Dec.19/19 - Appendix A revised

Staff report

DATE: December 4, 2019

FILE: 5330-20/Saratoga

TO: Chair and Directors
Electoral Areas Services Committee

Supported by Russell Dyson
Chief Administrative Officer

R. Dyson

FROM: Russell Dyson
Chief Administrative Officer

RE: **Saratoga Miracle Beach – Master Drainage Plan**

Purpose

The purpose of this report is to present the Saratoga Miracle Beach Master Drainage Plan and recommendations for next steps.

Recommendations from the Chief Administrative Officer:

1. THAT staff work with the Ministry of Transportation and Infrastructure to identify opportunities to implement rainwater volume reduction best management practices within the road right of way in select areas of the Saratoga Beach neighbourhood.

2. THAT Engineering Services staff work with the Planning and Development Services branch to incorporate rainwater management language, performance standards, targets and design criteria into a subdivision and development servicing bylaw and development permit area for the Saratoga Beach settlement node.

3. THAT $20,000 be allocated to a study to identify service structure options for a local service area to provide funding for public rainwater management infrastructure, to be funded from rainwater management implementation funds included in the proposed 2020-2024 financial plan for the Liquid Waste Management Planning Service, function 340.

Executive Summary

The Saratoga Beach area is one of three rural settlement nodes designated in the Regional Growth Strategy and is thus anticipated to experience increased development in the coming years, if community servicing is provided. Due to its proximity to the Oyster River and the presence of multiple smaller water courses, the Saratoga Beach neighborhood often experiences seasonal flooding.

As part of a 2018 Local Area Plan (LAP) update process for this area, rainwater/drainage impacts due to development were identified as requiring further study. The Saratoga Miracle Beach Area Master Drainage Plan, prepared by Jim Dumont and attached to this report as Appendix A, investigated anticipated rainwater/drainage impacts from increased development, and provides recommendations for mitigation that can be applied to future land use decisions and policy development work for the area.

Increased development without mitigation works will result in significant increases in stormwater flows, resulting in downstream impacts such as flooding, increased erosion and environmental damage. The Master Drainage Plan anticipates that a blend of private (i.e. on-lot rain gardens) and public (i.e. detention ponds in open spaces and linear rain gardens within road rights of way) drainage facilities will be necessary to mitigate future impacts.

The implementation of these recommendations will require the development of new regulatory tools, establishment of a local service area (LSA) for the operation and management of public rainwater infrastructure as well as approval of the Ministry of Transportation and Infrastructure (MoTI) for any infrastructure proposed to be constructed within the road right of way.

The targets, design standards and performance measures identified in the Master Drainage Plan will be included in a subdivision and development servicing bylaw and development permit area for the Saratoga Beach settlement node.

Prepared by:	Concurrence:	Concurrence:
V. Van Tongeren	***D. Monteith***	***M. Rutten***
Vince Van Tongeren, B.Sc. Environmental Analyst	Darry Monteith Manager of Liquid Waste Planning	Marc Rutten P.Eng. General Manager of Engineering Services

Stakeholder Distribution (Upon Agenda Publication)

Ministry of Transportation and Infrastructure	✔

Background/Current Situation

The Comox Valley Regional District presently influences rainwater management at the rezoning and development permitting stages via requirements for site drainage plans as outlined in Bylaw 337, being the "Rural Comox Valley Official Community Plan Bylaw No. 337, 2014." Such requirements have limited temporal and spatial applications, only impacting a small portion of the total land base within the electoral areas and only on a property by property basis at the time of development. In recent years, staff have been able to work with MoTI to secure conditions of subdivision relating to rainwater management where MoTI has drainage concerns.

Much land alteration occurs without triggering a requirement for rezoning or development permit (DP) or without public knowledge of the need for a DP (e.g. land clearing, re-grading, ditch and culvert installation, and construction activities). Development and other landscape changes increase impervious surfaces and alter the natural water balance of our watersheds. The cumulative impacts of these changes are already being experienced in the CVRD electoral areas, and are likely to increase into the future where higher density development is contemplated unless changes are made to current land development and land management practices. Significant development pressures are currently being experienced in the three electoral area settlement nodes, bringing the potential to increase flood risks and damage to aquatic and riparian habitats.

Saratoga Beach is one of three electoral area settlement nodes identified in the CVRD Regional Growth Strategy. During Saratoga Beach local area planning work in 2018, the importance of preserving and enhancing the natural function of the drainage systems in the area was identified. The Saratoga Miracle Beach Area Master Drainage Plan (Appendix A) includes a high level inventory of drainage assets within the LAP boundaries, and corresponding mitigation targets and recommendations to help preserve and restore the natural water balance in the area.

Future preservation of aquatic habitat and mitigation of downstream flood risk is dependent upon post-development flows that mimic pre-development natural flows in terms of volume and duration. The Master Drainage Plan includes area-specific targets that can be used to guide land development drainage design by controlling discharge rate and volume such that pre-development or natural flow characteristics can be maintained. The importance of these targets is illustrated below in Figure 1, which shows that continued development with no mitigation works would result in significant increases in flows, resulting in downstream impacts such as flooding, increased erosion and environmental damage.

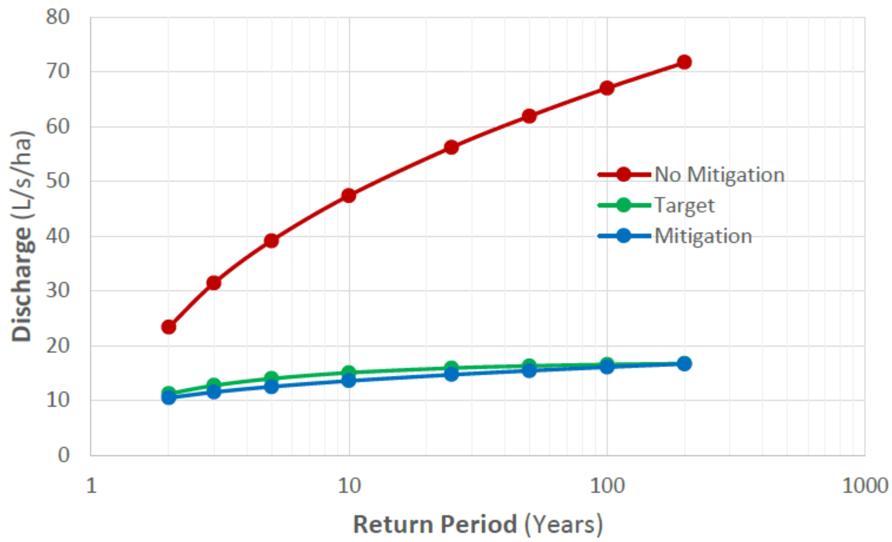

Figure 1 – Flood Discharge Estimates (No Mitigation, Target, & Mitigation), 2 – 200 year return period events

Incorporating these area-specific targets into land development processes and requirements would allow for future development to design drainage infrastructure to meet these targets. This would help clarify expectations and create consistency in the drainage plans that are developed and submitted as part of the land development process, and ensure that these plans meet MoTI requirements.

As land development in the area progresses, the Master Drainage Plan anticipates that a blend of private (i.e. on-lot raingardens) and public (i.e. detention ponds in open spaces and linear rain gardens within road rights of way) drainage facilities, will be necessary to meet the area-specific targets discussed above. There are some challenges with this approach, as identified below:

- Construction and maintenance of public drainage facilities – The Master Drainage Plan anticipates construction of detention ponds within property owned by the CVRD and construction of volume reduction best management practices (i.e. linear rain gardens) within the road right of way. This would require property acquisition by the CVRD for detention ponds, and acceptance by MoTI of an enhanced standard to substitute existing roadside ditches for linear rain gardens. Both instances will require stable funding for ongoing operations and maintenance, which would likely have to be provided through a drainage LSA.
- Construction of private drainage facilities – In the case of drainage facilities constructed on private land, a mechanism to ensure their ongoing maintenance would be required to ensure their effectiveness over time (i.e. through changes in property ownership). While including drainage infrastructure within Section 219 covenants under the *Land Title Act* is an option, these covenants can be onerous to monitor and enforce. Requiring property owners to grant rights of way to accommodate ongoing operation and maintenance of these facilities by the CVRD is another option, though this could be met with resistance from some residents and would also require a stable funding source.

New regulatory tools will be needed to implement the proposed mitigation targets. The Master Drainage Plan identifies options to address this, similar to those recommended in the 2013 Fernhill/West Coast Environmental Law, Rainwater Management Strategy report. These include tools such as a subdivision and development servicing bylaw and associated drainage local service area, a rainwater management development permit area or a rainwater management bylaw. Engineering staff will work with the planning and development services branch to develop these new tools for the Saratoga Beach settlement node. This work is anticipated to being in spring 2020 following adoption of the 2020-2024 financial plan and completion of the costal flood mapping project outlined below.

An additional consideration addressed in the Master Drainage Plan is the capacity of existing stream crossings and adjacent upstream and downstream drainage channels. Of the nine crossings investigated in the report, only two were confirmed to have adequate capacity for a 100 year return period flood. This adds to the importance of future development meeting the proposed area-specific targets, particularly where the proposed development is upstream of existing stream crossings.

The Master Drainage Plan also highlights the need to establish flood construction levels and extents (the floodplain) in order to provide protection to people and property as development proceeds. The floodplain setbacks may differ from riparian area setbacks, with the more conservative setback being applied to future development. Keeping future development clear of floodplains in the area will help mitigate potential impacts of flooding in the future.

The CVRD has received National Disaster Mitigation Program (NDMP) funding to undertake coastal flood mapping of the entire CVRD coastline, including the floodplain of the Oyster River. The mapping and data is required to account for sea level rise and come into compliance with new provincial guidelines. Once the mapping has been acquired, this information will be used to identify sea level rise planning areas. These planning areas are intended to be the focus of future land use planning bylaws and policies as recommended by the provincial guidelines. The mapping phase of this work is anticipated for completion in spring of 2020.

Also proposed for the Saratoga area in 2020 is an Ecological Accounting Protocol demonstration application, to be led by the Partnership for Water Sustainability in BC. This process would provide metrics to establish the "worth" of natural assets (streams, riparian areas, wetlands, etc.) and the ecological services that they provide. This work will be used, together with the Master Drainage Plan and flood mapping work, to inform the development of new regulatory tools and to assist in communicating the value of these natural assets to the public during future community engagement efforts. This work is dependent on grant funding applications currently under review by the Federation of Canadian Municipalities and the Real Estate Foundation of BC.

In the interim, the Master Drainage Plan can be made available to prospective developers in the area, such that drainage infrastructure supporting their land development proposals can be designed to meet the targets identified in the plan.

Policy Analysis
Bylaw No. 2422, being the "Regional District of Comox-Strathcona Liquid Waste Management Planning Service Bylaw No. 2422, 2002," provides planning services to the rural areas with regard to liquid waste management.

Bylaw No. 337, being the "Rural Comox Valley Official Community Plan Bylaw No. 337, 2014," provides objectives and policies to guide decisions on planning and land use management in the electoral areas.

Bylaw No. 120, being the "Comox Valley Regional Growth Strategy Bylaw No. 120, 2010," provides regional policy direction to guide land use planning and infrastructure decision making across the electoral areas and municipalities.

Outside of municipal boundaries, the Ministry of Transportation and Infrastructure is responsible for managing drainage for the construction and maintenance of the provincial road network, and through the subdivision approval process. Section 1010 of the BC Supplement to TAC Geometric Guide and Standard Specifications for Highway Construction outlines MoTI requirements regarding drainage for land development.

The CVRD has the responsibility to ensure proper rainwater management when land alteration occurs as a result of development that was enabled by the CVRD, typically through a rezoning or development permit process. Sections 488, 500, 506 and 523 of the *Local Government Act* provide local governments the authority to establish development permit areas for protection of the natural environment and protection of development from hazardous conditions or enact bylaws to regulate tree cutting, subdivision and development servicing and surface runoff requirements.

