping tests across the RDN which are shown plotted on the image below. This data were critical to the completion of the Phase 1 Water Budget project. Appendix D explains how this quantitative data was compiled with well yield data from preliminary tests completed at the time of drilling to assign aquifer transmissivity values to all 28 mapped aquifers in the RDN.



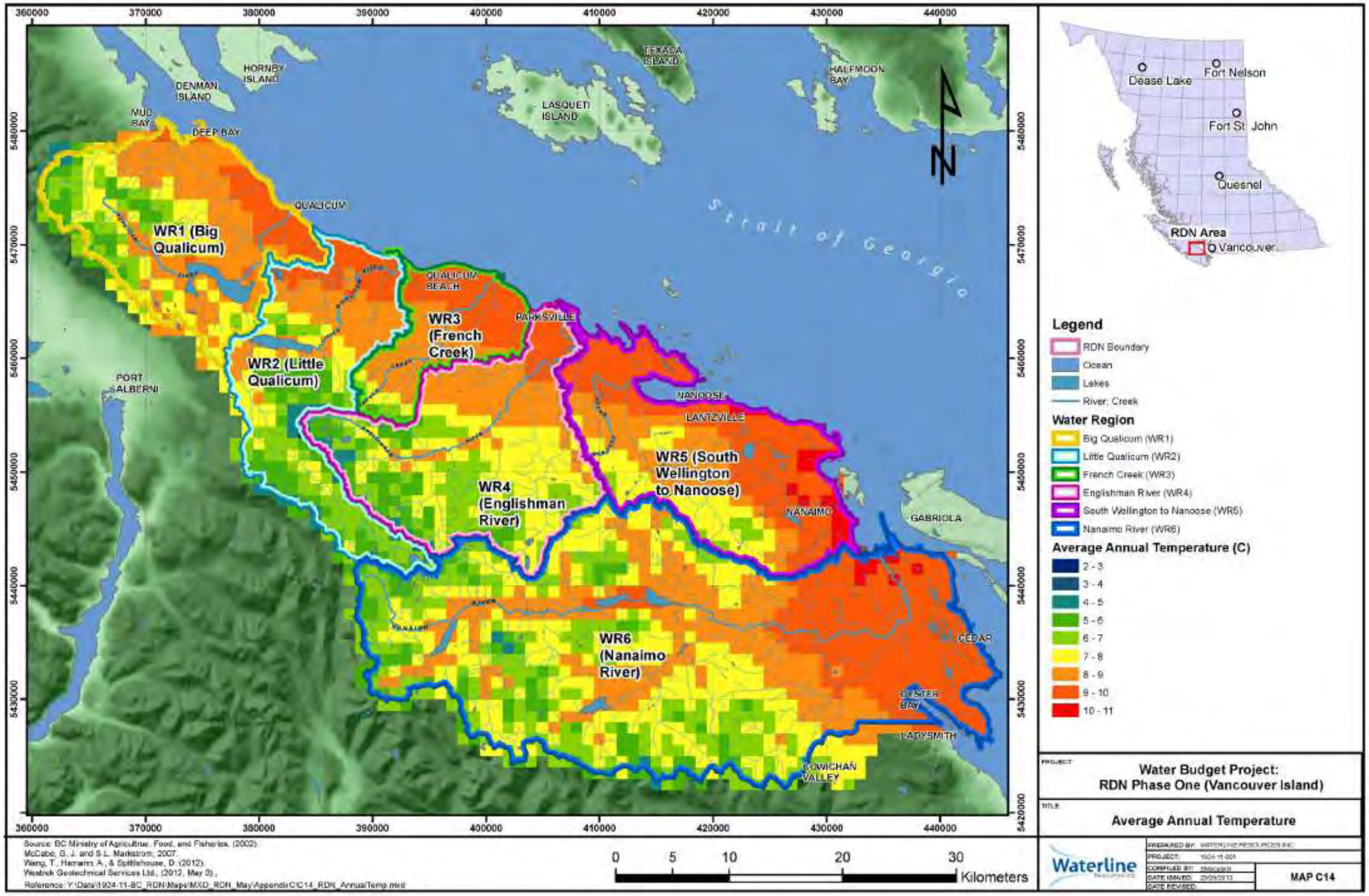
Map C11: NRCAN Remote Sensing Data – Leaf Area Index - Leaf Area Index (LAI) data collected by NRCAN as part of a regional remote sensing program was reprocessed by Waterline and KWL so that it could be used to adjust estimates of snow accumulation and melt over the RDN. Grid cells with area weighted average LAI of greater than 50% LAI where considered to be forested while grid cells having area weighted average LAI of less than 50% were considered to be open. Forested areas where were assumed to have melt rates approximately half of forested areas. This ratio is based on information provided in the Compendium of Forest Hydrology (Winkler, 2010) and discussions with W. Floyd (Floyd, 2012). For additional details on how snowmelt accumulation and melt has been calculated please refer to Appendix D.



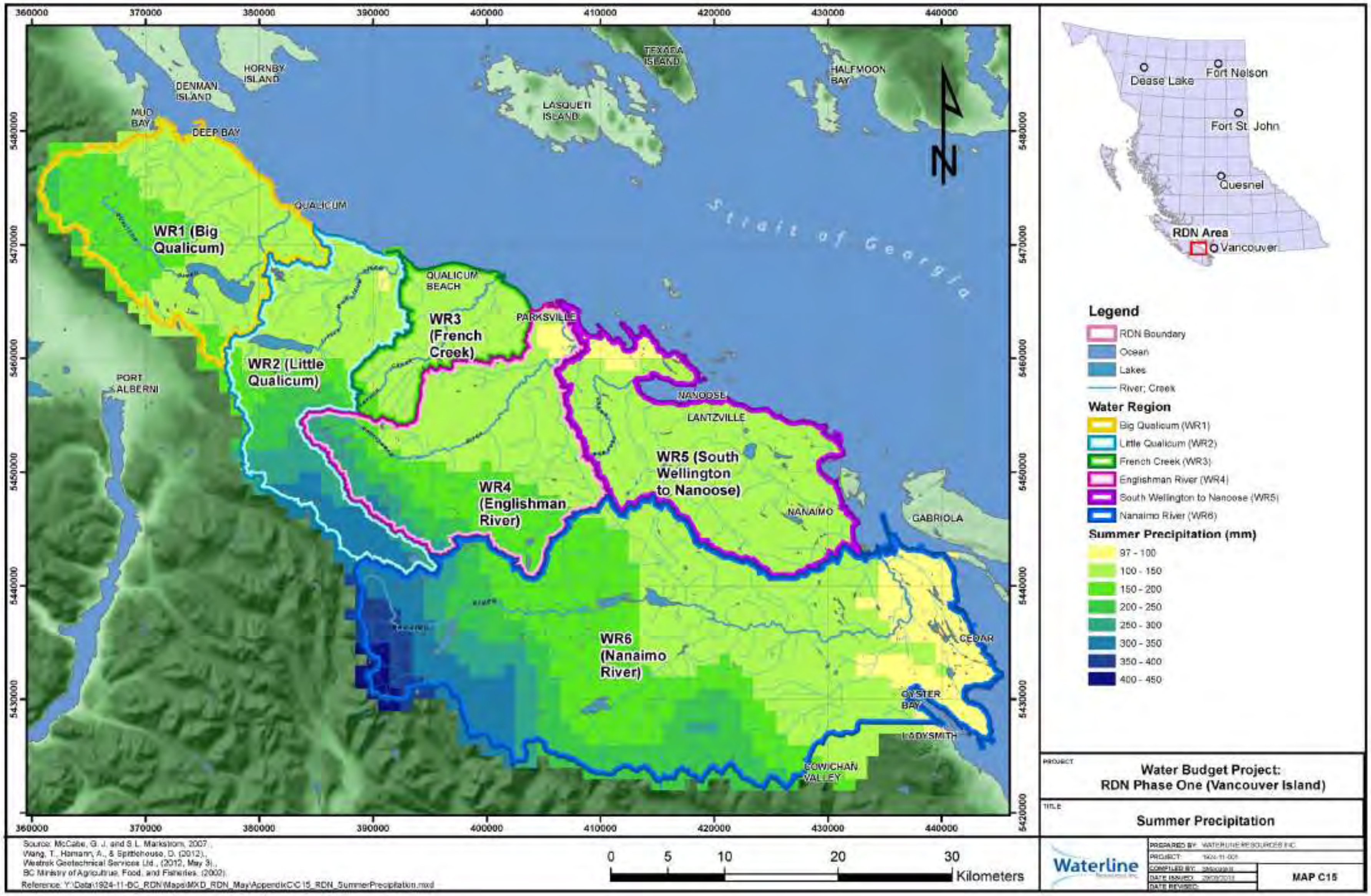
Map C12: Soil Drainage - Waterline reprocessed the government soils map data (Map C2) and assigned drainage values to defined soil polygons. This information was then input into the surface water model by Kerr Wood Leidal and gridded infiltration values assigned across the RDN (Maps C19, and C20). This data, along with LAI (Map C11), and land cover data (Map C13) allowed for the surface water model to calculate infiltration rates over a 1x1 Km grid pattern (Maps C19, and C20).



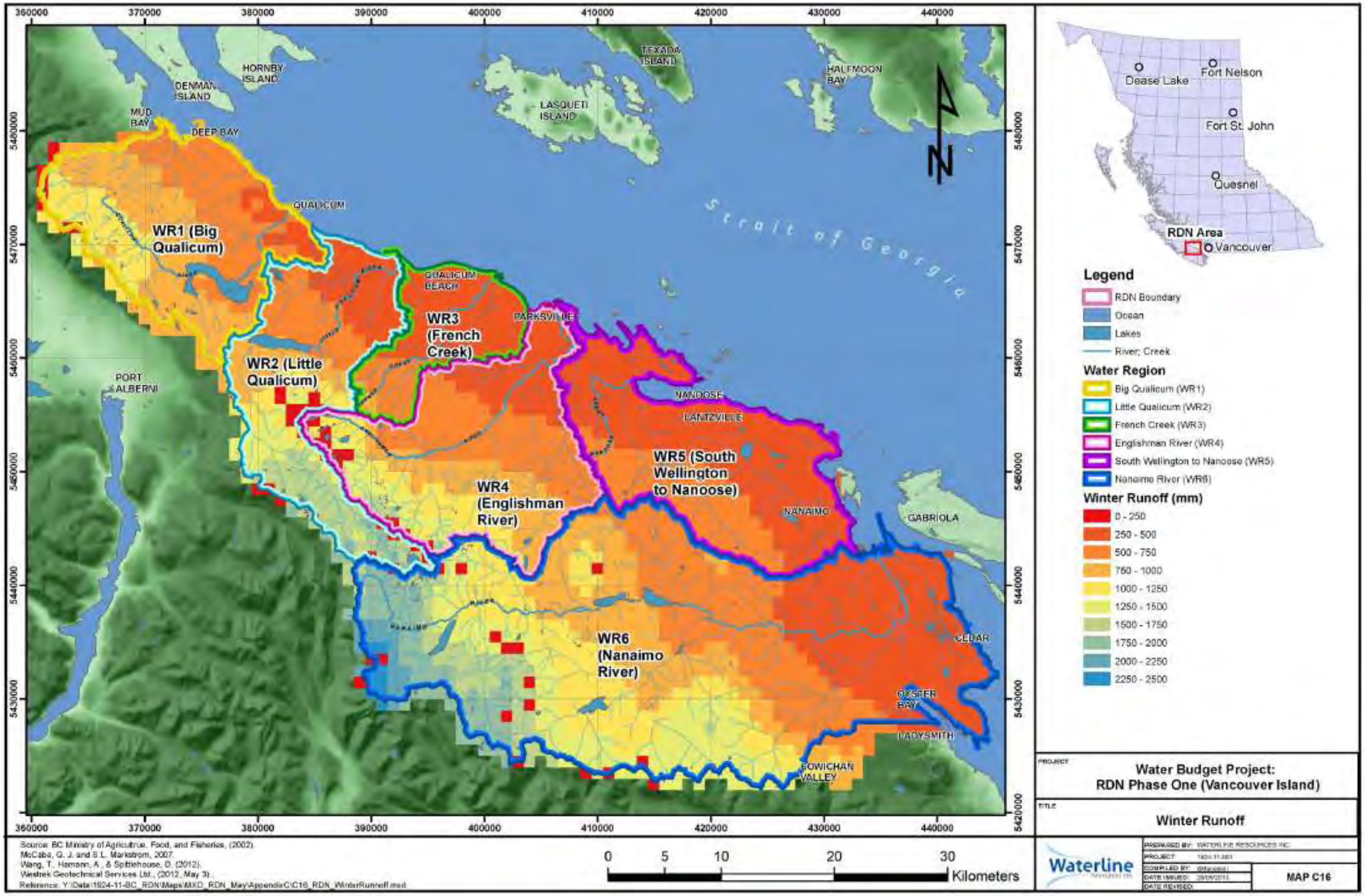
Map C13: NRCAN Remote Sensing Data – Land Cover - Land cover data collected by NRCAN as part of a regional remote sensing program was reprocessed by Waterline so that it could be used to adjust base potential evapotranspiration estimates calculated using the Hamon Equation to account for variation in land cover. The PET adjustment parameters for each 1 km^2 grid cell are based on the area weighted average of each land cover type within the grid cell. These have then been used to calculate PET and actual evapotranspiration within the regional surface water balance model. Further details of the model are described in Appendix D.