At the February 27, 2018 meeting of the CVRD Board, the following resolution was passed:

> *THAT staff utilize the available budgetary allowance for rainwater management in the 2018 Liquid Waste Management Planning Service (function 340) budget to complete the following work:*
> *a) Develop rainwater management language, performance standards and processes that support a subdivision and development servicing bylaw for the electoral area settlement nodes of Saratoga and Miracle Beach, Union Bay and Mt. Washington;*
> *b) Evaluate the viability of a rainwater service(s) in the electoral areas; and*
> *c) Develop a rainwater management public education program.*

The CVRD Board received a report from Fernhill Consulting and WCEL titled "The Rainwater Management Strategy for the Comox Valley Regional District Electoral Areas" (December 2013) at their February 2014 meeting. A recommendation to develop watershed-specific targets, performance standards and design criteria for rainwater management was passed at this meeting.

Options

The following options are presented for consideration:

1. Work with the Ministry of Transportation and Infrastructure to better understand ownership and maintenance implications of a potential program to implement volume reduction best management practices (i.e. linear rain gardens) within the road right of way in the Saratoga Beach neighborhood.
2. Incorporate the mitigation targets identified in the Master Drainage Plan into a rainwater management development permit area, and include design criteria in a subdivision and development servicing bylaw for the Saratoga Beach settlement node.
3. Investigate service structure options for a local service area to provide funding for public rainwater management infrastructure.
4. Not consider any further rainwater management regulatory measures at this time.

The Saratoga Beach area is experiencing significant development pressure, and further development, if not done in accordance with water balance principles as identified in the Master Drainage Plan, could put downstream areas at further risk of flooding, erosion and habitat destruction. For these reasons, Options 1 through 3 are recommended.

Financial Factors
Fully implementing a rainwater management strategy within the electoral areas is a multi-year project that requires continued effort and resources. The proposed 2020-2024 budget for the Liquid Waste Management Planning Service, function 340, includes funds that could be used towards further study and implementation of rainwater management initiatives as outlined in this report.

A $10,000 local government contribution in required to enable the EAP demonstration application. Staff are proposing to use the Community Works Funds allocated to rainwater management in the proposed 2020-2024 budget for function 340 to complete this work.

Legal Factors
A legal review of regulatory tools for improved rainwater management was completed by West Coast Environmental Law and contained in the Fernhill Consulting report. This work will be consulted as regulatory mechanisms are further developed in support of improved rainwater management.

Multiple sections of the *Local Government Act* (RSBC 2015 c.1) grant regional districts the authority, under bylaw, to regulate the land development activities that impact drainage. Further legal review of these sections, and the risks involved in enacting this authority, will be completed as part of the work to develop new regulatory tools. The findings of a recent governance study for the Queen's Ditch will also be consulted for background on legal and regulatory context and considerations for regional district drainage services.

Regional Growth Strategy Implications
Rainwater initiatives will be developed to align with the goals and objectives of the Comox Valley Regional Growth Strategy to "provide affordable, effective and efficient services and infrastructure that conserves land, water and energy resources." In particular, the Master Drainage Plan will work towards achieving Objective 5-C of the RGS: "Stormwater is managed to preserve ecosystem and watershed health."

Intergovernmental Factors
In order to manage rainwater according to best practices, an integrated, watershed based approach is suggested. This will involve close collaboration between the CVRD, MoTI, large private land owners and the stewardship industry.

The CVRD will continue to work collaboratively with MoTI through a joint planning agreement signed in 2016 to optimize rainwater management related regulations and requirements for the electoral areas.

Interdepartmental Involvement
The Engineering Services branch has taken the lead in preparing this report in collaboration with the Planning and Development Services branch.

Citizen/Public Relations
Proper management of rainwater is an important issue to many residents in the electoral areas as it can impact the development potential and value of private property. During periods of wet weather, the CVRD receives many drainage complaints from residents, many of whom expect a level of service that the CVRD is unable to provide with current resources. In addition to the policy development and implementation work discussed in this report, work is also required to increase

public understanding of rainwater management and the role it plays in overall watershed function and health. A communications strategy is under development to inform this work.

Attachments: Appendix A – "Saratoga Miracle Beach Area Master Drainage Plan"

Saratoga Miracle Beach Area Master Drainage Plan

Volume 1 - Summary Report

Comox Valley Regional District

Presented to:

Alana Mullaly, MCIP RPP
Senior Manager of RGS and Sustainability,
Planning and Development Services Branch
Comox Valley Regional District
600 Comox Road,
Courtenay, BC V9N 3P6

Revised
17 December 2019

December 17, 2019

Alana Mullaly, MCIP RPP
Senior Manager of RGS and Sustainability,
Planning and Development Services Branch

Comox Valley Regional District
600 Comox Road
Courtenay, BC V9N 3P6

Dear Alana:

Re: **Saratoga Miracle Beach Local Area Master Drainage Plan**

The purpose of the study is to establish the natural assets within the area and to create a framework that can be applied to future land use decisions to protect these assets. The reporting for this study includes two volumes: **Volume 1 – Summary** and **Volume 2 - Technical Report**. The summary contains a subset of information created during the course of the study while greater detail is provided in Volume 2 which would be the basis for future decisions and designs.

The CVRD and MOTI have an opportunity to preserve the natural environmental assets and to prevent increased risks of flooding within the study area by adopting standards that are consistent with those of other jurisdictions and that are in compliance with the stated objectives of both organizations. The recommendations contained within the report can be summarized to include:

1. All future developments should be required to comply with the design guidelines of MOTI in order to prevent increased flood risks and stream erosion downstream of any future development.
2. Where an on-site drainage report is required, the report should be prepared by a qualified professional to ensure the pre-development or natural hydrologic regime is maintained and restored by the development in order to protect the functional values of rainwater management.
3. The Water Balance Methodology should be used to control the rate and volume of future stormwater discharges as found here: http://comox.waterbalance-express.ca/
4. MOTI should be encouraged to enforce compliance of the design guidelines during approval of subdivisions and the issuance of any permits.
5. Enforcement of the design guidelines should be required as a condition of issuing a building permit.
6. The CVRD should consider the creation of a local service area for stormwater and drainage for the Saratoga Beach Local Area Plan boundaries and participation in the service area should be

considered as a condition of approval of any future development including subdivision and rezoning.

7. Where a biophysical assessment is required, the report should be prepared by a qualified professional to assess potential water quality and quantity impacts in order to protect the ecological values of the aquatic and riparian habitat.

I have enjoyed creating this Master Drainage Plan for the CVRD and expect that it will guide you as development occurs within the Saratoga Miracle Beach Area.

Please contact me if you have any comments or questions.

Regards

J. M. K. (Jim), Dumont, P.Eng.

Mr. Jim Dumont has been retained by the Comox Valley Regional District (CVRD) to undertake a study of the resources associated with the surface water features within the **Saratoga Miracle Beach Local Area Plan**. The purpose of the study is to identify the natural assets within the area and to create a framework that can be applied to future land use decisions to protect these assets.

Development has an adverse impact upon the integrity of natural assets within a watershed which are comprised of the stream corridor, wetlands and terrestrial areas through altering the surface cover of the watershed and by increasing the rates and volumes of watershed runoff. The impacts are manifested in i**ncreased flooding** and **loss of both aquatic and riparian habitat**. Key to managing and eliminating the future impacts is to establish standards and criteria specific to the watershed for future subdivision and construction associated with changes in land cover. Preservation of the environmental values of these assets will also protect people and property from increased flood damage and the effects of steam erosion.

The reporting for this study includes two volumes; this **Volume 1 - Summary Report** and **Volume 2 - Technical Report**. This summary contains a subset of information created during the course of the study while greater detail is provided in Volume 2. Any decisions regarding the development in the study area and any designs for developments will utilize the full information and recommendations contained in the Volume 2 - Technical Report.

Drainage design within the CVRD is governed by the requirements of the BC Ministry of Transportation and Infrastructure. The processes and requirements for Rural Subdivision Approvals is documented by the Province of British Columbia, Ministry of Transportation and Infrastructure on their web site located at http://www.th.gov.bc.ca/DA/L3_min_trans.asp.

There are multiple risks to the CVRD that result from development, these include:

1. **Increased flood risks** in downstream reaches;
2. **Aquatic habitat damage** and the loss of fisheries resources;
3. **Increased stream erosion** and property damage; and
4. **Costs** associated with flood damage and repairs to eroded streams.

Over the past decades the understanding of stormwater management has evolved to address unanticipated impacts. The evolution of stormwater management techniques has not been universally applied in all regions with some jurisdictions adopting all advances while other jurisdictions have not participated in the adoption of the evolving methods of managing stormwater.

Development within the study area is comprised of man-made alterations to the natural environment. The current and proposed alterations will provide the regions with the additional capability of economic growth while planning is undertaken to minimize the associated adverse impacts to the natural environment. The current developments have significantly altered the hydrology of the study and future developments will continue that trend unless mitigation measures are implemented to protect the important natural features.

Natural assets are assets of the natural environment. These consist of biological assets (produced or wild), land and water areas with their ecosystems, subsoil assets and air. For the purposes of this study we have confined the scope to include the landscape features that provide a benefit to the residents of the study area, the CVRD and to our society as a whole.

Natural assets within the study area include, but are not limited to, **streams, wetlands, riparian areas, and terrestrial habitat**. Natural assets are often found intertwined and inseparable in terms of function and derived benefits. For instance streams always have a riparian area, whether it is natural or highly modified by man. Wetlands will have riparian areas although the nature of a wetland can vary from one that is permanently wet and readily identifiable to areas that flood seasonally with the associated flora that is adapted to this hydrologic process. Wetlands are often fed or drained by streams. Often a riparian area may form on the flat verge of a stream and are comprised of wetlands that are both permanently and seasonally wet. The areas that are in direct contact with, or nearby, water will form aquatic habitat whereas areas that are exposed only to water in the form of precipitation are terrestrial habitat. Function of the natural assets are often overlooked or the value of that function will be discounted to such an extent that the value is overlooked. The degradation of the function and hence the value of the natural asset will occur as the landscape is altered for development.

The **drainage** within the study area is determined by the topography with surface water flowing perpendicular to the contours, except where ditching has been used to redirect the natural flow path of the water.

There are **numerous impacts that result from development** and human intervention in the landscape within the area. These include an **increase in flooding**, **increased risk to peopl**e **and property** along the stream corridors and wetland areas, as well as damage to the aquatic, riparian and terrestrial habitat occupied by the flora and fauna of the area.

The capacity of the channels located beyond the immediate vicinity of the road crossings have not been determined. **As development proceeds there is a need to establish the design flood levels and extents, or the floodplain, which is associated with a channel in order to provide flood protection to both people and property**. Establishing the floodplain and Flood Construction will be critical to the safety of future development in the study area.

The potentially designated floodplain setbacks are not the same as the setbacks required for Riparian Areas. As a result there may be two different setback requirements and the most conservative will apply to any development.

Habitat degradation can occur when the **increased volumes of discharge** occur in a stream as a result of the increased impervious area and drainage improvements associated with development in the study area. An additional impact will be a **decrease in the base flow rates during dry seasons** with streams that flow continuously becoming ephemeral. A fisheries resource would be lost should this occur. In areas that have “improved” drainage, i.e. a drainage system altered by human intervention the **flow duration is decreased by increasing the flow rates**.

Mitigation of the impacts caused by development would include the **management of flow duration after development** as documented within the report Establish Water Balance Targets for Water Balance Express, May, 2016 as prepared for the Comox Valley Regional District. The size of the mitigation works can be summarized in the three target values for the study area and include:

1. **Retention Volume** on site 164 m^3/ha of development, with neighbourhood detention facilities having a 1 in 100 year volume of 420 m^3/ha of contributing area
2. **Base Flow Release Rate** 1.0 L/s/ha from on-site systems, and maximum controlled release rate of 11.2 L/s/ha of developed area for neighbourhood facilities. Overflows are allowed from all facilities.
3. **Infiltration Area** 100 m^2/ha of development area for on-site facilities.

Impacts resulting from development of the off-lot areas will require mitigation that can be undertaken at the time of subdivision or development through construction of stormwater retention and detention facilities to manage both the rates and volumes of discharges from the area. Development can proceed as there is no specific need to embark upon a costly field investigation to provide the next level of detail. As additional information becomes available it can be incorporated into the models to provide updated watershed targets. Given the level of detail available I do not believe that the additional detail would be sufficiently different to alter the watershed target values significantly.

The **rainwater management systems** envisioned would provide a developed watershed provide with a hydrologic response and flood risks which would be equal to those found if no development were to have occurred. Two basic types of physical mitigation measures can be defined by their operational characteristics. The two types include landscape features and retention systems:

1. **Landscape surface features** that capture and contain rainwater before it has an opportunity to begin to flow over the surface. These systems can be described as rainwater absorption devices because they act to prevent surface runoff. These features can include enhanced topsoil and other absorbent features built with the intent to retain rainwater without having surface runoff.
2. **Volume retention systems** capture and store surface runoff while allowing the volume to infiltrate deeper into the ground. Where surface runoff occurs then the systems are no longer acting to absorb rainfall; rather they are containing and managing surface runoff. This is how the two types are differentiated. The retention systems would typically be connected to, and receive runoff from, an impervious surface such as a building roof or a driving surface. These retention systems must be constructed with a base flow release system to allow a portion of the drained water to flow into the drainage system so as to mimic the lost interflow system.

Any areas that are disturbed by a development process should be restored with no less than 150 mm and up to 300 mm of topsoil as described above.

In rural areas there are fewer constraints available to use the ground surface. Generally rain gardens occupy small areas where the ground surface has been depressed below the surrounding surface and which will receive runoff from impervious areas. These can have natural vegetation or can be small wetland areas. The key components will include these features:

- Depressed ground surface to contain and to pond water temporarily.
- A top soil or planting media that will retain water for plant growth.

Locating the **off-site retention systems** would be **within the road R-O-W** and could be considered a modification of the existing ditch system that provides drainage. Rather than a simple vegetated ditch the components of the new facilities would include the volume, area, and release rates required to satisfy the watershed targets.

The ownership and responsibility for operation and maintenance of the retention systems must be decide prior to commencing development. There are two models that can be considered:

1. A joint public and private system where the public systems would be constructed for the roadways within the road R-O-W and the remaining systems constructed on site. This would results in both public and private systems which would be operated and maintained by the respective owner.
2. A fully public system would see the systems constructed within the road R-O-W sized to mitigate the on-site impacts. These systems may require additional R-O-W width to accommodate the facilities which would be owned and operated by the CVED.

The **off-site neighbourhood retention pond** can be designed with the standard details which would be used for any neighbourhood pond. The only constraint is the maximum controlled discharge rate for up to full design depth with an overflow to allow for situations where the flood event is larger than the design would accommodate and an overflow is required.

Inclusion of **rainwater management** can be a **complex regulatory issue** in light of how land development occurs and the responsibilities of the individuals and firms which are a part of the process. A vast majority of the newly created properties are sold to new owners who would then complete the development process. The building construction is the final step in the overall process where the property owner applies for a building permit to construct a dwelling.

Design and construction of on-lot rainwater management systems would occur following subdivision. The two most significant reasons for this sequence are described below.

1. The first reason is to establish the building location within the building envelope to allow sufficient clearance and to avoid conflicts between the location of the building and the various components of the rainwater management system.

2. The second reason is that subdivision creates serviced lots without any provision for on-lot construction. The latter must meet building code provisions, and municipal staff carry out inspections at specific points during construction.

The CVRD must revise their building permit standards to when including the on-site rainwater management systems necessary to mitigate the impacts in the study area. The Water Balance Express can form one component in the building permit process in providing mitigation of on-lot development or redevelopment.

Implementing rainwater management systems is a good and environmentally sound decision in any local government. The aesthetics and livability of neighbourhoods and communities can be enhanced while allowing development and protecting the environment.

The rainwater infrastructure constructed within Rights-Of-Way requires review and approval of the local government and MOTI in rural areas. The infrastructure could be constructed as part of the servicing of the subdivision and prior to the sale of individual lots. **The design of the portions of the drainage which include conveyance capacity would be completed by using existing established methods and would be subject to the standards as applied before completion of this Master Drainage Plan. Only those parts of the rainwater management system intended to provide volume and rate control would be subject to new design standards and processes.**

Thus, the **Land Development Process would require a balance of enforceable regulation provided through Bylaws and Administrative process.** This would allow a bridge to be formed between the two steps of the Land Development process which are comprised of Subdivision and Building Construction.

On-going operation and maintenance of all of the systems will be required. The on-site systems located on private property will require maintenance by the property owner and systems located within the road R-O-W or on lands dedicated to the CVRD will require operation and maintenance by the CVRD.

As development proceeds and the design of facilities occurs there will be a need to convey the information to staff. This will occur in two stages:

1. Submission of the subdivision design will be received by staff of the CVRD and MOTI. These **staff will require training** to understand the designs and to evaluate whether the proposed systems meet the requirements of this drainage plan.
2. The design and submission process should include the provision of **Operating and Maintenance (O&M) Manuals** for rainwater management systems. This will allow staff to properly operate and maintain the systems in the future.

Public acceptance of the rainwater management facilities will be required as will ongoing system maintenance of the facilities located on private property. A process of **providing information to future and existing property owners** is required. A formal program to provide initial and ongoing public **education for**

property owners and developers should be in place to provide support to the public and to demonstrate the benefits of the systems and their maintenance.

Land Use Governance carries with it a **responsibility to protect the public, their property, and the environment**. Future development within the Saratoga Miracle Beach Area has the potential to adversely increase flood risks and result in the adverse damage to aquatic and riparian habitat. The **potential impacts can be mitigated with the control of stormwater discharge rates and volumes combined with protection of the riparian areas along the stream and within wetlands**.

Reduction of the potential impacts resulting from ongoing development within the study area will **require a new way of managing the development process and in educating both staff and the public** which includes developers and their engineers. Adopting new methods and processes is not a new concept as history shows us that we adapt as we acquire new knowledge of risk and adverse impacts in the process of occupying and altering the landscape to suit new uses and for human occupation.

Stormwater management has evolved into rainwater management with new knowledge of our impacts upon the environment and of the increased flood risks associated with previous land drainage practices. The regulated requirements have been revised in the past and will continue to be revised in the future. **The CVRD and MOTI have an opportunity to preserve the natural environmental assets and to prevent increased risks of flooding within the study area by adopting standards that are consistent with those of other jurisdictions and that are in compliance with the stated objectives of both organizations**. The rainwater **volume control measures could be designed with the use of the Water Balance Express whether they are located on-site or within the road R-O-W.** Access to the tool is through a web page located at http://comox.waterbalance-express.ca/. The neighbourhood r**etention ponds would be sized to contain the watershed target volume** while releasing the allowable discharge rates; no additional analysis would be required.

Establishing a Local Service Area for drainage and stormwater management would be initiated with the first development and can be expanded with each subsequent development, whether a subdivision or other type of development. The funding is through an annual parcel tax based upon the costs to operate and maintain the stormwater and drainage infrastructure. In this way any future costs can be recovered by the users of the system without affecting the budgets of the CVRD.

LIST OF FIGURES

LIST OF TABLES

This report has been reissued on December 17, 2019 to allow correction of errors in Table 3.1

1. INTRODUCTION

Mr. Jim Dumont has been retained by the Comox Valley Regional District (CVRD) to undertake a study of the resources associated with the surface water features within the Saratoga Miracle Beach Local Area Plan. The purpose of the study is to identify the natural assets within the area and to create a framework that can be applied to future land use decisions to protect these assets.

The stream corridors comprised of both the aquatic and riparian areas form a vibrant ecological asset within the CVRD that is often overlooked by the public and developers. The stream corridors provide habitat for wildlife in addition to flood attenuation, and conveyance of runoff from the watershed. Development has been found to have an adverse impact upon the integrity of the stream corridor by increasing the rates and volumes of watershed runoff. The impacts are manifested in increased stream erosion, increased flooding and loss of both aquatic and riparian habitat. Key to managing and eliminating the future impacts is to establish standards and criteria specific to the watershed for future subdivision and construction associated with changes in land cover. It is clear that preservation of the environmental values of these assets will also protect people and property from increased flood damage and the effects of steam erosion.

The reporting for this study includes two volumes; this **Volume 1 - Summary Report** and **Volume 2 - Technical Report**. Volume 1 contains a subset of information created during the course of the study while greater detail is provided in Volume 2. Any decisions regarding the development in the study area and any designs for developments will utilize the full information and recommendations contained in the Volume 2- Technical Report.

1.1 Study Area

The study area lies within the CVRD as illustrated on **Figure 1-1** as supplied by the CVRD. This area has been identified on Map 3 of Appendix A, "Rural Comox Valley Official Community Plan Bylaw No. 337, 2014" as a Settlement Node where future development will be concentrated in a mixture of labs uses and densities. Revisions to the existing land uses will be made through the defined processes of the CVRD. Of particular note there are no areas specifically designated for preservation in their natural state and that all of the land is subject to alteration of the surface conditions.

1.2 Scope of Analysis

The scope of this study creates a Drainage Plan that has several clear and definable deliverables that include:

1. Identify the water courses and the natural function they provide within the study area.
2. Define the pre-development hydrologic conditions, discharge rates, volumes, and flow durations for adjacent properties with some

development potential. Make recommendations for the preservation of key assets in their natural state.

3. Develop area specific performance standards and design criteria for future development that ensure surface flow, interflow and groundwater flow maintain or mimic the natural hydrologic regime.
4. Make recommendations for on-site and off-site, specific works that should be made by the qualified professional and land owner at the time of subdivision, development, or building applications being made. These works would be designed using the criteria referenced above to ensure pre-development conditions are maintained.
5. Identify the opportunities and constraints for future development which can be used to inform land use designations and environmental setbacks for the area.
6. Clarify and document how to avoid changing the drainage system so that adverse impacts are not created within the area.
7. Make recommendations on how these proposed mitigation measures may be implemented, required, enforced, and maintained into the future.