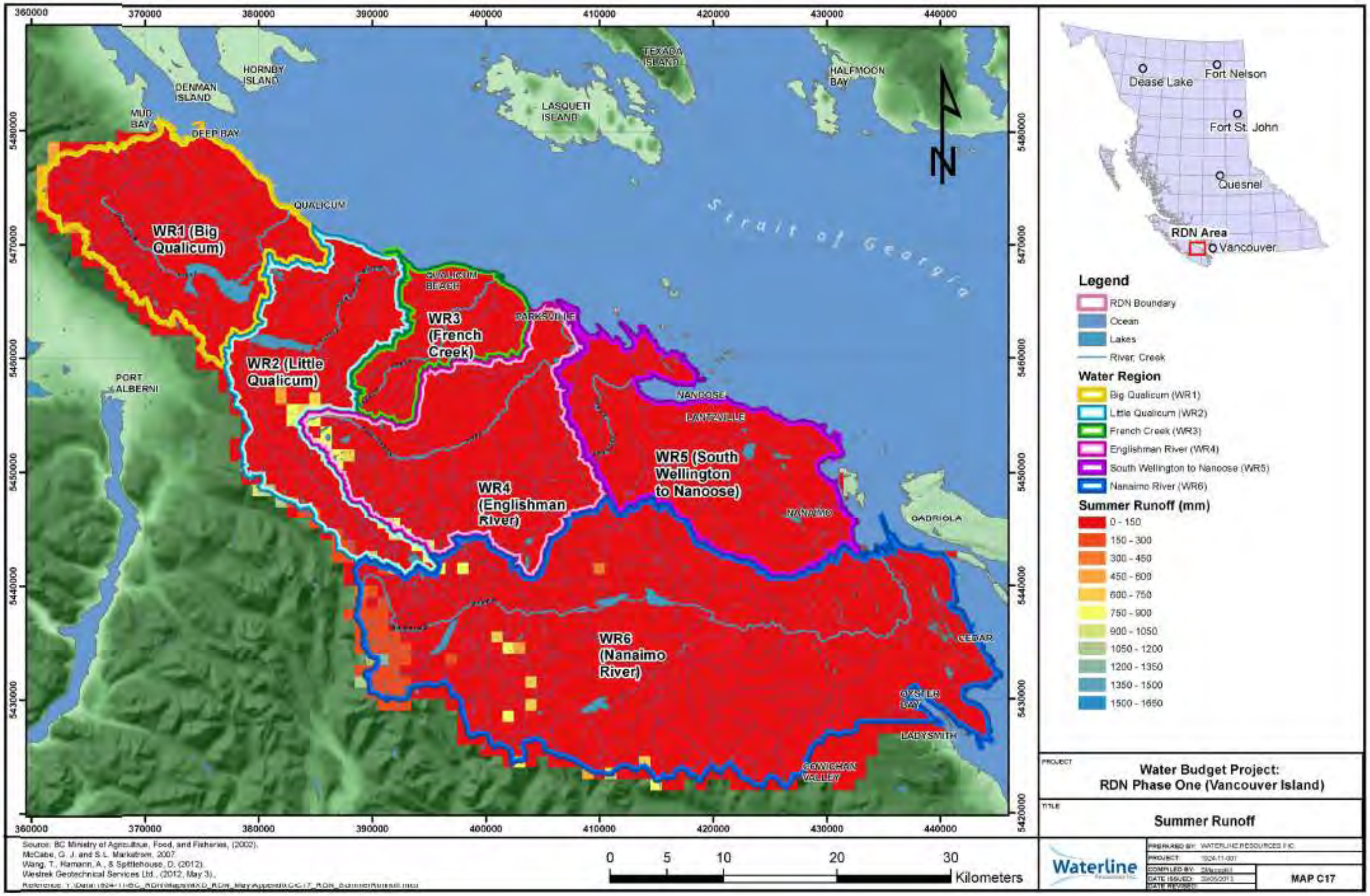
Map C14: Avg. Annual Temperature - Monthly average temperature data for the 1971 to 2000 climate normal period have been extracted from the Climate Western North America model (Climate WNA) (Wang et. al., 2012) at 1 sq. km. grid spacing. The Climate NWA model uses temperature and precipitation lapse rates to downscale the Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate data set (Daly et. al. 2002). PRISM is a unique knowledge-based system that uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of monthly, yearly, and event-based climatic parameters. The model incorporates point data, a digital elevation model, and expert knowledge of complex climatic extremes, including rain shadows, coastal effects, and temperature inversions. Monthly data has been used in the analysis but average annual temperature data is shown in Map C-14 for clarity.



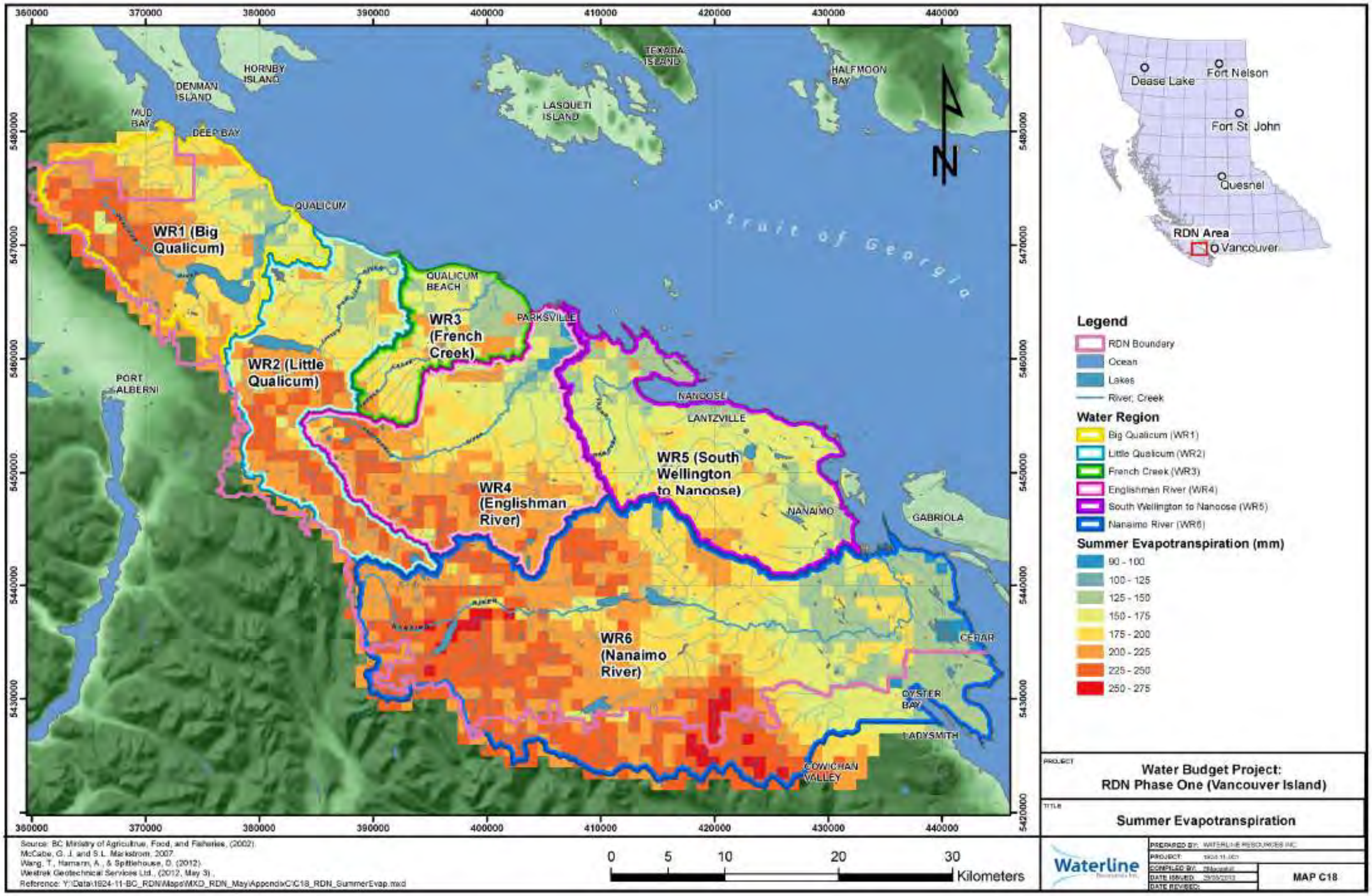
Map C15: Summer Precipitation - Monthly average precipitation data for the 1971 to 2000 climate normal period have been extracted from the Climate Western North America model (Climate WNA) (Wang et. al., 2012) at 1 sq. km. grid spacing. The Climate NWA model uses temperature and precipitation lapse rates to downscale the Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate data set (Daly et. al. 2002). PRISM is a unique knowledge-based system that uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of monthly, yearly, and event-based climatic parameters. The model incorporates point data, a digital elevation model, and expert knowledge of complex climatic extremes, including rain shadows, coastal effects, and temperature inversions. Monthly data has been used in the analysis but summer and winter average precipitation plots are included in Map C-15 and Map C-16 for clarity.



Map C16: Winter Runoff - Gridded Runoff (discharge per unit watershed area) has been calculated using the gridded Climate WNA temperature and precipitation (Maps C14 to C17) and the adapted USGS Monthly Water Balance model (McCabe and Markstrom, 2007). The USGS water balance model converts precipitation into surface water runoff and ground water recharge by accounting for how water is collected in storage including snow storage, soil moisture storage, surface storage (lakes and reservoirs) and ground water storage as well as the flux into and out of these storage areas including evapotranspiration, snow melt, infiltration, ground water recharge and surface water runoff. A more detailed outline of the model is included in Appendix D. Monthly estimates of runoff have been calculated but winter and summer runoff is included in Maps C16 and C 17 for clarity.

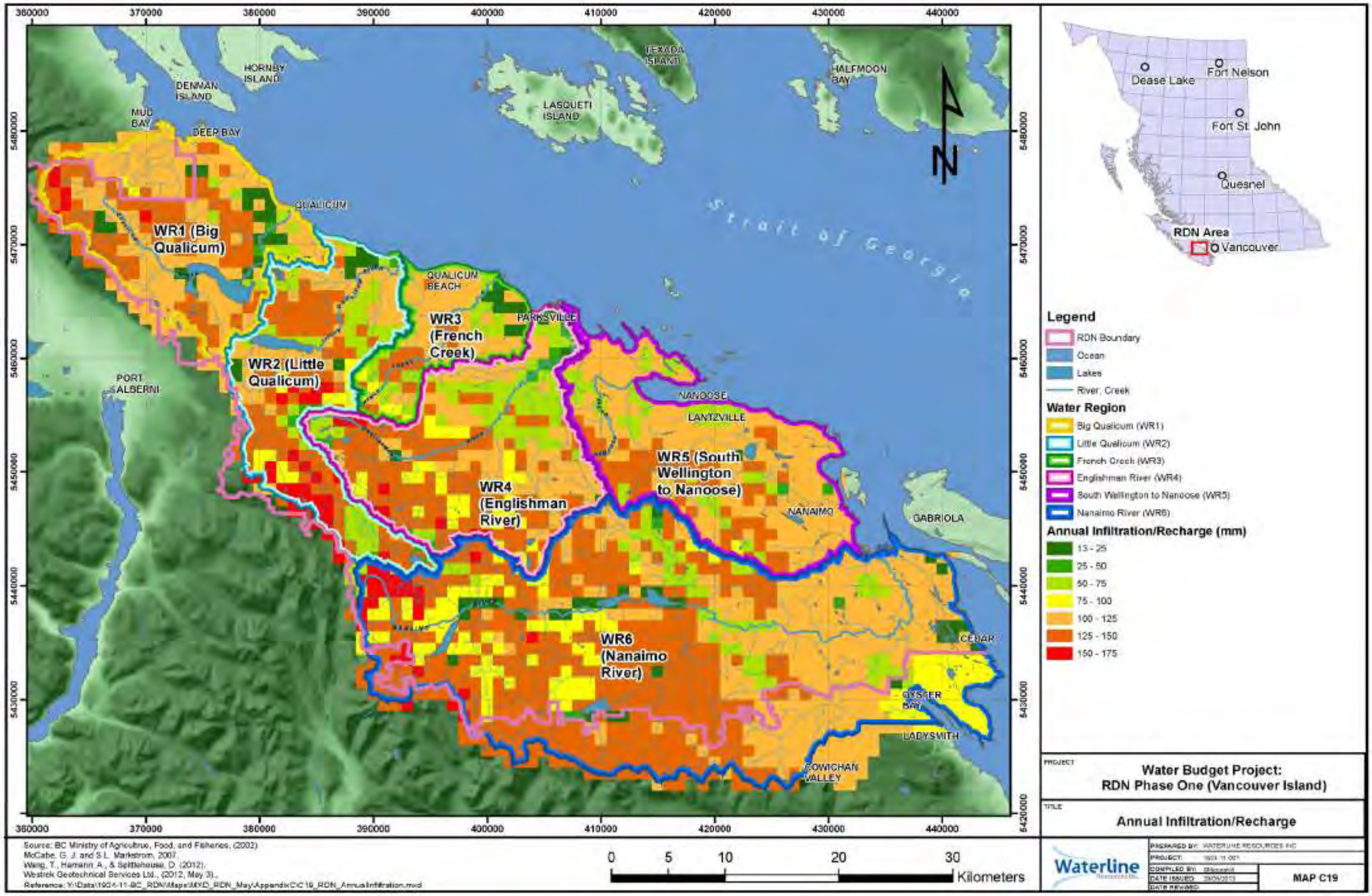


Map C17: Summer Runoff - Gridded Runoff (discharge per unit watershed area) has been calculated using the gridded Climate WNA temperature and precipitation (Maps C14 to C17) and the adapted USGS Monthly Water Balance model (McCabe and Markstrom, 2007). The USGS water balance model converts precipitation into surface water runoff and ground water recharge by accounting for how water is collected in storage including snow storage, soil moisture storage, surface storage (lakes and reservoirs) and ground water storage as well as the flux into and out of these storage areas including evapotranspiration, snow melt, infiltration, ground water recharge and surface water runoff. A more detailed outline of the model is included in Appendix D. Monthly estimates of runoff have been calculated but winter and summer runoff is included in Maps C16 and C 17 for clarity.