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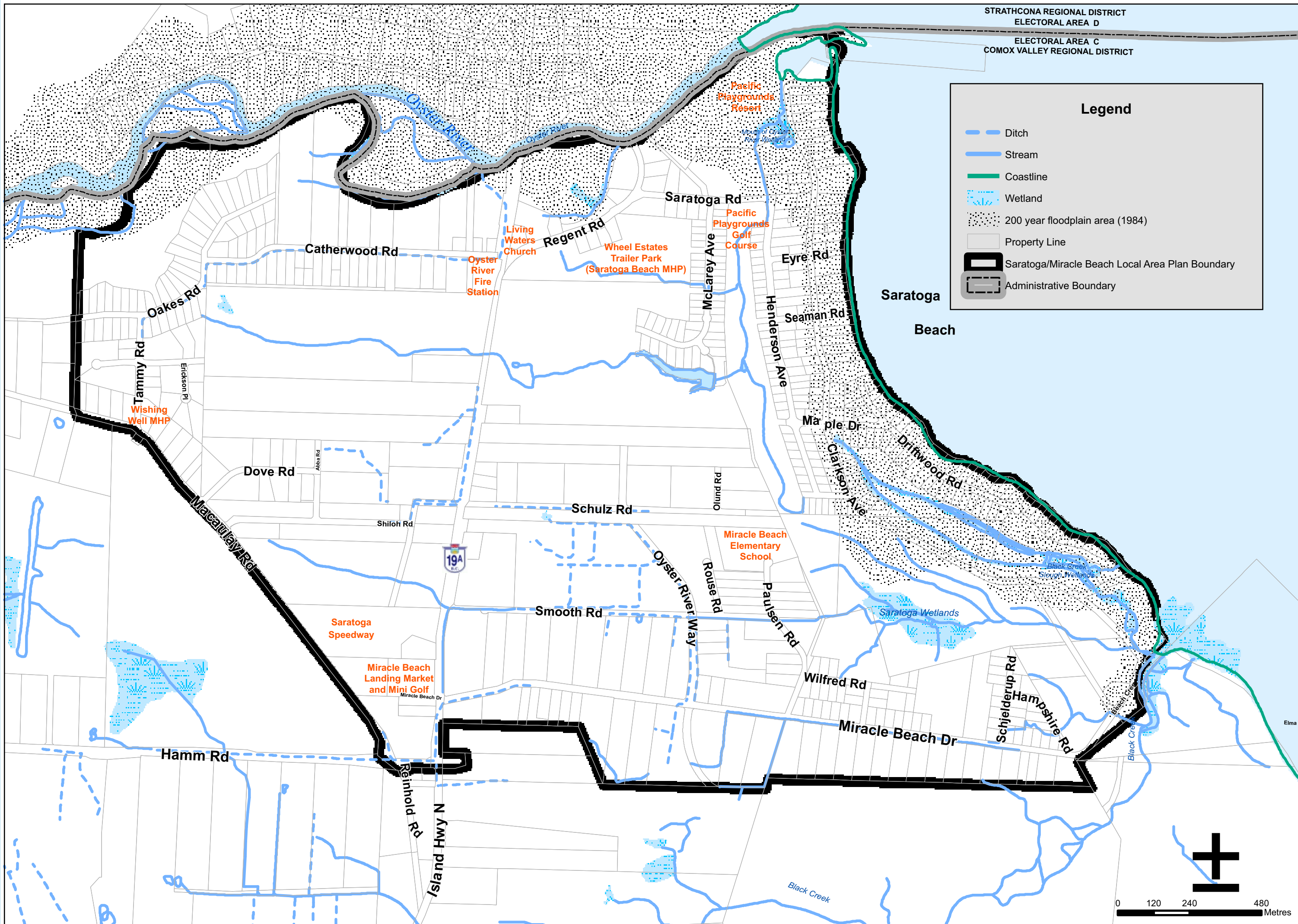

Comox Valley
REGIONAL DISTRICT

Saratoga Miracle Beach Area Drainage Plan Study Area

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Figure 1-1
Study Area
Saratoga Miracle Beach Area Drainage Plan

2. BACKGROUND INFORMATION

2.1 Drainage Design Standards

Drainage standards often use and refer to a "Return Period" that is used to determine the capacity of, or level of flood protection provided by drainage works. Commonly a return period event is selected where the return period is the inverse of the probability of occurrence. In simple terms the 5 year return period event has a 20 percent probability of occurring in any given year. A 100 year return period event would have a 1 percent probability of occurring in any given year. In even simpler terms it would be reasonable to expect that a 5 year return period event would occur in any given 5 year period. The intent of applying a probability or return period is to provide a rationale for the size and cost of stormwater management facilities.

Drainage design within the CVRD is governed by the requirements of the BC Ministry of Transportation and Infrastructure. The processes and requirements for Rural Subdivision Approvals is documented by the Province of British Columbia, Ministry of Transportation and Infrastructure on their web site located at http://www.th.gov.bc.ca/DA/L3_min_trans.asp.

The drainage section of the BC Supplement to the TAC Guide can be found at this MOTI web page https://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/highway-design-and-survey/tac/tac-2007-supplement/ch1000-2007.pdf

Excerpts from the Design Guide include the following

1. *All drainage systems must include run-off controls to limit post-development peak discharge rates to the predevelopment rates for 5 year return period storms.* Page 1010-2*.*

2. *An additional Ministry requirement is an assessment of the receiving ditch or watercourse for peak flows greater than a 5 year return period up to a 100 year return period. The assessment must document the net change in water velocity in the ditch or receiving water, identify any potential impacts from increased peak flows, and make recommendations for mitigation. In other words, flows must be managed to ensure that no increase in flooding and stream erosion occur as a result of development storm drainage.* Page 1010-2*.*

3. *Proposed works for a development should be designed using the following criteria:*
    - *an increase in downstream flooding or stream erosion will not be allowed. Designs will achieve this requirement unless it can be demonstrated that these changes do not adversely impact property or the environment;* Page 1010-3.

4. *In areas where a Master Drainage Plan has been developed, all subsequent drainage designs should conform to the plan.* Page 1010-3.

Based upon the text of the Guideline I believe that intent of MOTI is to protect the residents, property and the environment from the impacts of development and that innovative methods may be required to achieve these objectives.

2.2 Groundwater Studies

Two studies have been undertaken for the CVRD to investigate groundwater conditions within the immediate area. These include:

1. Black Creek/Oyster Bay groundwater asset characterization, and
2. 2015 Saratoga Beach – Puntledge Black Creek (Area ‘C’) – Groundwater Monitoring Program.

Black Creek/Oyster Bay Groundwater Asset Characterization

A study was undertaken to establish the potential ground water supply for future developments within the area due to observed declines in the production of water from the existing water supply wells. The water levels associated with the aquifers was reported to be approximately 5.0 m below the ground surface (page 6 of 28 of that report).

The study determined that the producing aquifer was not directly connected to the Oyster River, rather the pump yield and recovery of the aquifer were only slightly affected by the discharge in the river. This leads us to conclude that the aquifer is largely independent of the surface water in the watershed

2015 Saratoga Beach – Puntledge Black Creek (Area ‘C’) – Groundwater Monitoring Program.

A study was undertaken to evaluate the performance of onsite treatment systems in the Saratoga Beach settlement node based on the quality of the groundwater. Currently, wastewater in the Saratoga Beach area is managed by onsite sewerage systems, including residential septic systems and a few communal or cluster sewage systems.

Shallow test holes were used to observe the water table at levels approximately 0.35 to 1.40 m below ground surface. The study concluded that failure of on-site sewage treatment systems are probably linked to higher density, shallow groundwater levels and age of the systems. This leads us to conclude that the water supply aquifer is independent of the shallow groundwater that would be impacted by onsite treatment systems in the watershed.

2.3 Stormwater Management

There are multiple risks to the CVRD that result from development, these include:

1. **Increased flood risks** in downstream reaches;
2. **Aquatic habitat damage** and the loss of fisheries resources;

3. **Increased stream erosion** and property damage; and
4. **Costs** associated with flood damage and repairs to eroded streams.

INCREASED FLOOD RISKS

As rural land is undergoing development drainage works are created which direct any surface runoff more quickly to the receiving stream. Additionally there is an increase in impervious areas such as roads, buildings, driveways, sidewalks, etc., and in the number of directly connected methods of drainage, such as ditches, sewers and roadways which results in an increase in greater runoff. These factors combine to yield higher volumes of surface runoff volumes and flow rates as compared to predevelopment conditions.

In a conventional drainage system either the downstream system to receive the flow is enlarged, or new outlets for the stormwater runoff are constructed to accommodate development. Increased flood risks occur, particularly in areas where the flood plain of the streams have not been defined. Potential flooding in the study area may exhibit the characteristics as shown in **Figure 2-1** which include images from other watersheds.

Figure 2-1 Photos of Flooding

The MOTI design guidelines indicate that consideration must be given to the potential of increases in the magnitude of downstream floods and the potential to increase downstream erosion. Every development must therefore adequately address these issues as part of the planning and design of the project.

Aquatic Habitat Damage

Research presented in "*Watershed Determinants in Ecosystem Functioning*", Horner, et, al, 1996 documented the impacts of urban development upon the aquatic environment with some very interesting findings. They reported that the impacts from urban development fell into four different categories with the effects from highest to lowest being:

1. Changes in hydrology;
2. Disturbance to riparian corridor;
3. Degradation of in-stream habitat; and
4. Deterioration of water quality.

The conclusion of this information is that the impacts to the stream hydrology and aquatic habitat of development must be mitigated in order to allow healthy populations of cold water fish species which include all species of salmonids.

Increased Erosion

The increased erosion in the streams is an impact of development that relates to the changes in hydrology which include greater rates and volumes of discharge in the stream. The erosion in streams has been found to be related to the duration of discharge above critical threshold value rather than simply the discharge rate. Further, the threshold discharges are less than the commonly accepted Q_2 or Q_5 events. Therefore an increase in erosion can be avoided if both the duration and flow and the rates of discharge are maintained following urban development.

Increased Costs

Increased costs associated with stream erosion induced by development have long been documented. A very recent example can be found in the Town of Comox where Brooklyn Creek has experienced increased erosion due to upstream development. The eroded material accumulated in the lower reaches of the stream with the result being a reduced stream capacity and increases in flood levels. An extensive and very expensive rehabilitation program has been undertaken to protect properties from eroding stream banks and increased flood damages. The costs of the stream rehabilitation were unexpected and costly.

2.4 Advances in Rainwater Management

Over the past decades the understanding of stormwater management has evolved to address unanticipated impacts. The evolution of stormwater management techniques has not been universally applied in all regions with some jurisdictions adopting all advances while other jurisdictions have not participated in the adoption of the evolving methods of managing stormwater. The east coast of Vancouver Island and the CVRD specifically has been one of the regions where stormwater management has been largely ignored.

The evolution of stormwater management has taken many steps. For example prior to the 1970's the drainage objective was to quickly dispose of stormwater to prevent local flooding and to allow the local area to dry and become usable. The unintended consequences resulted in flooding of other properties in downstream areas and the increased risk to people and property. To address that measurable impact detention ponds were created to attenuate the rate of post development discharge to predevelopment rates so as to reduce the increases in downstream flooding. Most of the design standards applied within British Columbia now include a requirement for managing discharge rates through the construction of detention ponds.

During the 1980's and 1990's observation and research indicated that while the creation of detention ponds could reduce the risk of flooding the unintended consequence was that they actually increased stream erosion and led to the destruction of aquatic habitat. Where erosion increased then property was lost and in areas where sediment was deposited flooding was increased. An example of this can be seen in Brooklyn Creek which drains a portion of the CVRD, City of Courtenay, and the Town of Comox.

Since approximately 2000 the evolution of stormwater management has focussed upon reducing the volume of discharge so as to reduce the duration of discharges that result in the increases in stream erosion.

2.5 Watershed Hydrology

When assessing and creating a drainage plan an understanding of the hydrologic operation of a watershed is essential. The ideal situation would occur when there are records of both streamflow and climate within the watershed. As there are no climate or streamflow recording stations within the study area examination of available regional data is necessary. This will establish an expectation as to the hydrologic operation of the study area and to validate any hydrologic calculations completed as part of any design.

2.6 Vegetation Zonation

The major characteristic of the vegetation region is that it is dominated by the rain shadow effect of descending air on the leeward side of the Vancouver Island Range. The Saratoga Miracle Beach Area lies in the **Coastal Grand Fir - Western Red Cedar Zone** which occurs from sea level to about 300 m elevation. It is characterized by a climax forest of grand fir and western red cedar growing on deep, well drained sites. In response to frequent disturbance, coast Douglas-fir is the predominant seral species found on most sites. Broad-leaved tree species such as Pacific Madronne, Garry Oak, and big leaf maple are also common on some sites.

2.7 Groundwater Flow

In 2005 the United States Geological Service (USGS) identified a need to examine previously assumed concepts used to describe the processes of water flowing beneath the ground surface. There was a need to address the issues associated with accurately describing the flow path and routing of the water. This led to a calculation system which separated the groundwater into interflow and groundwater flow as shown in **Figure 2-2**.

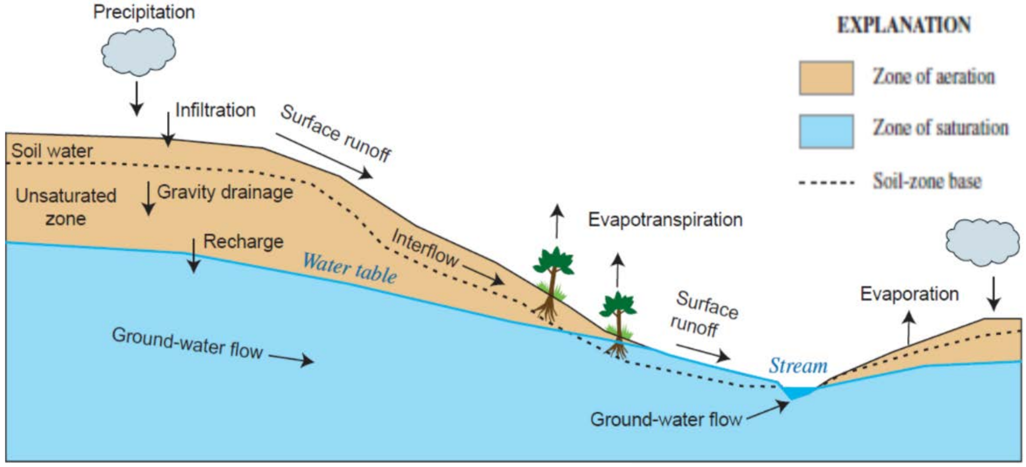


Figure 2-2 Groundwater Flows

2.8 Surface Soils

Examination of surface soils is critical to understanding the hydrology of an area particularly when considering interflow and groundwater interactions to stream discharges. The shallow (less than 1 m in depth) soils are most affected and altered by the interaction of both rainwater and biological activity are commonly referred to as "top soil". The surface soils are modified over time by these factors and their physical and chemical characteristics will be altered from those of the original geological materials found when the glaciers melted some 10,000 years ago.

2.9 Development

Development within the study area is comprised of man-made alterations to the natural environment. The current and proposed alterations will provide the regions with the additional capability of economic growth while planning is undertaken to minimize the associated adverse impacts to the natural environment.

The current developments have significantly altered the hydrology of the study and future developments will continue that trend unless mitigation measures are implemented to protect the important natural features.

3. NATURAL ASSETS

Natural assets are assets of the natural environment. These consist of biological assets (produced or wild), land and water areas with their ecosystems, subsoil assets and air. For the purposes of this study we will confine the scope to include the landscape features that provide a benefit to the residents of the study area, the CVRD and to our society as a whole.

Natural assets within the study area include, but are not limited to, streams, wetlands, riparian areas, and terrestrial habitat. Natural assets are often found intertwined and are inseparable in terms of function and derived benefits. For instance streams always have a riparian area, whether it is natural or highly modified by man. Wetlands will have riparian areas although the nature of a wetland can vary from one that is permanently wet and readily identifiable to areas that flood seasonally with the associated flora that is adapted to this hydrologic process. Wetlands are often fed or drained by streams. Often a riparian area may form on the flat verge of a stream and comprise wetlands that are both permanently and seasonally wet. The areas that are in direct contact with, or nearby, water will form aquatic habitat whereas areas that are exposed only to water in the form of precipitation are terrestrial habitat. For more information regarding the environmental findings refer to the report Saratoga-Miracle Beach Local Area Brief Environmental Inventory, Current Environmental, October 31, 2017.

Function of the natural assets are often overlooked or the value of that function can be discounted to such an extent that the value is overlooked. The degradation of the function and hence the value of the natural asset will occur as the landscape is altered for development.

3.1 Streams

The natural function of a stream is complex: however in the simplest of terms the stream provides engineering, recreational, and environmental functions. Streams in the study area have been generally identified in the CVRD GIS system as shown on **Figure 3.1.**

Streams provide a complex function in drainage as both a conveyor and retainer of water. Conveying water from upstream areas to downstream areas allows safe human use of the upstream areas for development, farming, recreation, and business. The counter to this is that the stream also retains and limits the drainage which will reduce the flooding of downstream areas unless the channel is modified. These two engineering functions are opposed as the reduction of flood discharge is often overlooked in favor of channel modification to increase discharge capacity.

Increasing a channel discharge either by increasing the capacity, or by reducing the retention will adversely affect the stability of the channel and increase costs associated with maintenance.

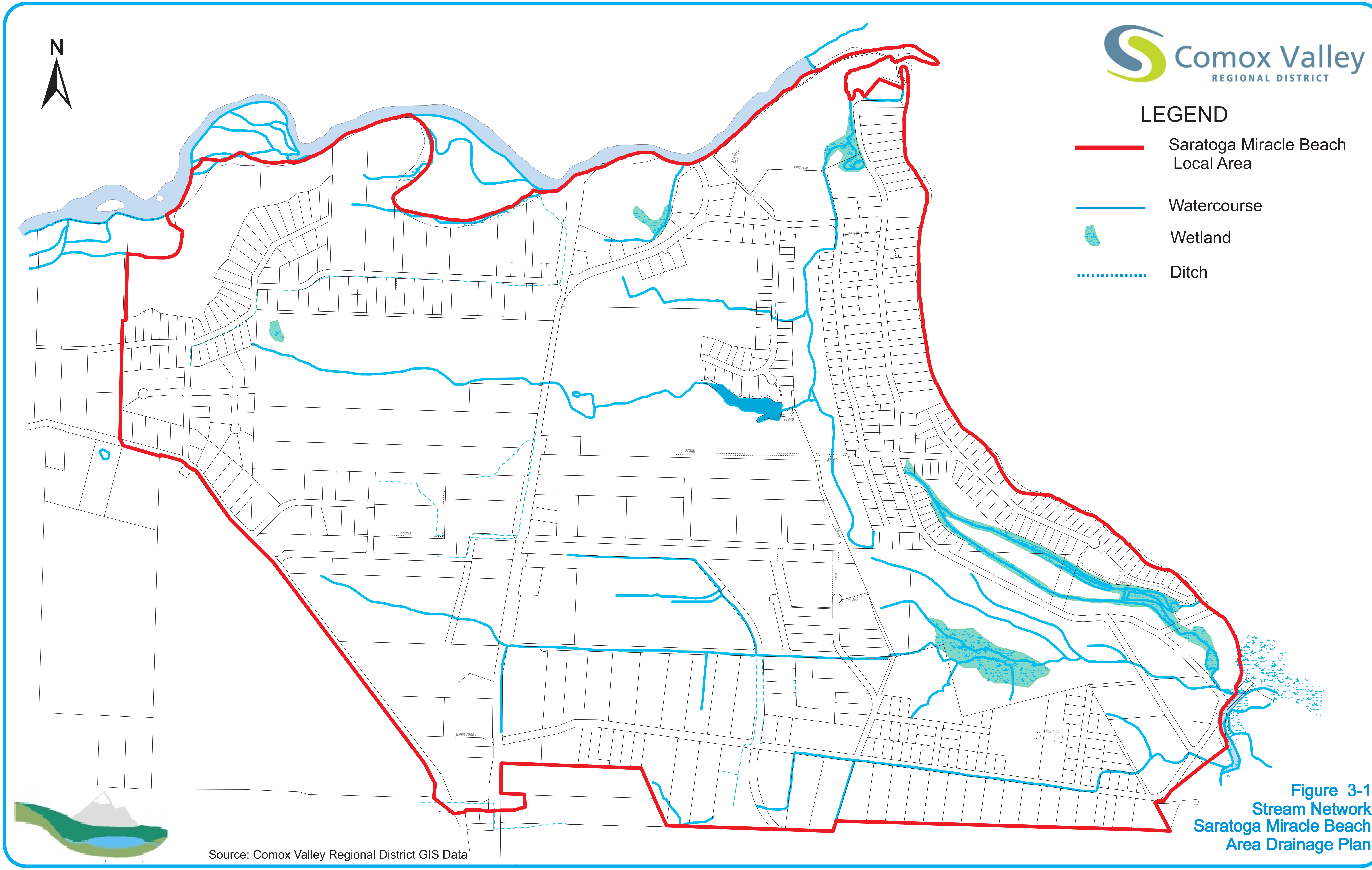


Figure 3-1
Stream Network
Saratoga Miracle Beach
Area Drainage Plan

Source: Comox Valley Regional District GIS Data

Streams in the study area are described in the Saratoga-Miracle Beach Local Area Brief Environmental Inventory, by Current Environmental.

Black Creek is a highly productive fish-bearing stream originating in wetland complexes on the east side of Highway 19, and flowing into Elma Bay. Fish species known to inhabit Black Creek include chum and coho salmon, resident and anadromous cutthroat trout, rainbow trout and steelhead. The creek is identified in the Fisheries Information Summary System as being sensitive coho habitat and one of the best coho-producing streams for its size on Vancouver Island.

3.2 Wetlands

Current Environmental indicates that Wetland ecosystems are rare and account for only 1.7% of the total sensitive ecosystems inventory on Eastern Vancouver Island and the Gulf Islands. The wetland complexes identified within the study area are comprised of slough-sedge dominated wetland area and drier areas dominated by hardhack and Pacific crab apple. The environmental descriptions listed below are extracted from the Current Environmental report, which should be consulted for additional detail.

The wetlands within the study area provide a wide range of functions that are important in their impacts upon properties and the potential of risk to the residents of the area. The wetlands are areas with a relatively large surface area, very small longitudinal slopes. These areas act as barriers to flow and detain large volumes of water with two important functions. The first physical function is to reduce the discharges through flow attenuation and thus provide flood protection to downstream areas. Increasing the conveyance capacity by ditching or enlarging the channel will reduce the local area that experiences occasional flooding and transfer the risk of flooding on to downstream areas. The second function is to improve the quality of the discharges through two processes of filtration and nutrient uptake. The wetland vegetation will filter the water to reduce solids such as sediment and floating debris. The vegetation will also absorb and utilize nutrients and other dissolved material in the water.

The study area contains two high-value wetland complexes; the Saratoga (Clarkson) wetlands bounded by Miracle Beach Drive, Paulsen Road, and Clarkson Ave (the southeast corner of the SMB area), and the wetlands surrounding the Black Creek slough bounded by Maple Drive, Driftwood Road, and Clarkson Ave. These areas provide habitat for avians, amphibians, fish, and other species. Other ecological functions include supplying vital nutrients to downstream habitats and flow regulation. Some of these wetland areas have been identified by the Comox Valley Land Trust (CVLT) as priority lands for conservation efforts.

The wetland areas provide wildlife habitat to a diverse number of avian species, amphibian forage and rearing habitat, fish habitat (food production, winter refuge/rearing, and migration to upstream areas), and numerous wildlife trees (snags). There are patches of mature (~110 years old) forest in sections surrounding the central swamp wetland – these areas have very high wildlife and recreational/esthetic value.

3.3 Riparian Areas

Riparian areas can include wetlands and other areas adjacent to streams, whether flowing or ephemeral. The riparian areas have a function similar to that of wetlands in providing habitat and food sources for wildlife while sheltering the streams from sunlight and warming of the water which would be harmful to the fish populations.

Riparian areas can provide additional flood discharge capability however their extent may not correspond directly to the floodplain. Each stream has a floodplain that is defined by the extent of the area necessary to convey the design flood. The floodplain is often different than the riparian area defined by the environmental function.