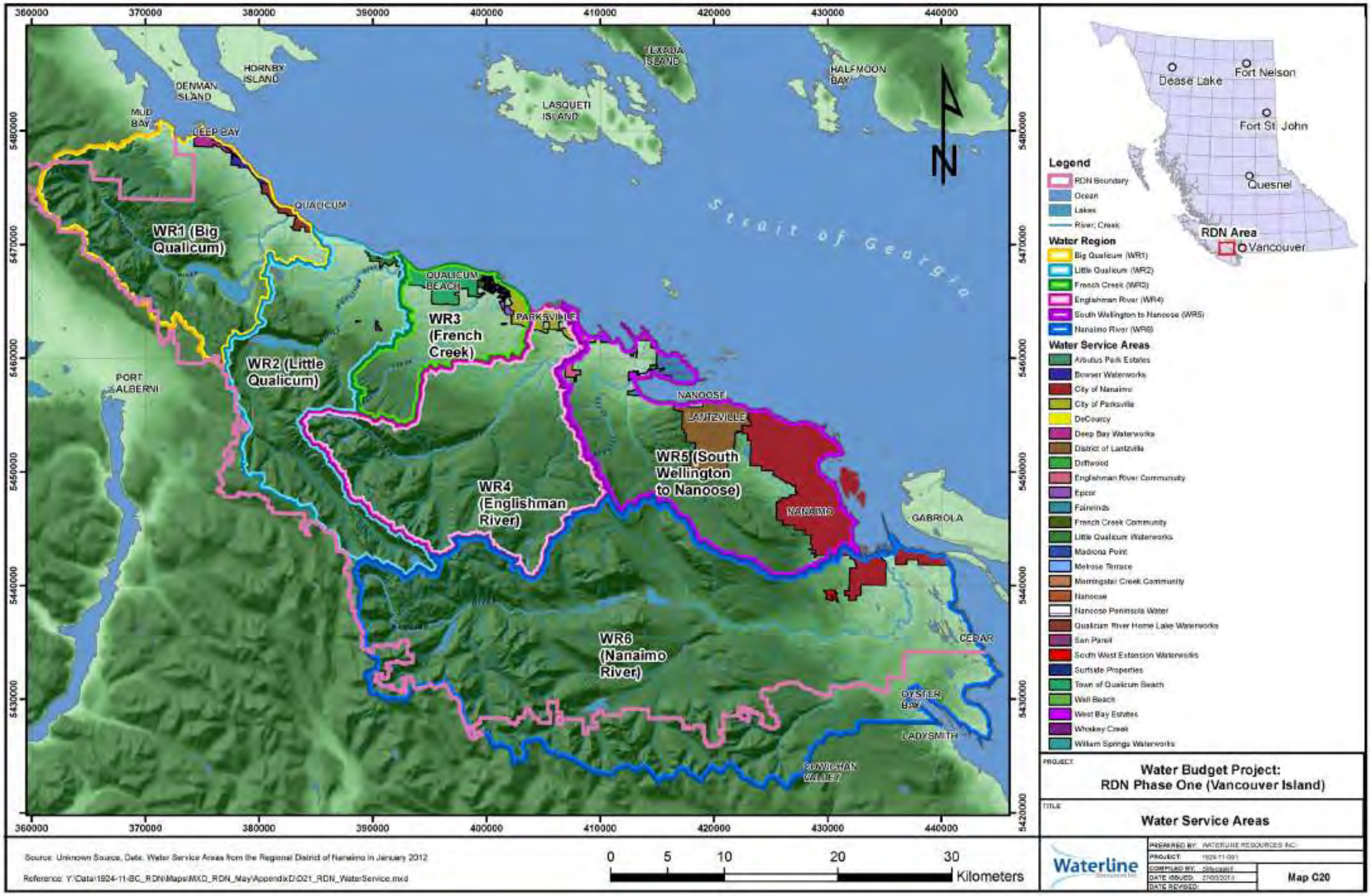


Map C18: Summer Evapo-transpiration

See map C13 for description.

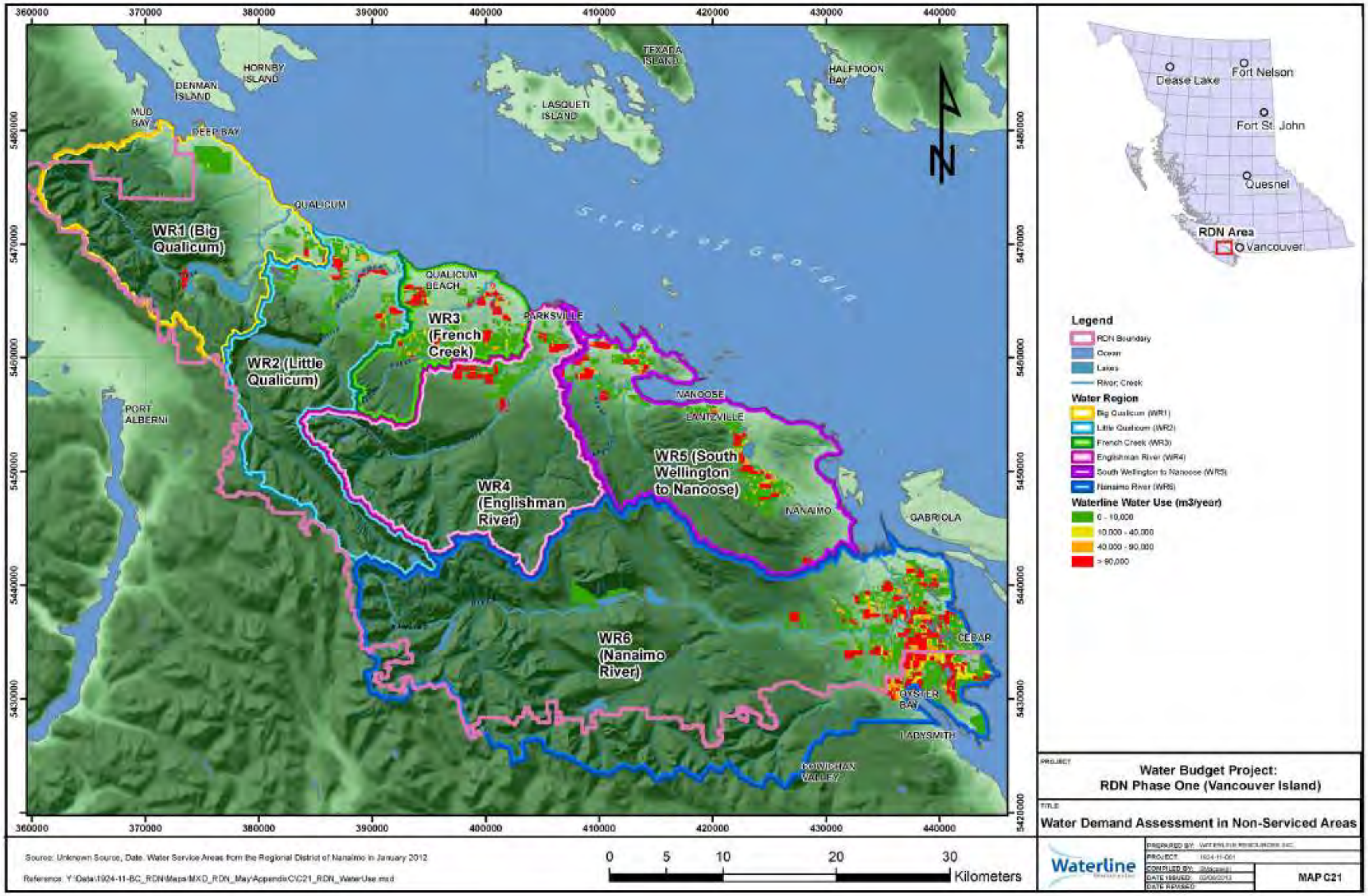


Map C19: Annual Infiltration/Recharge - Gridded Recharge (ground water recharge per unit watershed area) has been calculated using the gridded Climate WNA temperature and precipitation (Maps C14 to C17) and the adapted USGS Monthly Water Balance model (McCabe and Markstrom, 2007). The USGS water balance model converts precipitation into surface water runoff and ground water recharge by accounting for how water is collected in storage including snow storage, soil moisture storage, surface storage (lakes and reservoirs) and ground water storage as well as the flux into and out of these storage areas including evapotranspiration, snow melt, infiltration, ground water recharge and surface water runoff. A more detailed outline of the model is included in Appendix D. Monthly estimates of recharge runoff have been calculated but total annual recharge is shown on Map C20 for clarity.



Map C20: Water Service Areas

Data provided by RDN.



Map C21: Water Demand Assessment in Non-Service Areas - The RDN provided parcel water use data from metered RDN and municipal water service areas. Waterline removed all forest and vacant land parcels from the data set as there is no water use in these area. We retained agricultural parcels & lots already approved for development which were, primarily residential, and the assigned agricultural water use values based on Ministry of agriculture recommended method. Waterline then cross-referenced against the 2011 air photos and civic addresses outside municipal service areas to confirm surface or groundwater use. In the analysis, Waterline assumed all water use in non-service areas get supply from wells which was verified on the Waterline Geodatabase using civic address, air photo, water wells, and license surface water points layers. A final calibration check was completed by aggregating parcel water use estimates within service areas against measured water

APPENDIX D
METHODOLOGY FOR SURFACE WATER AND WATER BUDGET CALCULATIONS

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1.0 SURFACE WATER BUDGET CALCULATIONS

1.1 Water Budget Assessment and Assumptions

Water balance techniques have been extensively used to make quantitative estimates of water resources and the impact of various human activities on the hydrologic cycle within a defined water region or watershed. It is possible to evaluate quantitatively individual contribution of sources of water in the system, over different time periods, and to establish the degree of variation in the water regime due to changes in components of the system. The basic concept of water budget is that input to the system, minus outflow from the system is equal to change in storage of the system over a specified period of time.

The water budget assumes that a watershed is a closed system with only precipitation as input with evapotranspiration, surface water runoff and groundwater exfiltration as output. This assumes that groundwater table generally follows the surface topography such that groundwater flow into and out of the watershed is negligible. For those areas where aquifers are known to cross surface watershed boundaries, more detailed analysis has been carried out under the ground water balance section described in Section 2 below.

The monthly water balance assessment carried out also assumes that travel time for surface water flow is less than one month, except for surface water storage. In other words, all surface water runoff that is generated flows to the outlet of the watershed within one month. The only exception is surface water storage such as lakes or reservoirs which are accounted for separately in the water budget.

Finally, the surface water budget assumes that ground water and surface water storage can be assumed to act similar to a linear reservoir in which the outflow from the storage at time T+1 is a function of the amount of water in storage at time T. The linear reservoir parameters for surface water and ground water are developed through calibration of the model to recorded values. Once general ground water balance (i.e.: ground water recharge and outflow) is established in the surface water model. The values have been used to refine the estimates in the ground water budget described in Section 2.

1.2 USGS Monthly Water Balance Model

The surface water supply for the Regional District of Nanaimo was assessed using the US Geological Survey (USGS) monthly water balance model (McCabe and Markstrom, 2007). The model is a GIS-based distributed conceptual model which calculates surface runoff (surface flow per unit watershed area), unit groundwater recharge for each one square kilometer grid cell in the watershed. Runoff and ground recharge are calculated by using climate variables (precipitation and temperature), soil characteristics and land cover. The model calculates runoff and ground water recharge for each square kilometer grid in the watershed, which is then used to estimate total runoff from watersheds using flow accumulation routine in GIS.

1.3 Model Overview

The USGS Model is a water balance accounting model which calculates how water moves between various storage components, such as snowpack storage, soil moisture and groundwater, and how much water is lost to atmosphere through evapotranspiration, surface water runoff or groundwater recharge. The model runs on a monthly time scale using monthly average climate data.

The model accounts for snow accumulation and melt using precipitation and temperature climate data, evaporation and soil moisture using a Thorntwaite based approach to estimate potential evapotranspiration (PET) and actual evapotranspiration (ET), and ground water recharge through soil moisture estimates and soil infiltration estimates based on soil types (Thorntwaite, 1948).

A schematic of the model algorithm is shown in Figure 1. More detailed description of these various components is outlined below.

1.3.1 Climate

The monthly climate data (temperature and precipitation) used in the model is based on output from the Climate BC model developed by the UBC Faculty of Forestry (Wang, et. al., 2006). The model down scales climate variables (temperature, precipitation, etc.) from larger scale data sources such as; historical climate data from the PRISM data set as well as forecast future climate from Global Circulation Models (GCMs) or Regional Climate Models (RCMs). Climate BC model uses temperature and precipitation lapse rates (rate of change of climate with elevation) to adjust the larger scale data to take account of topography not captured in the larger grid sizes of the larger scale datasets. For the RDN study, the watersheds have been divided into one square kilometer grid cells. For each grid cell, the average elevation has been estimated using the 1:50,000 National Topographic Survey (NTS) digital elevation model. The latitude and longitude of the centroid of each grid cell and the average elevation have been used as input to the ClimateBC model to estimate average monthly temperature and precipitation data for each grid cell across the region. For the RDN study, only average monthly data for the 1971 to 2000 normal climate period have been used.

1.3.2 Snow Accumulation and Melt

Snow accumulation and melt is derived from monthly average precipitation and temperatures. The phase of precipitation as rain or snow is estimated by assuming when average temperature is less than -2oC then all precipitation falls as snow and when monthly average temperatures are greater than 2oC then all the monthly precipitation falls as rain. When monthly average temperatures fall between -2oC and 2oC then ratio of snow to rainfall during the month is assumed to be the percentage that the observed temperature of the range between -2oC and 2oC, such that:

P_{rain} = P (Tmonth – (-2oC) / 4oC)
P_{snow} = 1 – P (Tmonth – (-2oC) / 4oC)

Where P is the total monthly precipitation (rain and/or snow), P_{rain} is the total monthly rainfall and P_{snow} is the total monthly snowfall.
The temperature range was based on a review of temperature records to determine at what average temperature does daily temperature tend to stay below zero for the entire month as well as model calibration with available snow pack data.

A melt rate function for snow was based on a standard rate. The melt rate was adjusted to account for open areas versus forested areas. Forested areas were assumed to have a melt rate approximately half of the forested areas (Floyd, 2012 and Winkler, 2010)

1.3.3 Vegetation/Land Cover Component and Potential Evapotranspiration

Land cover data was determined by using the Land cover data provided by the RDN. Land cover was classified into 18 unique categories as shown below. The land cover classifications are based on photo interpretation of SPOT Satellite imagery collected in 2011.
The land cover data was analyzed at each grid cell to determine a Potential Evapotranspiration (PET) factor which is used to adjust PET calculated using the Hamon Equation (Hamon, 1961) to account for variations in PET with land cover. PET factors were applied based on the knowledge that a heavily vegetated area will have a higher PET than open areas. A listing of the PET factors used for each of the land classes is shown in Table 2.

<u>Water Balance Model Schematic:</u>

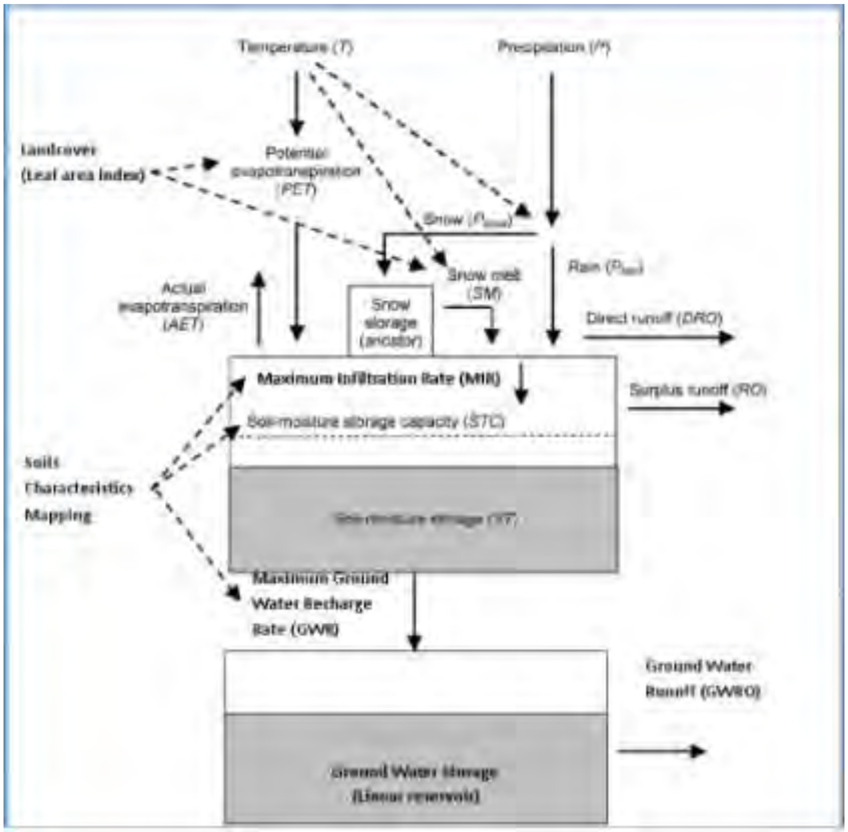


Table D1: Land Cover Map of Nanaimo Region, BC Descriptions of Land Cover Classes (Below)

TREE DOMINATED

Land dominated by vegetation with a tree (woody plants with a height exceeding approximately 5 metres in most cases)

1) Coniferous (210 conifer forest)

Predominantly coniferous forests or treed areas. Dense forest with structural variability and gap dynamics.

(2) Deciduous (220 deciduous forest)

Predominantly broadleaf/deciduous forests or treed areas. Moderate to dense predominately deciduous forest.

(3) Mixed (230 mixed forest)

Mixed coniferous and broadleaf/deciduous forests or treed areas. Moderate to dense mixed forest.

(4) Coniferous recent disturbance origin ~last 50 years (210 conifer forest)

More dense canopies with reduced vertical structural variability compared to Coniferous (1) of disturbance origin within the last 50 years.

(5) Mixed Regeneration Shrub Dominated (50 shrubland)

Regeneration from disturbance typically after tree planting creating a mixed forest condition, generally dominated by shrub.

(6) Mixed Regeneration Conifer Dominated (230 mixed forest)

Older regeneration from disturbance, where conifer trees have become greater than 2 m tall and more dominate coverage.

SHRUBLAND

Land dominated by vegetation with a shrub (perennial woody plants that branches at ground level from several

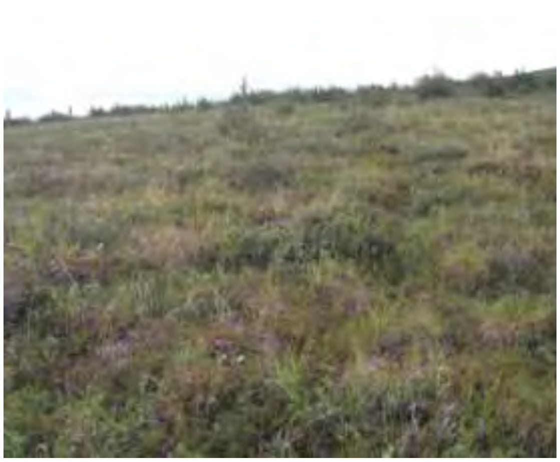
Predominantly woody vegetation of relatively low height (generally ±2 meters). Comments: May include grass or grassland wetlands with woody vegetation, regenerating forest.

HERB DOMINATED

Land dominated by plants without woody stems, including grasses, forbs and ferns.

(8) Wetland (80 wetland)

Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes (semi-permanent or permanent wetland vegetation, including fens, bogs, swamps, sloughs, marshes, etc.). Comments: This class is mapped based on cover properties corresponding with image date(s) conditions.



(9) Low Vegetation (100 herb)

Grass and other low lying herbaceous covers.

(10) Cropland high biomass (120 cultivated cropland)

Agricultural land with cultivated crops.

(11) Cropland low biomass (120 cultivated cropland)

Agriculture land where crops have not be cultivated, typical pasture and fallow post harvesting.

NONVASCULAR DOMINATED Barren land.

12) Barren (33 exposed land)

Predominately non-vegetated and non-developed. Includes: exposed lands, snow, glacier, rock, sediments, burned areas, rubble, mines, other naturally occurring non-vegetated surfaces. Comments: Mines or similar human activity may be mapped by this class, or may be mapped by the developed class.

VEGETATION NOT DOMINANT

Vegetation is scattered or nearly absent; total vegetation cover is generally less than 10%.

13) Urban (34 developed)
Land that predominantly built-up or developed. This includes road surfaces, railway surfaces, buildings and paved surfaces, urban areas, industrial sites, mine structures.

(14) Water (20 water)

Area covered with liquid water including open ocean, lakes, and rivers.

(15) Snow/Ice (31 snow/ice)

Land covered with permanent ice or snow.

(16) Unpaved Road (33 exposed land)

Gravel or dirt roads.

(17) Paved Road (33 exposed land)

Asphalt or concrete roads.

No image available.

(18) Coastal Aquatic Vegetation

Sea grasses, algae, and other marine plane life along the sea coast.

Table D2:Potential Evapotranspiration Factors for various land cover types.

Land Cover ID	Description	PET Factor
LND_CVR_1	Coniferous Forest	1
LND_CVR_2	Deciduous Forest	0.95
LND_CVR_3	Mixed Forest	0.95
LND_CVR_4	Coniferous - recent disturbance	0.9
LND_CVR_5	Mixed Regeneration Shrub	0.9
LND_CVR_6	Mixed Regeneration Confider Dominated	0.9
LND_CVR_7	Shrub	0.85
LND_CVR_8	Wetland	0.9
LND_CVR_9	Low vegetation	0.9
LND_CVR_10	Cropland High biomass	0.85
LND_CVR_11	Cropland low biomass	0.8
LND_CVR_12	Barren	0.5
LND_CVR_13	Urban	0.7

LND_CVR_14	Water	1
LND_CVR_15	Snow/Ice	1
LND_CVR_16	Unpaved Road	0.5
LND_CVR_17	Paved Road	0.7
LND_CVR_18	Coastal Aquatic Vegetation	0.65

Notes: PET Factor is used to adjust standard PET calculated using Thortnwaite Equation to account for various land cover type. These are based on textbook values and calibrated for regional conditions.

1.1.1 Soil Component

Soil data was provided by the RDN (Westrek, 2012) and integrated with GIS to determine the soil properties of each grid cell in the study area. Soil varies greatly through the region from impermeable bedrock to porous gravel. Each unique soil type in the RDN was assigned a value for the following properties:

- Soil Moisture Storage Capacity (STC) [mm]
- Maximum Infiltration Rate (MIR) [mm]
- Maximum Groundwater Recharge Rate (GWR) [mm]

The STC for each soil type was estimated using values from the (BC Ministry of Agriculture, Food, and Fisheries, 2002) as shown in Table D3 for reference.

Table D3: Soil Moisture Storage Capacity

Textural Class	Soil Moisture Storage Capacity (mm water / m soil)
Clay	200
Clay Loam	200
Silt loam	208
Clay loam	200
Loam	175
Fine sandy loam	142
Sandy loam	125
Loamy sand	100
Sand	83

Source: BC Ministry of Agriculture, Food, and Fisheries (2002)

STC values for soil types in the RDN that are not in Table D3 were estimated by using the known values as a reference. For example, it is expected that gravelly sand will have a lesser STC than sand.

The Maximum infiltration rate (MIR) was determined through model calibration and limited permeability data (Westrek, 2012). MIR was used to determine the soil moisture recharge rate, the drier the soil the quicker the soil can recharge compared to when it is near saturation.

Groundwater recharge (GWR) was included in the USGS model through a slight modification. The model assumed that a portion of the soil moisture provided groundwater recharge during periods of saturated soils (i.e. wet winter months). The model assumed that a portion of the groundwater supply was released as surface water, and provided discharge during dry summer periods.

GWR was estimated to be 10% of the MIR through model calibration and discussions with technical groundwater experts. A groundwater-surface water interaction monitoring program would provide essential data to confirm and improve the hydrologic model.

1.1.2 SURFACE WATER BUDGET

Surface water budgets for each of the major watersheds have been developed using estimates of monthly natural flow from output from the regional hydrology model, the licensed water withdrawal volumes, licensed storage volumes, recorded water withdrawal volumes (where available), and estimates of required minimum conservation flows (see Figure 2 in main report). As limited surface water withdrawal data is available, the total annual volumes quoted in water licenses have been used as an estimate of the actual water withdrawal amount.

The total monthly withdrawal volumes have been estimated using the annual withdrawal volume and typical demand distributions. For waterworks demand, the distribution is based on water withdrawal records from the City of Nanaimo, and Town of Parksville, for domestic demand it has been assumed that July, Aug and September demand is twice the demand during the remainder of the year, industrial demand has been assumed to be constant throughout the year and agricultural demand is assumed to take place during the spring and summer months only from May to September at a constant rate. Where recorded withdrawal data is available, actual water demand values have been used in the assessment.

The required minimum conservation flow is based on typical value of 10% of average discharge. This is based on the modified Tennant (Montana) method (Tennant, 1976) and is considered to be standard planning value used by the Ministry of Environment for river habitat protection.