3.4 Terrestrial Areas

The terrestrial areas are all areas that are not counted as wetlands or riparian areas. The engineering and environmental functions can be altered dramatically by human intervention in the watershed through deforestation, drainage improvements with ditching, agriculture, increasing imperviousness, and water diversions. The result is always greater peak flood discharges and smaller dry period discharges.

3.5 Drainage Patterns

The drainage within the study area is determined by the topography with surface water flowing perpendicular to the contours, except where ditching has been used to redirect the natural flow path of the water as shown in **Figure 3.2**. There are several obvious stream relocations that have occurred and these include:

1. South of Schulz Road and west of Oyster Way where the drainage pattern is now formed by manmade ditches;
2. A topographic low point which would have been a wetland located to the north of Schulz Road and west of Oyster River Way has been drained by the ditches created during the construction of Schulz Road;
3. The ditch immediately to the north of the properties on the north side of Miracle Beach Drive west of Oyster River Way;
4. Redirection of the drainage to follow the ditches created by road construction; and
5. Several ditches that follow property lines.

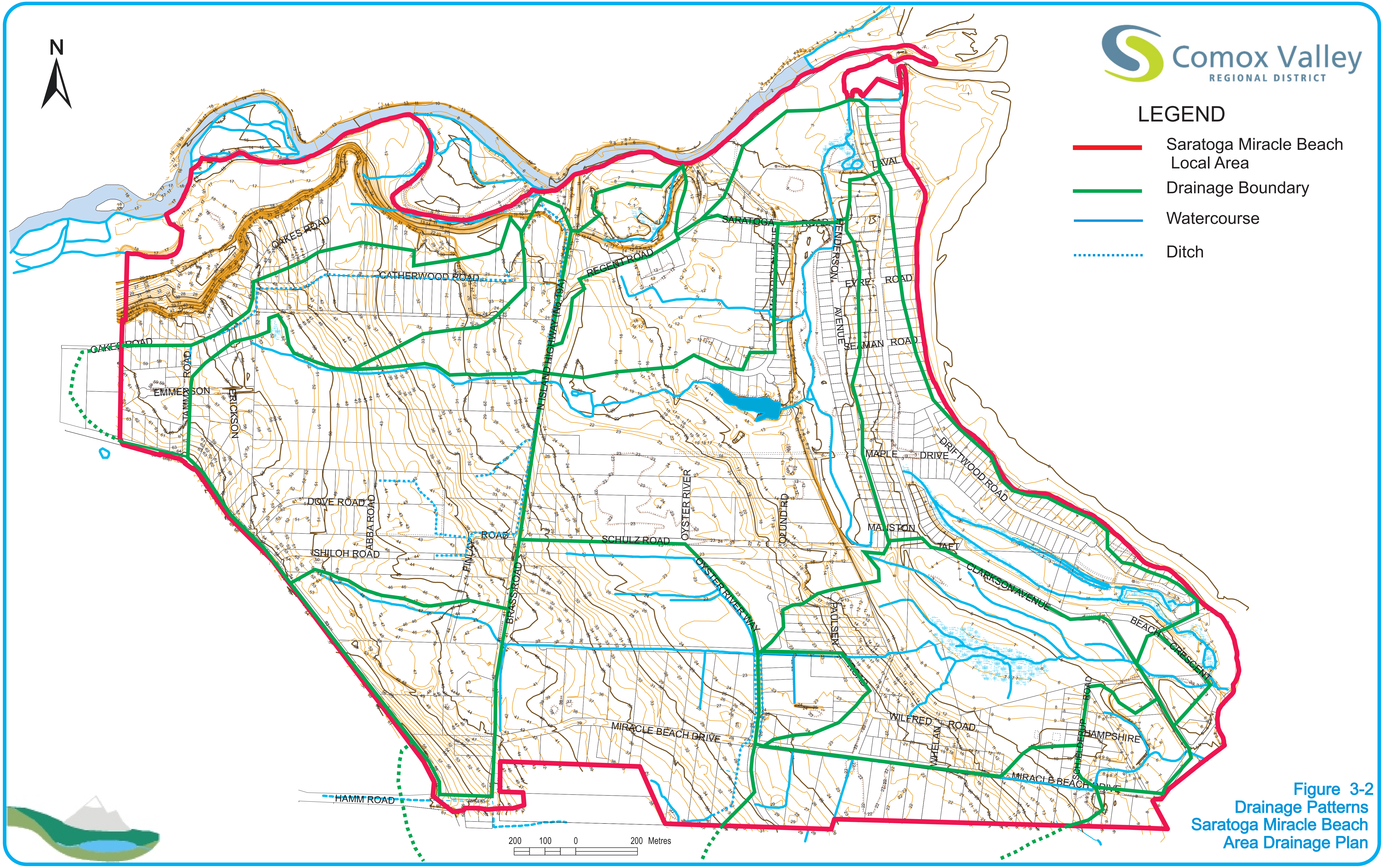


Figure 3-2
Drainage Patterns
Saratoga Miracle Beach
Area Drainage Plan

3.6 Impacts of Development

As indicated in previous sections of this report there are numerous impacts that result from development and human intervention in the landscape within the area. These include an increase in flooding, increased risk to people along the stream corridors and wetland areas, damage to the aquatic, riparian and terrestrial habitat occupied by the flora and fauna of the area.

Increased Flooding

Development which can vary from deforestation to agricultural practices, and on to land use changes for subdivision development of residential, commercial, industrial, and institutional purposes. All of these activities will increase the peak discharge rates when compared to the predevelopment land forms. The increases of peak discharge rates will increase the depth of flooding and the extent of the flood across the land. Of particular concern would be the relatively flat wetland areas that are subject to occasional flooding. The depths of flood levels will increase the area of flooding to include areas that did not previously experience flooding.

The increase in flooding will result in additional flood damages to land and properties within the active flood zone. Where people have contact with the flood waters they will experience an increased risk of injury and possibly death. Adoption of new design standards would minimize the potential risks to people and property.

The results of an assessment of the stream crossings and the nearby conveyance channels is shown in **Table 3.1**. As can be seen, most of the crossings and channels do not have sufficient capacity to convey the 100 year return period flood event, or storm.

Table 3.1 – Stream Flood Potential

Stream Crossing	Adequate 100 Year Flood Capacity at the Crossing		
	Crossing	Channel Immediately Upstream	Channel Immediately Downstream
1	No	No	No
2	Unknown	Unknown	Unknown
3	No	No	No
4	Unknown	Unknown	Unknown
5	Unknown	Unknown	Unknown
6	Yes	Yes	Yes
7	No	No	No
8	No	No	No
9	Yes	Yes	Yes

Further development within the study area should protect the public and property from flood risks.

The capacity of the channels located beyond the immediate vicinity of the road crossings have not been determined. As development proceeds there is a need to establish the design flood levels and extents, or the floodplain, which is associated with a channel in order to provide flood protection to both people and property. Establishing the floodplain and Flood Construction levels for future developments within the study area will be essential to protecting the public and property from the risks of flooding.

The potentially designated floodplain setbacks are not the same as the setbacks required for Riparian Areas. As a result there may be two different setback requirements and the most conservative will apply to any development. The two setbacks may include:

1. Riparian Area Setback, and
2. Floodplain Setback.

Environmental Impacts

Along with the increase in flooding is the increase in stream erosion that will move sediment and alter the form of the bed and banks of the stream resulting in damages to the aquatic habitat along the streams. Habitat degradation can also occur when the increased volumes of discharge occur in a stream as a result of the increased impervious area and drainage improvements associated with development in the study area.

An additional impact will be a decrease in the base flow rates during dry seasons with streams that flow continuously becoming ephemeral. A fisheries resource would be lost should this occur.

In areas that have “improved” drainage; that is a drainage system altered by human intervention where the flow duration is decreased by increasing the flow rates. While this has the benefit of increasing the load bearing capacity of the soil and allows for cultivation or other human activities there is a reduction in the amount of time that the land is moist or wet. In this manner the wetland characteristics and environmental values of land are reduced. Preservation of wetland areas must include retention of both their natural condition and the flow conditions that feed water to the wetland. If the hydrologic functions of the watershed that contribute water to the wetland are altered then the wetland will be adversely impacted, even if their area and features are protected.

3.7 Area Specific Targets

Mitigation of the impacts caused by development would include the management of flow duration after development as documented within the report Establish Water Balance Targets for Water Balance Express, May, 2016 as prepared for the Comox Valley Regional District.

The size of the mitigation works can be summarized in the three target values for the study area and include:

1. **Retention Volume** on site 164 m^3/ha of development, with neighbourhood detention facilities having a 1 in 100 year volume of 420 m^3/ha of contributing area;
2. **Base Flow Release Rate** 1.0 L/s/ha from on-site systems, and maximum controlled release rate of 11.2 L/s/ha of developed area for neighbourhood facilities. Overflows are allowed from all facilities; and

3. **Infiltration Area** 100 m^2/ha of development area for on-site facilities.

Impacts resulting from development of the off-lot areas will require mitigation that can be undertaken at the time of subdivision or development through construction of stormwater retention and detention facilities to manage both the rates and volumes of discharges from the area.

As detailed site specific data, climate records, and stream flow records become available the continuous simulation models can be enhanced with the additional data. Adding information to the models can become part of an ongoing process to increase the local accuracy of the watershed targets.

Development can proceed without completing a costly field investigation to provide the next level of detail. As additional information becomes available it can be incorporated into the models to provide updated watershed targets. Given the level of detail available I do not believe that the additional detail would be sufficiently different to alter the watershed target values significantly.

3.8 On-Site and Off-Site Standards

The rainwater management systems envisioned would provide a developed watershed with a hydrologic response and flood risks which would be equal to those found if no development were to have occurred.

Two basic types of physical mitigation measures can be defined by their operational characteristics. The two types include landscape features and retention systems:

1. **Landscape surface features** capture and contain rainwater before it has an opportunity to begin to flow over the surface. These systems can be described as rainwater absorption devices because they act to prevent surface runoff. These features can include enhanced topsoil and other absorbent features built with the intent to retain rainwater without having surface runoff; and
2. **Volume retention systems** capture and store surface runoff while allowing the volume to infiltrate deeper into the ground. Where surface runoff occurs then the systems are no longer acting to absorb rainfall, rather they are containing and managing surface runoff. This is how the two types are differentiated. The retention systems would typically be connected to, and receive runoff from, an impervious surface such as a building roof or a driving surface. These retention systems must be constructed with a base flow release system to allow a portion of the drained water to flow into the drainage system so as to mimic the lost interflow system.

The key to rainwater absorption landscaping features is to have a soil texture with approximately equal proportions of sand, silt and clay. This soil texture will retain a maximum amount of soil moisture for plant use. A soil with a greater proportion of sand will only temporarily detain rainwater as a sand soil will drain and dry out quickly.

The ideal soil will be a Silty Loam or a Clay Loam with no more than 8% organic content by weight. Excess organic matter will reduce the load carrying capacity of a wet soil and create a boggy condition when the soil is wet.

Any areas that are disturbed by a development process should be restored with no less than 150 mm and up to 300 mm of topsoil as described above.

Volume retention systems have three physical components which include and accommodate the watershed target criteria for:

- Detained volume,
- Control allowing baseflow release, and
- Surface contact area to allow infiltration to deep groundwater.

The main components of any rain garden can be defined and measured as shown on **Figure 3-3**.