2.0 AQUIFER WATER BUDGET CALCULATIONS

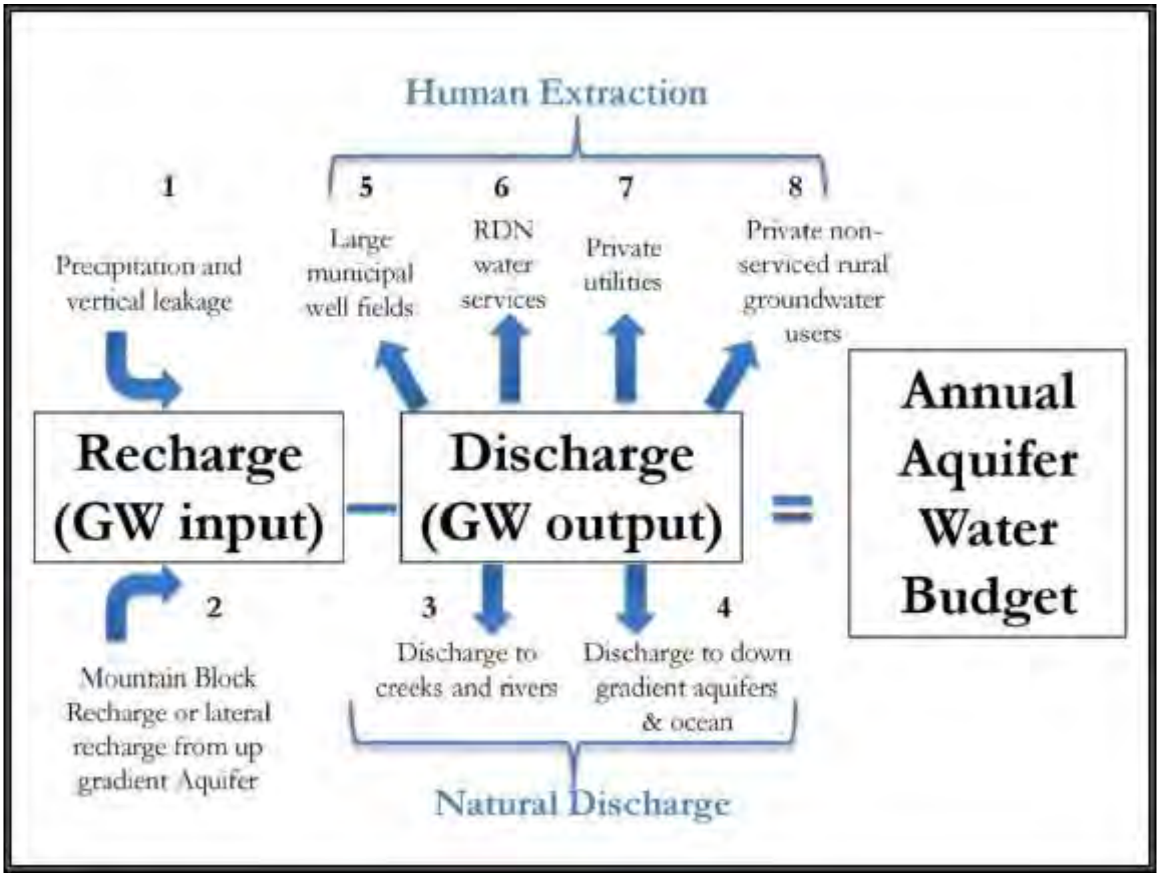
2.1 Approach Used For Water Budget Calculations

The RDN is bounded to the west by mountains and to the east by Georgia Strait. Surface water and groundwater drain from high to low elevations, thus the steep coastal profile creates a natural gravity-driven system with relatively high hydraulic gradients to the ocean. Fresh water resources that do not evaporate or transpire will eventually flow to the ocean, unless intercepted by wells or surface intakes for water supply use. The groundwater flow paths in aquifers across the RDN tend to follow the topography of the land and flow towards the ocean. Maps C8 and C9 (Appendix C) show piezometric surface contour maps developed for wells from 0-25 m and 25-50 m depth below ground.

Surface water and groundwater systems are dynamic systems and constantly in a state of flux in accordance to the changing seasons and longer term climate variability on the Pacific Coast of North America. Both surface and groundwater systems in the RDN are expected to have short residence times resulting in relatively young groundwater (10's to 100's of years old) from the point of recharge at higher elevations to discharge points in local creeks, or near the coast. Rivers and creeks exchange water with shallow aquifers through the watershed. Over time, rivers and creeks erode away surficial materials and cut down into underlying aquifers causing direct exchange between the surface water and groundwater systems.

Aquifer recharge occurs when precipitation percolates (infiltrates) through the soil and replenishes the underlying groundwater systems. In addition, as groundwater flows from areas of high topographic elevation to areas of lower elevation, aquifers can also receive lateral recharge from adjacent up gradient aquifers. This is referred to as 'mountain block recharge'.

The following generalized equation was used to assess aquifer water budgets. The stress on each aquifer was estimated as a percentage of the groundwater demand versus aquifer recharge from precipitation (vertical) and the upgradient mountain block or lateral recharge.



Aquifer Water Budget Components

Each parameter is described as follows:

1. Precipitation and vertical leakage is rainwater or snowmelt that recharges the subsurface or water that moves from an overlying aquifer to an underlying aquifer through vertical leakage,

2. Lateral through-flow and mountain block recharge is an important source of aquifer recharge. Aquifers that have been mapped at the higher elevations tend to receive recharge directly from the upgradient mountain block and will also then feed aquifers at lower elevation located near the coast and is referred as lateral recharge from upgradient;

3. Some of the creeks are in direct hydraulic communication with the various creeks and rivers within each water region. There is a certain amount of groundwater that discharges to these creeks and it is important that this is maintained in an effort to preserve a healthy ecosystem. This volume of groundwater was estimated for aquifers that were considered to be connected to a local creek or river and factored into the aquifer water budget analysis;

4. All aquifers mapped in each water region will discharge to an adjacent down gradient aquifer which maintains the health and water balance in the system. The volume of groundwater moving out of one aquifer (discharge) and into a down gradient aquifer (recharge) was also considered in the aquifer water budget assessment;

5. Human extraction of groundwater by pumping was also considered wherever data was available. Annual extraction from large municipal wells that service communities were consider in the Aquifer Water budget assessment;

6. Similarly, RDN has a number of water service wells located in various aquifers and locales across the RDN. Annual water abstraction data for each system was used to assess aquifer water budgets in each respective area;

7. In areas not serviced by a community system, the water use was estimated by assigning water use parcels based on zoning and land use. For instance, agricultural parcels were assign a groundwater use based on the BC Ministry of Agriculture and Lands water demand model previously developed for the RDN. Other land use parcels such as residential, commercial, and industrial were assigned water use values in accordance to estimates provided by the RDN for water service areas where the water use was metered. The estimates were applied to non-service areas where groundwater was thought to be in use based on the existence of water wells in those respective areas.

8. The final aquifer water budget (surplus or deficit) was determined by the summing the recharge components (inputs) and subtracting the sum of all discharge components (outputs). A negative number would indicate that there is less water recharging the aquifer than is discharging from the aquifer. In which case one would expect declining water levels in the aquifer. Where available, the long-term water levels trends were considered in the final aquifer water budget assessment as a calibration check.

2.2 Fundamental Assumptions – Aquifer Water Budgets

Several fundamental assumptions are implicit in the aquifer water budget assessment as follows:

• As very little aquifer parameter data was available (see Map C10, Appendix C) each aquifer was assumed to be ideal in terms of uniformity and homogeneity and was represented by average aquifer parameters (transmissivity and storativity terms). In reality, however; unconsolidated layered sedimentary deposits or fractured bedrock aquifers tend to be more complex and rarely uniform or homogeneous. In order to elevate the level of accuracy of the groundwater flow estimates, regulatory change must be implemented whereby pumping tests are interpreted to provide aquifer transmissivity values. The values obtained for aquifers mapped within the RDN were taken from Carmichael (2012).

• Although the exchange of water between aquifers and rivers/creeks varies seasonally, insufficient long-term monitoring data are available at the aquifer scale to allow for meaningful assessment of aquifer water budgets on a monthly basis. Therefore, it was assumed that annual aquifer water budgets would provide some indication of stress on major aquifers within the RDN. A more detailed assessment can only be completed once more time series data is available and a computer model is developed during full Tier 1 or Tier 2 assessment as per OMNR (2012).

• Given the steep natural water table gradients directing water downslope towards the ocean, Waterline assumed that groundwater was constantly discharging to the major rivers/creeks (no seasonal change causing creek/rivers to reverse from influent to effluent). This provides a conservative approach to the water budget calculation.

• Where aquifers were assessed to discharge directly to the ocean, the volume of groundwater leaving the system was not considered in the water budget and stress calculation. The rationale for this is that any groundwater that can be captured before discharging to should not have a significant impact to the environment. This assumption makes the water budget estimate for coastal aquifers more favorable in comparison to upgradient aquifers that provide needed recharge to down gradient aquifers or to rivers and creeks that may rely of groundwater discharge to maintain base flow.

• In terms of anthropogenic groundwater use, Waterline used measured water use data for the 2010 period as it appeared to provide the most complete data set for all municipal, RDN, and private water utilities across the RDN. Where no groundwater extraction data was available for large users or for rural areas not serviced by a water supply system, it was assumed that groundwater demand could be estimated based on measured demand in serviced areas and applied based on designated land use parcels. However, it is recognized that this is a very crude estimate of groundwater use which need to be confirm by actual measurements.

These simplifying assumptions allow for completion of the aquifer groundwater budget assessment in the absence of detailed data. However, it should be cautioned that non-ideal aquifer conditions and a sparse data set can lead to erroneous conclusions and aquifer protection and management decisions. The aquifer water budget calculations completed by Waterline allow for a relative, aquifer to aquifer comparison, rather than providing absolute measure of groundwater availability. All aquifer water budgets calculations should therefore be considered as qualitative for use in assessing and conceptualizing interconnections between aquifers and surface water features inferred by the geological model or observations made but not measured. As the RDN moves to an equivalent Tier 1 or Tier 2 level of assessment (OMNR 2012) in each water region, more data will lead to more certainty.

2.3 Vertical Recharge from Precipitation

Aquifer recharge from above was estimated by applying the gridded infiltration/recharge values developed by KWL over the surface area of the aquifer taken from the ARC GIS Model. The infiltration values were generated by KWL using the modified USGS model as described in the section above and shown on Map C19 (Appendix C).

Table D4 presents estimated average infiltration values for each aquifer mapped within the 6 water regions across the RDN. These values were used to estimate vertical recharge to aquifers in the aquifer water budget calculations.

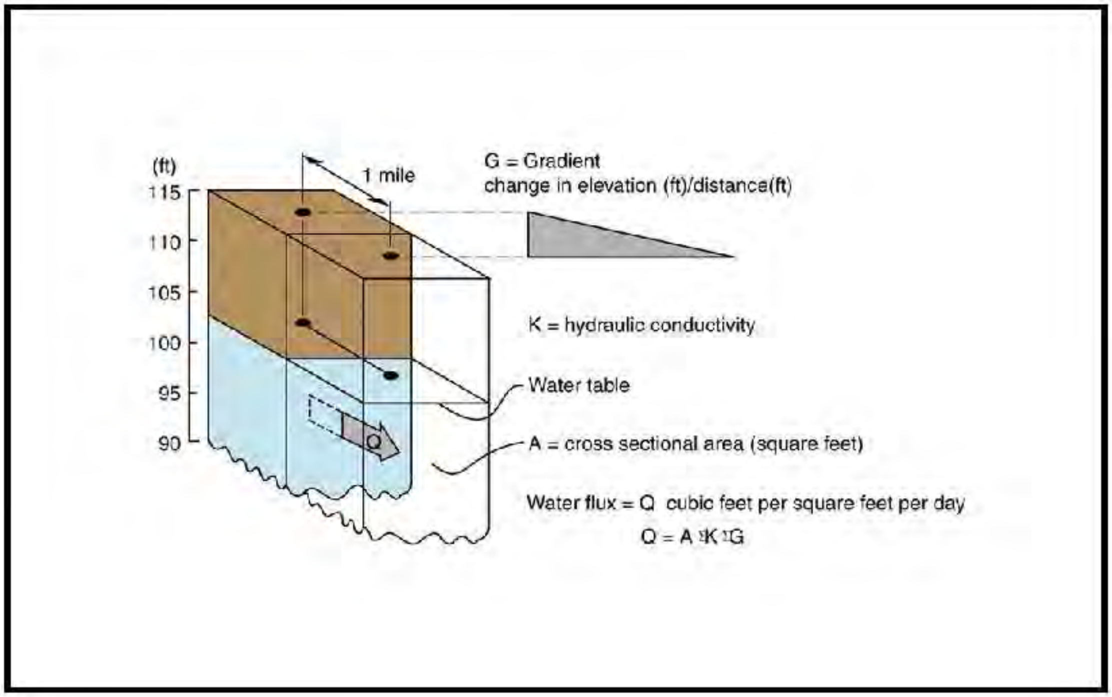
Table D4: Estimated Average Infiltration Values Per Aquifer (From KWL Model)

Aquifer	# of values	Min. Infiltration. (mm)	Max. Infiltration. (mm)	Ave. Infiltration (mm)	Material at Surface
0160	5	120	195	150.0	Sand and Gravel
0161	31	30	195	162.4	Sand and Gravel
0162	78	30	195	163.9	Bedrock
0163	1	175	175	175.0	Sand and Gravel
0164	6	100	195	175.8	Bedrock
0165	15	120	195	169.3	Bedrock
0166	13	175	195	179.6	Bedrock
0167	2	175	175	175.0	Sand and Gravel
0209	8	120	195	150.0	Sand and Gravel
0210	5	120	175	164.0	Bedrock
0211	20	100	195	174.0	Bedrock
0212	7	50	195	119.3	Bedrock
0213	41	30	195	151.0	Bedrock
0214	5	30	195	110.0	Bedrock
0215	15	30	195	145.0	Sand and Gravel
0216	22	50	195	116.1	Sand and Gravel
0217	40	120	195	174.9	Sand and Gravel
0218	13	120	195	150.0	Bedrock
0219	30	30	195	151.8	Sand and Gravel
0220	43	120	195	174.5	Bedrock
0221	4	30	195	71.3	Sand and Gravel
0416	14	100	195	176.8	Sand and Gravel
0421	7	100	195	167.1	Sand and Gravel
0661	8	120	195	129.4	Sand and Gravel
0662	56	30	195	141.3	Sand and Gravel
0663	10	120	195	135.0	Sand and Gravel
0664	5	30	175	146.0	Sand and Gravel
0665	23	30	195	133.5	Sand and Gravel

Notes: Min means minimum, Max means Maximum, Ave. means Average. (See Map C19, Appendix C)

2.4 Mountain Block (Lateral) Recharge and Creek Discharge

Groundwater flow through an aquifer was calculated using the simplified Darcy flow equation as illustrated in below and provide as equation 1.



$$Q = KiA \qquad (1)$$

Where:

- Q = Volumetric Flow of water through an aquifer;
- K = hydraulic conductivity (permeability) from pumping tests (see Table D4 below);
- i = Hydraulic gradient or slope of the water table or piezometric surface measured from wells developed piezometric surface maps; and
- A = cross-sectional area of flow through and aquifer (from ARC GIS Database).