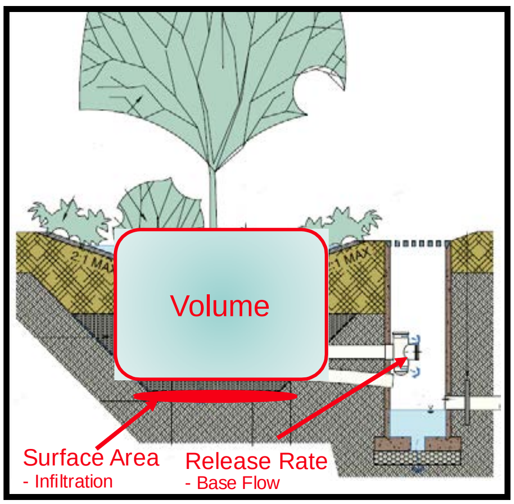


Figure 3-3 Components of a Typical Rain Garden

Plants within additional landscaping features may be desirable in retention systems so that retained water can be utilized for transpiration.

The potential shape and appearance of the volume retention systems is limited only by our imagination and constraints of a site and regulatory concerns. A typical on-lot rain garden can be seen on **Figure 3-4**.

Figure 3-4 On-Site Rain Garden

In rural areas there are fewer constraints available to use the ground surface. Generally rain gardens occupy small areas where the ground surface has been depressed below the surrounding surface and which will receive runoff from impervious areas. These can have natural vegetation or can be small wetland areas. The key components will include these features:

- Depressed ground surface to contain and to pond water temporarily.
- A top soil or planting media that will retain water for plant growth,

Locating the Off-site retention systems would be within the road R-O-W and could be considered a modification of the existing ditch system that provides drainage. Rather than a simple vegetated ditch the components of the new facilities would include the volume, area, and release rates required to satisfy the watershed targets. Images of linear rain gardens that can be constructed within the road R-O-W can be seen on **Figure 3-5**.

Figure 3-5 Linear Rain Garden

The off-site neighbourhood retention pond can be designed with the standard details which would be used for any neighbourhood pond. The only constraint is the maximum controlled discharge rate for up to full design depth with an overflow to allow for situations where the flood event is larger than the design would accommodate.

3.8.1 Public and Private Facilities

There are opportunities for providing a mix of public and private facilities within the study area. We anticipate that the detention ponds within property that is ultimately owned by the CVRD.

As seen above the volume reduction BMP's can be placed on private property and on public lands of the Rights-Of-Way. There is a choice of whether all of the BMP's are on public property or whether there is a mixture of public and private systems.

In the case of publicly owned and operated BMP's they would be constructed within the road R-O-W at the time of subdivision and would be operated and maintained by the CVRD. As the BMP's would occupy space within the R-O-W there may be a need to provide a greater width of R-O-W to accommodate all of the systems plus drainage from upstream areas. The on-lot disturbed areas would then be restored as described previously.

If there is a mixture of ownership the BMP's would be constructed in two stages during subdivision and development. The first stage would be to construct the BMP's required to service the roadways at the time of subdivision. The BMP's required for mitigating the on-site impacts would be authorized and constructed as part of the building permit process. In this case the BMP ownership would be both public and private with the responsibility for operation and maintenance falling upon the owner of the system.

3.9 Opportunities and Constraints

As the development occurs within the study area and as redevelopment of existing properties occur when older housing is replaced there exist opportunities to bring about changes in our use and construction standards that can have a benefit to the natural health of the watershed, wetlands and streams.

3.10 Implementation

Inclusion of rainwater management can be a complex regulatory issue in light of how land development occurs and the responsibilities of the individuals and firms which are a part of the process.

A vast majority of the newly created properties are sold to new owners who would then complete the development process. The building construction is the final step in the overall process where the property owner applies for a building permit to construct a dwelling.

Design and construction of on-lot rainwater management systems would occur following subdivision. The two most significant reasons for this sequence are described below:

1. The first reason is to establish the building location within the building envelope to allow sufficient clearance and to avoid conflicts between the location of the building and the various components of the rainwater management system; and
2. The second reason is that subdivision creates serviced lots without any provision for on-lot construction. The latter must meet building code provisions, and municipal staff carry out inspections at specific points during construction.

The CVRD must revise their building permit standards to include the rainwater management systems necessary to mitigate the impacts in the study area. The Water Balance Express can form one component in the building permit process in providing mitigation of on-lot development or redevelopment.

Implementing rainwater management systems is a good and environmentally sound decision in any local government. The aesthetics and livability of neighbourhoods and communities can be enhanced while allowing development and protecting the environment.

Rainwater infrastructure which is to be constructed on private property would require design review and inspections by a suitably qualified professional and / or building inspector as part of the building process and be regulated under the building permit process.

Alternatively a new administrative process of design, review, approval and acceptance may be created by the local government. A modified process may include a qualified professional for design and certification. Inclusion of a qualified professional would necessitate modification of the Development Agreements and the legal relationships between the local government, the developer, the home builder and the engineering consultants that have been a standard part of the land development process to date in other jurisdictions.

The rainwater infrastructure constructed within Rights-Of-Way requires review and approval of the local government and MOTI in rural areas. The infrastructure could be constructed as part of the servicing of the subdivision and prior to the sale of individual lots. The design of the portions of the drainage which include conveyance capacity would be completed by using existing established methods and would be subject to the standards as applied before completion of this Master Drainage Plan. Only those parts of the rainwater management system intended to provide volume and rate control would be subject to new design standards and processes.

Thus, the Land Development Process would require a balance of enforceable regulation provided through Bylaws and Administrative process that would allow a bridge to be formed between the two steps of the Land Development process which are comprised of Subdivision and Building Construction.

On-going operation and maintenance of all of the systems will be required. The on-site systems located on private property will require maintenance by the property owner and systems located within the road R-O-W or on lands dedicated to the CVRD will require operation and maintenance by the CVRD.

As development proceeds and the design of facilities occurs there will be a need to convey the information to staff. This will occur in two stages:

1. Submission of the subdivision design will be received by staff of the CVRD and MOTI. These staff will require training to understand the designs and to evaluate whether the proposed systems meet the requirements of this drainage plan: and
2. The design and submission process should include the provision of Operating and Maintenance (O&M) Manuals for rainwater management systems. This will allow staff to properly operate and maintain the systems in the future.

Public acceptance of the rainwater management facilities will be required as will ongoing system maintenance of the facilities located on private property. A process of providing information to potential future and existing property owners is required. A formal program to provide initial and ongoing public education for property owners and developers should be in place to provide support to the public and to demonstrate the benefits of the systems and their maintenance.

4. LAND USE GOVERNANCE

Land Use Governance carries with it a responsibility to protect the public, their property, and the environment. Future development within the Saratoga Miracle Beach Area has the potential to adversely increase flood risks and result in the adverse damage to aquatic and riparian habitat. The potential impacts can be mitigated with the control of stormwater discharge rates and volumes combined with protection of the riparian areas along the stream and within wetlands.

Reduction of the potential impacts resulting from ongoing development within the study area will require a new way of managing the development process and in educating both staff and the public which includes developers and their engineers. Adopting new methods and processes is not a new concept as history shows us that we adapt as we acquire new knowledge of risk and adverse impacts in the process of occupying and altering the landscape to suit new uses and for human occupation.

Stormwater management has evolved into rainwater management with new knowledge of our impacts upon the environment and of the increased flood risks associated with previous land drainage practices. The regulated requirements have been revised in the past and will continue to be revised in the future. The CVRD and MOTI have an opportunity to preserve the natural environmental assets and to prevent increased risks of flooding within the study area by adopting standards that are consistent with those of other jurisdictions and that are in compliance with the stated objectives of both organizations.

The design of the portions of the drainage which include conveyance capacity would be completed by using existing established methods and would be subject to the standards as applied before completion of this Master Drainage Plan. Only those parts of the rainwater management system intended to provide volume and rate control would be subject to new design standards and processes. The rainwater volume control measures could be designed with the use of the Water Balance Express; whether they are located on-site or within the road R-O-W. Access to the tool is through a web page located at http://comox.waterbalance-express.ca/.

The neighbourhood retention ponds would be sized to contain the watershed target volume while releasing the allowable discharge rates with no additional analysis.

Mitigation of the potential impacts will result in infrastructure constructed on both private and public lands. Thus there will be both public and private infrastructure designed and constructed during future development undertaken as part of both subdivision and building permit processes. This will result in ownership, operation, and maintenance being the responsibility of both the CVRD and the private property owners. This will require new administrative processes at both the CVRD and at MOTI to ensure that the objectives of this drainage plan are achieved:

1. MOTI would enforce compliance of the design guidelines during subdivision development; and
2. The CVRD would enforce compliance during the building permit process.

Subsequent to construction the infrastructure will require operation, maintenance and possibly replacement as the systems age. A funding process will be required to ensure ongoing funding to support the operation, maintenance, and replacement activities associated with the infrastructure. This can be accomplished through creation of a Local Service Area for Stormwater and Drainage under the authority derived from the British Columbia Local Services Act. A precedent for this has been set with the establishment of the Black Creek/Oyster Bay fire protection local service area.

Establishing a Local Service Area for drainage and stormwater management would be initiated with the first development and can be expanded with each subsequent development, whether a subdivision or other type of development. The funding is through an annual parcel tax based upon the costs to operate and maintain the stormwater and drainage infrastructure. In this way any future costs can be recovered by the users of the system without affecting the budgets of the CVRD.

An initial and ongoing education and training program will be needed to provide training to property owners, and the staff of both the CVRD and MOTI with regards to the details of design and requirements for operation and maintenance.

5. CORPORATE AUTHORIZATION

This document entitled:

Saratoga Miracle Beach Area
Master Drainage Plan

Client Name:

Comox Valley Regional District

Was prepared by:

J.M.K. (Jim) Dumont, P.Eng.

It is intended solely for the use of the Comox Valley Regional District for which this document was prepared, and for the purposes and within the limitations stated in the document. The material in this report reflects the best judgement of J.M.K. (Jim) Dumont, P.Eng. in the light of the information available at the time of preparation. Any use of, or reliance placed upon, the material contained in this report by third parties, or decisions based upon this report are the sole responsibility of those third parties. J.M.K. (Jim) Dumont, P.Eng. accepts no responsibility for damages suffered by any third parties as a result of decisions made, or actions taken, based upon information contained within this report. Duplication or distribution of this report or any portion hereof is forbidden and requires approval from the client and J.M.K. (Jim) Dumont, P.Eng.

Dec 17, 2019

Saratoga Miracle Beach Area Master Drainage Plan

Volume 2 – Technical Report

Comox Valley Regional District

Presented to:

Alana Mullaly, MCIP RPP
Manager of Planning Services, Planning and Development Services Branch
Comox Valley Regional District
600 Comox Road,
Courtenay, BC V9N 3P6

Revised
17 December 2019

LIST OF FIGURES

LIST OF TABLES

This report has been reissued on December 17, 2019 to allow correction of errors in

- Table 3.1,
- Table 3.2,
- Table 3.3, and
- Text describing capacity of road crossings in Section 3.5.

1. INTRODUCTION

Mr. Jim Dumont has been retained by the Comox Valley Regional District (CVRD) to undertake a study of the resources associated with the surface water features within the Saratoga Miracle Beach Local Area Plan. The purpose of the study is to identify the natural assets within the area and to create a framework that can be applied to future land use decisions to protect these assets.

The stream corridors comprised of both the aquatic and riparian areas form a vibrant ecological asset within the CVRD that is often overlooked by the public and developers. The stream corridors provide habitat for wildlife in addition to flood attenuation, and conveyance of runoff from the watershed. Development has been found to have an adverse impact upon the integrity of stream corridors by increasing the rates and volumes of watershed runoff. The impacts are manifested in increased stream erosion, increased flooding and loss of both aquatic and riparian habitat. Key to managing and eliminating the future impacts is to establish standards and criteria specific to the watershed for future subdivision and construction associated with changes in land cover. It is clear that preservation of the environmental values of these assets will also protect people and property from increased flood damage and the effects of steam erosion. The study has established reasonable, and cost-effective measures that can be applied to preserve and to protect both the public and properties within the Saratoga Miracle Beach Local Area Plan.