Hydraulic conductivity (K) values were assigned to each aquifer based on data compiled by Carmichael 2012 and provided to Waterline. Where no data was available, hydraulic conductivity values were estimated by comparing well yield values on driller's reports to calculated aquifer transmissivity in equivalent aquifer materials. Table D4 below summarizes the approach and hydraulic conductivity values used for each mapped aquifer within the RDN.

As described in the caption of Maps C7 and C8, Appendix C, the hydraulic gradient was estimated from piezometric surface maps developed in the area of each mapped aquifer.

Table D5: Aquifer Hydraulic Conductivity Values (From Carmichael 2012)

Aq #	Lithology	Water Region	Yield in BR		Yield S&G		Hydraulic Conductivity K (m/s)				
			# Records	Ave. Yield m^3/day	# Records	Ave. Yield m^3/day	# Records	Min.	Max.	Ave.	Estimated*
0416	Quadra	BQ	1	2.7	25	210.0	1	3.21E-05	3.21E-05	3.21E-05	3.21E-05
0421	Quadra	BQ	1	1.6	1	136.3	NA	NA	NA	NA	7.00E-04
0665	Capilano	BQ	NA	NA	3	1086.7	NA	NA	NA	NA	1.00E-02
0661	Kame	BQ/LQ	NA	NA	16	73.0	NA	NA	NA	NA	5.00E-04
0662	Quadra	BQ/LQ	1	130.9	141	80.1	NA	NA	NA	NA	5.75E-04
0663	Kame delta	FC/LQ			14	84.3	1	7.98E-04	7.98E-04	7.98E-04	7.98E-04
0664	Salish	FC/LQ	1	163.5	19	442.7	NA	NA	NA	NA	4.00E-03
0217	Quadra	ER/FC/LQ	7	29.9	121	147.4	41	3.06E-05	4.35E-03	6.68E-04	6.68E-04
0221	Salish		NA	NA	NA	NA	4	3.34E-04	3.24E-03	2.12E-03	2.12E-03
0214	NG		NA	NA	NA	NA	NA	NA	NA	NA	1.00E-06
0220	Haslam Fm	FC/ER	118	32.3	54	67.2	NA	NA	NA	NA	2.00E-06
0209	Quadra	ER	3	5.1	22	90.1	NA	NA	NA	NA	5.50E-04
0216	Quadra	FC/ER	11	30.7	105	118.7	6	4.98E-05	2.75E-04	1.69E-04	1.69E-04
0212	NG	ER	10	25.8	2	408.8	NA	NA	NA	NA	1.00E-06
0167	Capilano	SW-N	3	5.3	7	140.3	NA	NA	NA	NA	7.00E-04
0215	Quadra	SW-N			17	88.6	11	4.10E-05	1.60E-03	5.86E-04	5.86E-04
0219	Quadra	ER/SW-N	36	63.5	116	281.9	23	1.50E-05	2.41E-03	5.53E-04	5.53E-04
0166	VG	SW-N	13	35.5	0	NA	NA	NA	NA	NA	2.00E-06
0210		SW-N	36	52.0	4	21.5	NA	NA	NA	NA	3.00E-06
0211		SW-N	51	118.2	6	52.0	NA	NA	NA	NA	2.00E-04
0213	VG	SW-N	150	43.5	170	74.3	2	2.27E-06	1.08E-02	2.82E-06	2.82E-06
0218	Benson Fm	SW-N	44	43.2	7	525.5	2	1.33E-05	3.57E-05	2.45E-05	2.45E-05
0160	GF Vashon	NR/Cedar	5	79.9	92	162.4	NA	NA	NA	NA	8.00E-04
0161	Capilano	NR/Cedar	20	21.5	65	1824.2	3	3.7E-03	1.1E-02	7.9E-03	5.00E-02
0163	Quadra	Cedar	NA	NA	NA	NA	NA	NA	NA	NA	6.00E-04
0164	Extension Fm	NR	56	37.0	4	77.1	NA	NA	NA	NA	2.00E-06
0165	NG	NR	249	53.0	7	200.0	NA	NA	NA	NA	3.00E-06

Notes: FM means Formation, BQ=Big Qualicum, LQ=Little Qualicum, ER=Englishman River, FC-French Creek, SW-N=South Wellington to Nanoose, NR=Nanaimo River, BR means Bedrock aquifer, S&G means sand and gravel aquifer, NA means not available, Ave means average, min means minimum, max means maximum. * used in water budget calculation (Table D7 and D8)

The Darcy flow equation was used to estimate the volumetric flux of groundwater moving laterally into (and out of) an aquifer and also used to estimate groundwater discharging to creeks and rivers where the physical model constructed by Waterline, or a previous study, indicated that groundwater contribution to river baseflow was indicated (E.g.: Wendling 2012). The following approach was taken to complete the water budget calculation:

Recharge from Upgradient Lateral Flow from Mountain Block or adjacent aquifer

• Assess cross -sectional area of aquifer at up gradient boundary from 3D GIS mapping;
• Used average K value assigned to aquifer (Table D4);
• Use appropriate horizontal hydraulic gradient estimate from 0-25 or 0-50 m piezometric contour maps (Map C7 or C8, Appendix C) depending on the aquifer depth;
• Complete Darcy flux calculation (solve for Q in equation 1);
• Provides a conceptual value only.

Discharge to Creeks/Rivers or to adjacent down gradient aquifer

• Assess cross -sectional area of aquifer at up gradient boundary from 3D GIS mapping;
• Used average K value assigned to aquifer (Table D4);
• Use appropriate horizontal hydraulic gradient estimate from 0-25 or 0-50 m piezometric contour maps (Map C7 or C8, Appendix C) depending on the aquifer depth;
• Complete Darcy flux calculation (solve for Q in equation 1);
• Provides a conceptual value only.

2.5 Groundwater Use (Anthropogenic)

Wherever possible, actual measured values of anthropogenic groundwater use was considered in the water budget analysis for 2010 as it was found to be the most complete record across the RDN. These include the following:

• Large/small Municipal Wells (E.g.: Improvement Districts, Parksville, Qualicum Beach, etc...),
• RDN Water Systems (Annual data for 2010 on RDN website);
• Private Water Systems (E.g.: Epcor).

It should be noted that some of the water use records for large municipal wells and private water systems were incomplete, or requests for data by the RDN was not provided by the system purveyor, the water demand was estimated using the same approach for other non-serves areas described in the following sub-section.

2.6 Water Demand Assessment - Non-Service Areas

The RDN provided Waterline with water use data at the parcel level estimated based on water consumption data for the RDN and the City of Nanaimo. The shape files provided by the RDN included water consumption values for both the high-use and low use periods for each parcel, based on actual land use codes assigned based on the BC Land Assessment designation. Consumption data was not available for parcels with agricultural land use activities as the RDN retained the Ministry of Agriculture to complete the agricultural water demand model for the RDN which was released in February 2013. Although some attempt was made to incorporate MAL.

Waterline performed a systematic clean-up of the parcels, removing those parcels falling within Water Service Areas (e.g. Municipalities, RDN water service areas, and Private Water purveyors). Forest, vacant, or undeveloped lands were also removed through queries on the Actual Use codes and by comparison against 2011 digital orthimagery provided by the RDN.

The Agricultural Water Demand Model being worked on by MAL was not complete at the time of submission of Waterline's Draft report. Therefore a simplified method to calculate the water demand for agricultural parcels was applied by Waterline at the recommendation of MAL (Ted W. Van der Gulik, Pers. Comm, November 2012). The method involved an assessment of the moisture deficit from the closest climate station data available provided by Farmwest (2012) which was identified as the Qualicum Airport station. The moisture deficit value effectively indicates the amount of water required for irrigation. The values used for the RDN water budget calculations were reported for June 1st to Oct 10th, 2012 450 mm per unit area (Farmwest Model, 2012). Waterline then applied this value uniformly to agricultural lands across the entire RDN by multiplying the moisture deficit by the area of each agricultural parcel.

To complete the analysis, Waterline removed all forest and vacant land parcels from the data set as there is no water use in these area. Waterline then cross-referenced against the 2011 air photos and civic addresses outside municipal service areas to confirm surface or groundwater use. A final calibration check: was completed by aggregating parcel water use estimates within service areas against measured water use values. The calibration showed good agreement with the measured water demand numbers provided by the RDN for service areas across the RDN.

Once all water use parcels were updated in the Waterline geodatabase, the mapped aquifer layers were cross-referenced with the aquifer boundaries and then an aquifer number was assigned to each water use parcel. Once completed, the agricultural water use per aquifer was then assessed and annual water use numbers applied in the final aquifer water budget calculation for each aquifer.

2.7 Aquifer Water Budget and Stress Assessment

Tables D7and D8 presents of the aquifer water budget calculations. Table D8 is a continuation of Table D7 but the spreadsheet is too large to place in a single table. Each parameter is described in each column and equations are provided where applicable. The final aquifer stress assessment in Table D8 is the same that was provided in Table 40 in the main report. The general approach to assessing aquifer stress was provided in section 2.6 of the main report.

The analytical method used provides a crude approximation of stress to a particular aquifer. It should be noted that by using this method of assessment it is possible for an aquifer to be classified as being under some level of stress even though there is no significant anthropogenic use (i.e.: groundwater pumping). In this case the aquifer stress is natural and it may mean that the aquifer is vulnerable to pumping and development resulting from generally reduced recharge due to assessed ground/soil conditions or perhaps due to natural climate variability causing declining precipitation and recharge.
More detailed aquifer data and complex computer simulations (numerical modelling) are required to fully couple surface and groundwater systems, which would allow for a more accurate and quantitative assessment. Such calculations should be considered as the RDN moves to full Tier 1 or Tier 2 water budget assessments on a per watershed or subwatershed basis (OMNR 2012). As indicated previously, the stress assessment provided herein should only be used for comparison purposes only and should not be considered as a quantitative assessment for design or detailed watershed management purposes.

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Table D6: Aquifer Water Budget Calculations
Table D7: Aquifer Water Budget Calculations – Continued from Table D6

END

APPENDIX TWO – BIO-INVENTORY SUMMARIES FOR LOTS 11, 12 AND 13

<u>Couverdon Properties - Lot 11</u>

- Immediately adjacent to 10.5 ha unnamed RDN Park
- Total Area approximately 17 ha
- Early Seral Forest approx. 10 ha
- Mid-seral Forest approx. 7 ha
- Lower-third of Lot 11 most resembles Red-listed Fd – Dull Oregon Grape Plant Association of the CDFmm; some mature stands present.
- Upper two-thirds of Lot 11 most resembles the Blue-listed FdHw – Salal Plant Association of the CWHxm.
- Three small pockets of dry Rock Outcrop plant communities that are sensitive to disturbance.
- 11 native tree species recorded, including 5 veteran Douglas-fir trees
- 25 native shrub species recorded, including uncommon Hairy Manzanita
- 34 native non-woody plants recorded, including Blue-listed Macoun's Groundsel
- Four sizeable snags on property, ranging from 30 cm to 65 cm in diameter

- Documented use by Gray Wolf, Black Bear, and Black-tailed Deer
- Moderately high bird diversity: 25 species recorded, including use by Red-Tailed and Sharp-shinned Hawks, and Regionally Important Pileated Woodpecker.
- Documented use by 3 species of butterflies.
- Abundance of key food plant suggests high potential to support Red-listed Dun Skipper (related to butterflies)

<u>Couverdon Properties - Lot 12</u>

- Immediately adjacent to 10.5 ha unnamed RDN Park
- captures roughly 500 lineal m of SEI Polygon N0120 and virtually all of SEI Polygon N0790D-R2 (mature riparian forest)
- Total Lot 12 area approximately 11.5 ha
- Early Seral Forest approx. 6 ha
- Mid-seral Forest approx. 5.5 ha
- Mature Seral Forest approx. 1 ha
- Lower-third of Lot 12 most resembles Red-listed Fd – Dull Oregon Grape Plant Association of the CDFmm; mature stand present along south margins.
- Small area near central drainage in Lot 12 resembles Red-Listed CwFd – Kindbergia Plant Association of the CDFmm.
- Upper two-thirds of Lot 12 most resembles the Blue-listed FdHw – Salal Plant Association of the CWHxm; mid-seral stand present in central part of Lot 12.
- One small linear area of dry Rock Outcrop plant community that is sensitive to disturbance.
- 11 native tree species recorded, including 7 veteran Douglas-fir trees
- 26 native shrub species recorded, including uncommon Silver Luina

- 39 native non-woody plants recorded, including uncommon Wild Ginger, Tiger Lily, and Red Paintbrush
- Cluster of six snags in north-central part of property, ranging from 20- 30 cm in diameter.

- Documented use by Gray Wolf, Black Bear, and Black-tailed Deer
- High bird diversity: 28 species recorded, including use by Blue-Listed Band-Tailed Pigeon and various wood warblers.
- Documented use by 4 species of butterflies, including the uncommon Oreas Comma.
- Abundance of key food plant suggests high potential to support Red-listed Dun Skipper (related to butterflies)

Couverdon Properties - Lot 13

- Close proximity to 10.5 ha unnamed RDN Park
- Captures roughly 600 lineal m of SEI Polygon N0120
- Total Area of Lot 13 approximately 12.5 ha
- Early Seral Forest approx. 9.5 ha
- Mid-seral Forest approx. 2.5 ha
- Mature Seral Forest approx. 0.5 ha
- Most of Lot 13 resembles the Blue-listed FdHw – Salal Plant Association of the CWHxm.
- 12 native tree species recorded, including uncommon Trembling Aspen and large fir, hemlock and cedar specimens.
- 26 native shrub species recorded
- 26 native non-woody plants recorded
- One sizeable Shore P ine snag in southern part of property.

- Documented use by Black-tailed Deer, attractive Black Bear foraging area
- High bird diversity: 32 species recorded, including territorial behavior by Blue-listed Olive-sided Flycatcher, which likely nests on Lot 13.
- Documented use by 2 species of butterflies
- Abundance of key food plant suggests high potential to support Red-listed Dun Skipper (related to butterflies)

APPENDIX THREE – NANAIMO RIVER STAKEHOLDER SURVEY

My name is ________, I am a volunteer with NALT. We are in the initial stages of gathering data that will ultimately be used to produce a report on the Nanaimo River. The report will bring attention to the diversity of values that are associated with the river, and focus on threats to the river as well as opportunities for improved stewardship.

1. About the Stakeholder
    a. What are your interests and/or responsibilities with respect to the Nanaimo River and the broader watershed?
2. Description
    a. Please describe *(insert value, for example mining)* in the Nanaimo River watershed.
    b. Where does (*value, ex mining*) occur? Are there any maps showing where (*insert value, ex mining*) occurs in the watershed?
    c. How important is (*insert value, ex mining*) in the Nanaimo River? [Alternatively: How important is Nanaimo River to (*insert value, ex steelhead fish)?]*
    d. In your estimation, what are the long-term trends surrounding (*insert value, ex mining*) in the watershed (past and future)? Are there any graphs or charts showing trends?
    e. Do you have any photos of this value that you would be willing to share for possible inclusion in our final report?

3. Stakeholders
    a. Who are the groups that most benefit from, or are negatively impacted by, (*insert value, ex mining*) in Nanaimo River?
    b. Who are the groups that have the biggest impacts on (*insert value, ex mining*) in the watershed – either positive or negative? (For example, regulators, private sector, etc)
4. Risks
    a. In the past, what have been the factors that have had the biggest negative impact on (*insert value, ex mining*)?
    b. How about in the future – what are the most important threats to (*insert value, ex mining*)?
5. Opportunities
    a. What is needed to secure or enhance the future of (*insert value, ex mining*) in Nanaimo River?
    b. Are you aware of any concrete opportunities to pursue these actions?
6. Can you direct me to any written reports or other resources materials?
7. Is there anything else you would like to share regarding (*insert value, ex mining*) in the watershed?
8. Do you have any other comments or information regarding the Nanaimo River in general or values that we have not yet discussed?
9. Can you suggest some important stakeholders that you think we should talk to find out more about this aspect of the River? Name, phone, address, email of suggested contacts

Do you mind being contacted again if we have any further questions?

Thank you so much for your time today.

You can contact us through the NALT Stewardship Centre. The contact information is on the letter we emailed to you earlier this week. Did you get that letter? If not - I will make sure it is sent to you again. Our phone # is 250-714-1990 or by email paul@nalt.bc.ca

APPENDIX FOUR – NANAIMO RIVER RECREATION SURVEY

Recreational Values of the Nanaimo River

Date and Time: ____

Specific Location: ____

Weather at Survey Location: ____________________________________

For the following questions please select just one number for your response unless otherwise asked.

Q1 While visiting the river today, which of the following activities do you plan on participating in? Please select the primary reason you are at the river today *(circle just one primary reason)*

1. Swimming/tubing
2. Walking/Hiking
3. Dog walking
4. Cycling
5. Nature viewing (example: bird watching)
6. Fishing
7. Other ________________________

Q2 During the summer months (June to August), how often do you come to the Nanaimo River for the purpose of recreation? *(circle one)*

1. Less than once a month
2. 1-3 times a month
3. 4-6 times a month
4. 7-9 times a month
5. 10-12 times a month
6. More than 12 times month

Q3 During the rest of the year, how often do you come to the Nanaimo River for the purpose of recreation? *(circle one)*

1. Less than once a month
2. 1-3 times a month
3. 4-6 times a month
4. 7-9 times a month
5. 10-12 times a month
6. More than 12 times month

O4 How important is it to you to be able to enjoy recreational opportunities within the Nanaimo River watershed? *(circle one)*

1. Not at all important
2. Slightly important
3. Moderately important
4. Very important
5. Extremely important

Q5 Please identify the greatest concern/challenge to your ability to enjoy recreation on the Nanaimo River. *(circle all that apply)*

1. Lack of trails to areas of interest
2. Lack of safe, secure parking
3. Conflicts with other user groups
4. Lack of access to the river from private land ownership
5. Lack of facilities (ex. washrooms, maintained trails)
6. Other: ______________________________________

And finally, I would like to ask you a few questions about your personal background.

Q6 Are you… *(circle one)*

1. Female
2. Male

Q7 In which age group do you fall? *(circle one)*

1. younger than 19
2. 20-29
3. 30-39
4. 40-49
5. 50-59
6. Over 60

Q8 How close to the Nanaimo River do you live? *(circle one)*

1. Less than 1 km from the river
2. 1-9 km
3. 10-19 km
4. 20-29 km
5. Over 30 km

Q9 Is there any other information you would like to add or additional comments you would like to make regarding the recreational values of the Nanaimo River, or any aspect of the Nanaimo River that you feel is worth mentioning here?

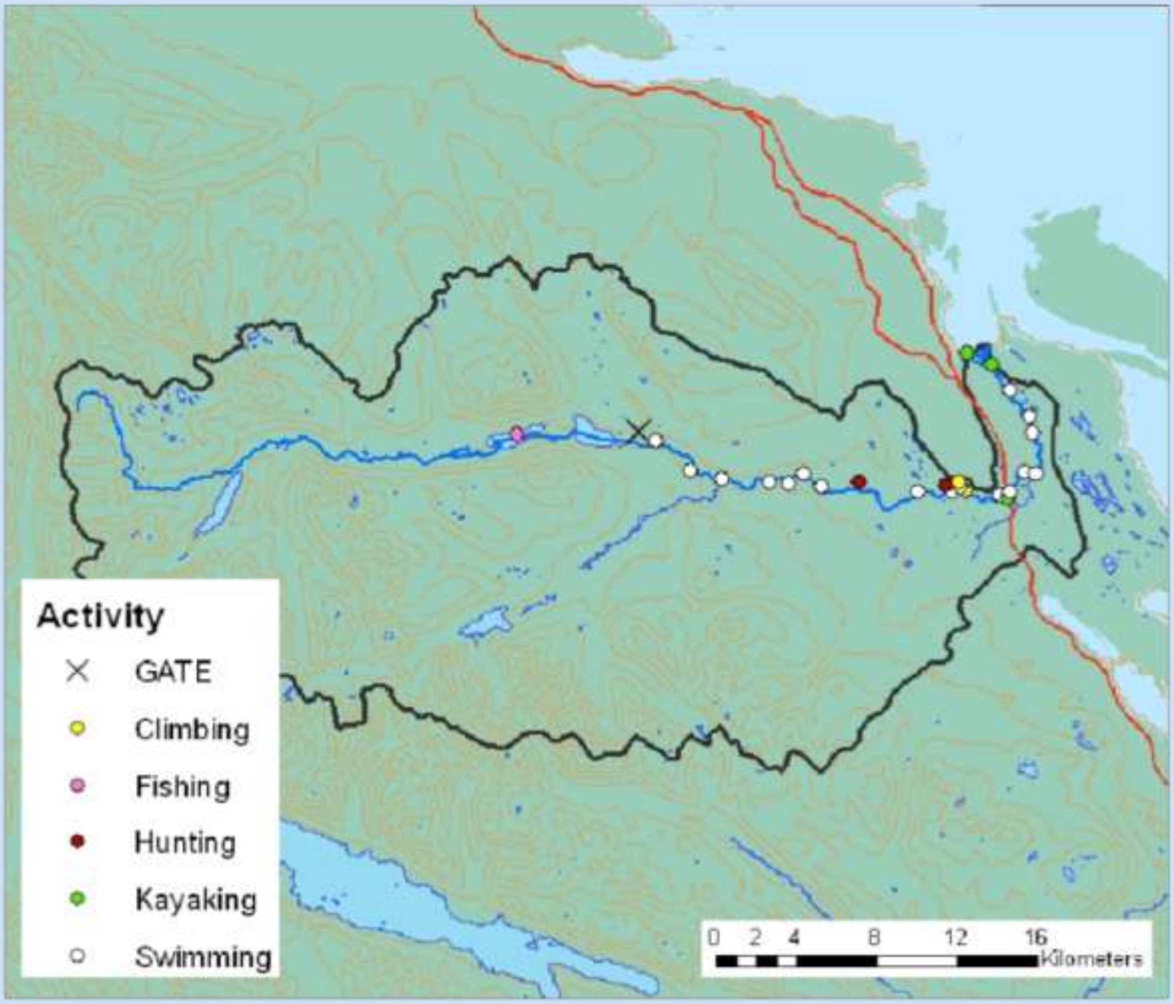
Bonus Q: what other locations do you use along the river ?

Thank you for taking the time to complete this survey; your contribution is appreciated.
Enjoy your time at the river today!

Matt Kellow M.A.
VIU Outdoor Recreation Technician

APPENDIX FIVE – MAP OF RECREATION SITES

Map of recreation sites in the Nanaimo River.



APPENDIX SIX – FROM THE ARCHIVES

First Nations/Fishing:

…On the Nanaimo river the Indians have a very ingenious contrivance for taking salmon, by constructing a weir; but, instead of putting baskets they pave a square space, about six feet wide and fourteen feet long, with white or light-coloured stones. This pavement is always on the lower side of the weir, leading to an opening. A stage is erected between two of these paved ways, where Indians, lying on their stomachs, can in an instant see if a salmon is traversing the white paved way. A long spear, barbed at the end, is held in readiness, and woe betide the adventurous fish that runs the gauntlet of this perilous passage!

Excerpt from The Naturalist in Vancouver Island and British Columbia by John Keast Lord, published in 1866.

Gold Placer Training Camp at Nanaimo River:

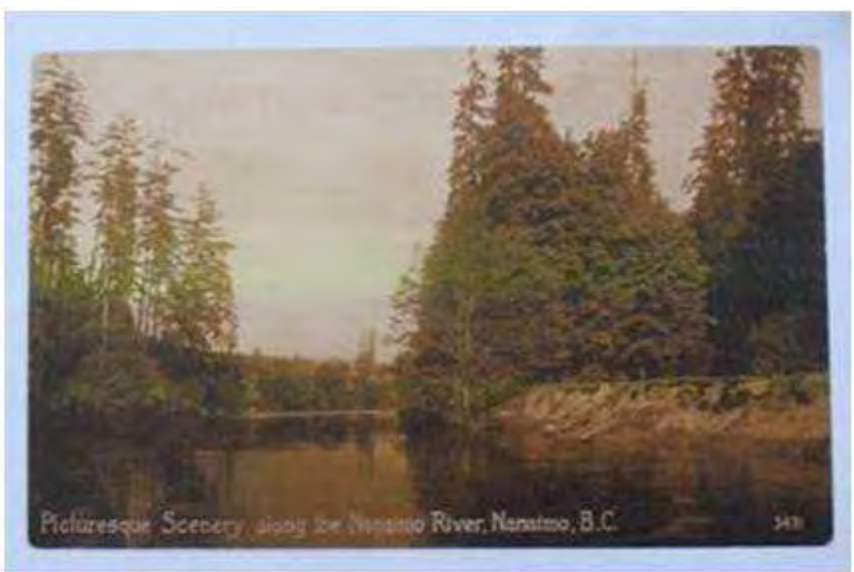
In 1935, the provincial Department of Labour established four placer training camps, including one at the Nanaimo River. Single, physically fit, unemployed men between the ages of 21 and 25 were taught placer-mining techniques and the "art of camp cooking and how to look after themselves in the hills." Any gold recovered during the training was split among the trainees. The camp trained about 50 men and appears to have operated for no more than two years.

Placer Training Camp, Nanaimo River.

Cedar Bridge:

Nanaimo Community Archives Photograph No.: 2001 001 A-P49 New Cedar Bridge, 1970

A view of the Nanaimo River:



Archival Dam Photo:

The Hepburn Stone:

Hepburn Stone

The Hepburn Stone

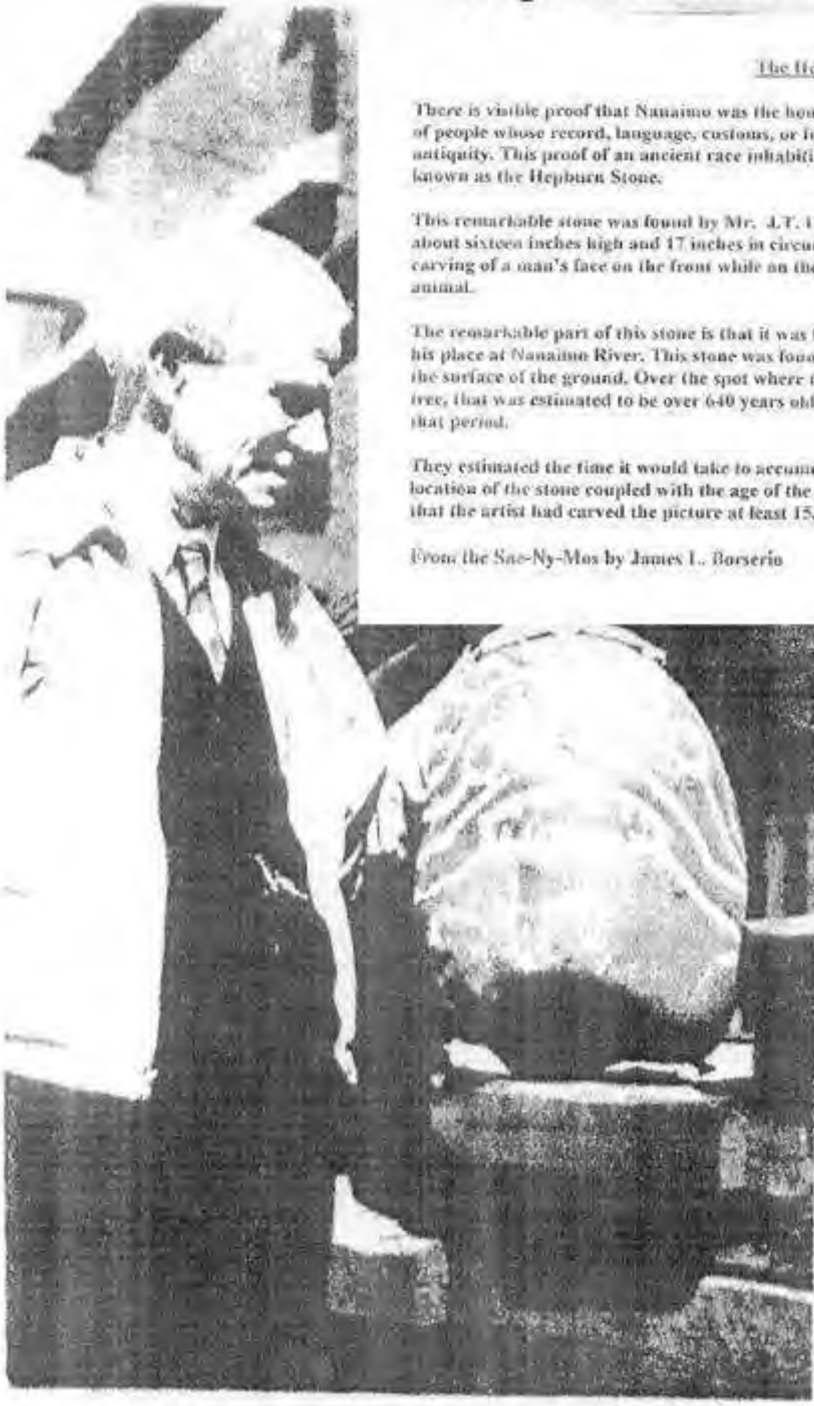
There is visible proof that Nanaimo was the home of a race of people some 15,000 years ago – a race of people whose record, language, customs, or from whence they came has been lost in the pages of antiquity. This proof of an ancient race inhabiting our shores is on display at the Bastion and is known as the Hepburn Stone.

This remarkable stone was found by Mr. J.T. Hepburn. The stone weighs about 100 pounds and is about sixteen inches high and 17 inches in circumference and is sort of pear shaped with a rude carving of a man's face on the front while on the other side forming part of his face is the face of an animal.

The remarkable part of this stone is that it was found by Mr. Hepburn while excavating for a well on his place at Nanaimo River. This stone was found near the bottom of the well – about 28 feet below the surface of the ground. Over the spot where the excavation had performed had grown a cedar tree, that was estimated to be over 640 years old. This discovery aroused the interest of scientists of that period.

They estimated the time it would take to accumulate 27 feet of debris, soil and rubbish over the location of the stone coupled with the age of the cedar. These British scientists concluded after study that the artist had carved the picture at least 15,000 years ago.

From the Sne-Ny-Mos by James L. Borserio



THE CUSTODIAN of Nanaimo's museum, Joseph Muir, displays petroglyph "Hepburn Stone," 10,000 years old. W. H. Gold photo.

A Story:

the children built. We lined the inside walls of the garage with tarpaper to keep out drafts. There wasn't much room for moving about. It was a severe winter and it was pretty hard to stay warm. I got plans made for a good two-story dwelling and began building it. We moved into the new house in March 1922. It was about half finished. A week after we had settled in our daughter, Jessie, was born on March 23, 1922.

It was a picturesque spot we had selected. Other neighbours were close at hand between our property and the main road (which had been the original Island Highway passing through Cedar District). The Cedar Church manse was nearby where the English Church Minister, Mr. Bolton and his wife were our nearest neighbours. The Robert's place was further along the high bluff overlooking the river and it adjoined the Church property. We had a beautiful view across the river to where a slough entered to the west of the Deep Hole. Mayor Harrison (Nanaimo's mayor) owned the small island opposite to our place. It was about an acre and a half in size. He would visit it once a year. He would walk through our property in order to preserve his right of way he told us. How the Mayor gained possession of his island was a funny story. Sheriff Trawford of Nanaimo had owned our own property. He had built the house, which had burned. The Sheriff was a boozer. He had invited the Mayor and a few others to a party at his summer cottage beside the river. The party was quite hilarious. Sam York had said that their shouts and singing could be heard all night up the hill at his farmhouse. When the Mayor got home to Nanaimo the next morning he went through his pockets to find out how much money he had lost. He discovered a paper. It was a deed to the island for which he had signed away the amount of five hundred dollars. It was signed all right along with witness's signatures. So, the wily Sheriff was richer by $500. The Mayor later declared he had known about it but the Sheriff's version was different.

APPENDIX SEVEN – COMMUNITY SURVEY AND RESULTS

Your Thoughts About the Nanaimo River Watershed

Instructions: Fill out this survey, save it to your computer and email it as an attachment to: Riverteam1@nalt.bc.ca

Date: ___________________

Q #1 Do you live within the Nanaimo River Watershed?
__Yes __No __Don't know

Q #2 How close to the Nanaimo River do you live?
__ less than 1 km from the river
__1-9 km
__10-19 km
__ 20-29 km
__ more than 30 km

Q #3 How long have you lived at this location?
__ less than I year
__1-5 years
__ 5-10 years
__10-20 years
__ more than 20 years

Q #4 On a scale of 1 to 10, how important is the Nanaimo River Watershed to you personally?

lowest 1 2 3 4 5 6 7 8 9 10 *highest*

Q #5 In what way(s) is the Nanaimo River Watershed important to you? *(check all that apply to you)*

__ I live in the watershed
__ I rely on the watershed for drinking water a) _ City tap water or
b) _ Groundwater (aquifers)
__ I rely on the watershed for irrigation water a) _ urban landscape
b) _ rural landscape or
c) _ rural homestead or farm
__ I rely on the watershed for employment *(please specify)*______________________________
__ I use the area for recreation *(check all that apply)*
__Swimming
__Walking/Hiking
__Dog walking
__Fishing
__Cycling

__Nature appreciation (example: bird-watching)
__Other ______________________________

__ I have had a personal connection with the Nanaimo River earlier in my life *(please explain)*____

Q #6 Would you be interested in participating in a two-day symposium in September that will lead to developing some long-term strategies for protection of the Nanaimo River?

__ YES
__ NO
__ NOT SURE

Q #7 What do you feel are the **3** biggest challenges facing the future health of the Nanaimo River and the surrounding watershed?

__ water quality
__ water quantity
__ declining fish stocks
__ growing population in the area
__ loss of wildlife habitat
__ private land ownership
__ land development / land use
__ timber harvesting
__ recreational uses / conflicts
__ other concerns ____

Q #8 If you had the opportunity to begin developing a strategy to deal with just ONE of the concerns about the river that you identified above

a) Which one would it be?___________________________
b) What might your strategy be?____
____

Q #9 Is there anything you would like to add, or additional comments you would like to make about what you feel are the challenges, issues or important aspects of the Nanaimo River and the surrounding watershed?____
____
____
____
____

Q #10 How did you hear about this meeting?

from invitation dropped at my door___ from a poster___ by email___
through word-of-mouth___ other *(please explain)*_____________________________

Q#11 On a scale from 1 to 5, how valuable has this meeting been for you?

Lowest 1 2 3 4 5 *Highest*

Thank you for taking the time to complete this survey. Your input is much appreciated. If you would like to be included on a contact list for updated information about the Symposium and the Nanaimo River Project, please share your email address or other contact information with us here.

Name:__________________________________

Contact Information:_____________________________________

We hope to see you at the Nanaimo River Symposium - September 24th and 25th

Community Meeting (Nanaimo River)
July 28, 2011 / August 2, 2011

Q #1 Do you live within the Nanaimo River Watershed?
Yes - 39 No - 4 Don't know - 2

Q #2 How close to the Nanaimo River do you live?
less than 1 km from the river - 13
1-9 km - 22
10-19 km - 7
20-29 km - 2
more than 30 km - 1

Q #3 How long have you lived at this location?
less than I year - 2
1-5 years - 5
5-10 years - 6
10-20 years - 13
more than 20 years - 19

Q #4 On a scale of 1 to 10, how important is the Nanaimo River Watershed to you personally?

lowest	1	2	3	4	5	6	7	8	9	10	*highest*
					1	*2*	*1*	*4*	*5*	*26*	

Q #5 In what way(s) is the Nanaimo River Watershed important to you? *(check all that apply to you)*

__ I live in the watershed
__ I rely on the watershed for drinking water a) _ City tap water or - 9
b) _ Groundwater (aquifers) - 20
__ I rely on the watershed for irrigation water a) _ urban landscape - 3
b) _ rural landscape or - 8

c) _ rural homestead or farm - 8

__ I rely on the watershed for employment *(please specify)*

HARMAC, Fruit and Vegetable farms, Adventure based tourism.

__ I use the area for recreation *(check all that apply)*

Swimming - 28
Walking/Hiking - 28
Dog walking - 11
Fishing - 6
Cycling - 15
Nature appreciation (example: bird-watching) - 23
Other – Spiritual Revitalization / Rafting / Kayaking

__ I have had a personal connection with the Nanaimo River earlier in my life *(please explain)*____

Q #6 Would you be interested in participating in a two-day symposium in September that will lead to developing some long-term strategies for protection of the Nanaimo River?

YES - 25
NO - 3
NOT SURE - 17

Q #7 What do you feel are the **3** biggest challenges facing the future health of the Nanaimo River and the surrounding watershed?

water quality - 19
water quantity - 20
declining fish stocks - 4
growing population in the area - 28
loss of wildlife habitat - 12
private land ownership - 11
land development / land use - 29
timber harvesting - 16
recreational uses / conflicts - 15
other concerns _____________________________________

Q #8 If you had the opportunity to begin developing a strategy to deal with just ONE of the concerns about the river that you identified above

a) Which one would it be?____________________________

b) What might your strategy be?____

Q #9 Is there anything you would like to add, or additional comments you would like to make about what you feel are the challenges, issues or important aspects of the Nanaimo River and the surrounding watershed?____

Q #10 How did you hear about this meeting?
from invitation dropped at my door - 19 from a poster - 2 by email - 20
through word-of-mouth - 5 other *(please explain)* – *Newspaper(3), MISSI, Signs*

Q#11 On a scale from 1 to 5, how valuable has this meeting been for you?

Lowest	1	2	3	4	5	*Highest*
		1	*6*	*16*	*12*	

Predominant community concerns:

- Growing populations
- Over-development
- Water Quality
- Timber Harvest
- Pulp Mill Operations
- Habitat Loss/Destruction
- Dwindling values concerning Conservation/Protection

Solutions presented by the community:

- Public ownership of lands
- Limited Development / Controlled Logging
- Public Education and Awareness (Interpretive Signs)
- Controlled water usage (eg: collection of rainwater for irrigation purposes)
- Garbage cans on location
- Water-driven turbines to generate lighting along riverside trails
- "Water Model Planning Tool" (public education initiative to help people identify all the water sources contained within the watershed.

Personal connections to the Nanaimo River:

- Learning how to swim on location
- Childhood activities (camping/fishing/scouts)
- Born and raised nearby
- Decades of single-family recreation
- Meditation
- Spiritual Revitalization