The study has built upon the knowledge of the area held within the CVRD GIS database and provided in previous studies. Thus, allowing us to use previously gathered data and analyses while minimizing the cost of the work preparing the Drainage Plan. The previous plans and studies include:

- Saratoga Beach Estates reports and information;
- Establish Water Balance Targets for Water Balance Express, J. Dumont, 2016; and
- Saratoga-Miracle Beach Local Area Brief Environmental Inventory, Current Environmental, October 31, 2017.

The reporting for this study includes two volumes; **Volume 1 - Summary Report** and this **Volume 2 - Technical Report**. Volume 1 contains a subset of information created during the course of the study while greater detail is provided in Volume 2. Any decisions regarding the development in the study area and any designs for developments will utilize the full information and recommendations contained in the Volume 2- Technical Report.

Study Area

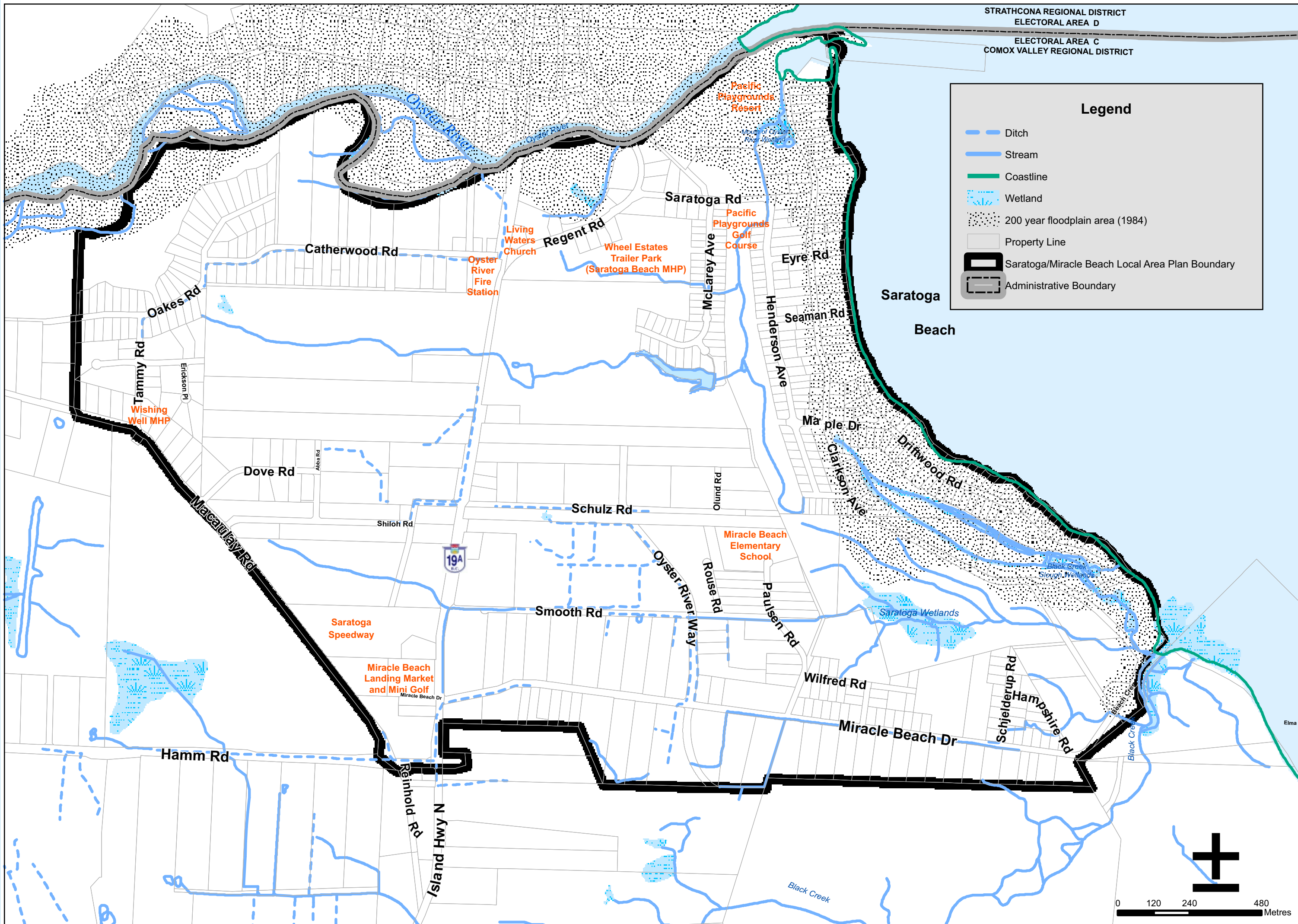
The study area lies within the CVRD as illustrated on **Figure 1-1** as supplied by the CVRD. This area has been identified on Map 3 of Appendix A, "Rural Comox Valley Official Community Plan Bylaw No. 337, 2014" as a Settlement Node where future development will be concentrated in a mixture of land uses and densities. Revisions to the existing land uses will be made through the defined processes of the CVRD. Of particular note there are no areas specifically designated for preservation in their natural state and that all of the land is subject to alteration of the surface conditions.

1.1 Scope of Analysis

The scope of this study creates a Drainage Plan that has several clear and definable deliverables that includes:

1. Identify the water courses and the natural function they provide within the study area.
2. Define the pre-development hydrologic conditions, discharge rates, volumes, and flow durations for adjacent properties with some development potential. Recommendations for the preservation of key assets in their natural state.
3. Develop area specific performance standards and design criteria for future development that ensure surface flow, interflow and groundwater flow maintain or mimic the natural hydrologic regime.
4. Make recommendations for on-site, and off-site, specific works that should be made by the qualified professional and land owner at the time of subdivision, development, or building applications being made. These works would be designed using the criteria referenced above to ensure pre-development conditions are maintained.
5. Identify the opportunities and constraints for future development which can be used to inform land use designations and environmental setbacks for the area.
6. Clarify and document how to avoid changing the drainage system so that adverse impacts are not created within the area.
7. Make recommendations on how these proposed mitigation measures may be implemented, required, enforced, and maintained into the future.

Comox Valley
REGIONAL DISTRICT



Saratoga Miracle Beach Area Drainage Plan Study Area

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Figure 1-1
Study Area
Saratoga Miracle Beach Area Drainage Plan

2. BACKGROUND INFORMATION

A minimum amount of information is required to undertake the watershed assessment and to formulate a drainage plan that would identify the natural assets within the area and to create a framework that can be applied to future land use decisions to protect these assets. The topics discussed in this background section includes:

1. Drainage design standards;
2. Groundwater studies;
3. Stormwater management;
4. Advances in rainwater management;
5. Watershed hydrology;
6. Vegetation zones; and
7. Surface soils.

2.1 Drainage Design Standards

Drainage standards often use and refer to a "Return Period" that is used to determine the capacity of, or level of flood protection provided by drainage works. Commonly a return period event is selected where the return period is the inverse of the probability of occurrence. In simple terms the 5 year return period event has a 20 percent probability of occurring in any given year. A 100 year return period event would have a 1 percent probability of occurring in any given year. In even simpler terms it would be reasonable to expect that a 5 year return period event would occur in any given 5 year period. The intent of applying a probability or return period is to provide rational for the size and cost of stormwater management facilities.

Drainage design within the CVRD is governed by the requirements of the BC Ministry of Transportation and Infrastructure. The processes and requirements for Rural Subdivision Approvals is documented by the Province of British Columbia, Ministry of Transportation and Infrastructure on their web site located at http://www.th.gov.bc.ca/DA/L3_min_trans.asp.

The topic of drainage is described on the MOTI web page http://www.th.gov.bc.ca/permits/Environmental%20Requirements.asp#Drainage. The information provided includes the following.

"*The highway drainage system is for the protection of the provincial highway right-of-way. It is not designed or intended to serve the drainage requirements of abutting properties beyond that which has historically flowed to the provincial right-of-way.*

Drainage to the provincial highway right-of-way will not be permitted to exceed the undeveloped historical flow. Instead, use controlled flow detention ponds to control the flow from developed properties. When the development requires curbs and gutters, you can eliminate the drainage ditch by installing *a storm sewer system. The Ministry shall determine the appropriate drainage controls necessary to meet existing or projected site-specific conditions.*

Ministry staff may find that the site requires a drainage study by a qualified engineer registered in British Columbia. The type, design, and condition of drainage structures must meet the approval of the Ministry of Transportation in unincorporated areas and the local government and the Ministry in incorporated areas. Ministry drainage design and specifications requirements are outlined in Section 1010 of the BC Supplement to TAC Geometric Guide and Standard Specifications for Highway Construction."

The BC Supplement to TAC Geometric Guide and Standard Specifications for Highway Construction and the specific drainage section can be found at this MOTI web site https://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/highway-design-survey/tac-bc

The drainage section of the BC Supplement to the TAC Guide can be found at this MOTI web page https://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/highway-design-and-survey/tac/tac-2007-supplement/ch1000-2007.pdf

Excerpts from the Design Guide include the following

1. *This chapter is not intended to be a textbook of hydraulic engineering but a reference book of guidelines and instructions. It does not cover all conceivable problems that might arise or address all of the possible methodologies. The scope of the chapter is limited to relatively simple hydrology and hydraulics.* Page 1010-1.

2. *All drainage systems must include run-off controls to limit post-development peak discharge rates to the predevelopment rates for 5 year return period storms.* Page 1010-2*.*

3. *An additional Ministry requirement is an assessment of the receiving ditch or watercourse for peak flows greater than a 5 year return period up to a 100 year return period. The assessment must document the net change in water velocity in the ditch or receiving water, identify any potential impacts from increased peak flows, and make recommendations for mitigation. In other words, flows must be managed to ensure that no increase in flooding and stream erosion occur as a result of development storm drainage.* Page 1010-2*.*

4. *Proposed works for a development should be designed using the following criteria:*
    - *an increase in downstream flooding or stream erosion will not be allowed. Designs will achieve this requirement unless it can be demonstrated that these changes do not adversely impact property or the environment;*
    - *a hydrograph method shall be used to calculate design run-off volumes;*
    - *un-attenuated flood waters in excess of the 5 year discharge that by-pass the detention facility must not adversely affect the receiving ditch or channel. Documentation of this assessment is required for all projects.* Page 1010-3.

5. *In areas where a Master Drainage Plan has been developed, all subsequent drainage designs should conform to the plan.* Page 1010-3.

The criteria noted in the second bullet of point 4 above directly contradicts the statement in point 2 above. While the more general statement in point 4 referring to flood protection can be violated if the limits of post development flow control only applies to rates of up to a 5 year event. In order to provide flood protection to a standard more often expected by the public the criteria would need to be increased to a 100 year event. This higher standard is required in many jurisdictions, both within and outside of British Columbia.

Based upon the text of the Guideline I believe that intent of MOTI is to protect the residents, property and the environment from the impacts of development and that innovative methods may be required to achieve these objectives.

The standard for drainage infrastructure applied by MOTI when reviewing and approving designs for construction is listed in **Table 2.1** as extracted from the drainage section of the BC Supplement to the TAC Guide.

Table 2.1 – Design Return Periods for Hydraulic Structures (years)

Road Classification Hydraulic Structure	Low Volume	Local	Collector	Arterial	Freeway
Gutters	-	5	5	5	5
Stormwater Inlets	-	5	5	5	5
Storm Sewers	-	10 to 25	10 to 25	10 to 25	10 to 25
Highway Ditches	10 to 25	10 to 25	10 to 25	10 to 25	10 to 25
Culvers < 3m Span[1]	50 to 100	50 to 100	100	100	100
Buried Structures and Culverts ≥ 3m Span[2]	100	200	200	200	200
Bridges[2]	200	200	200	200	200
River Training and Channel Control Works	100	200	200	200	200

[1] For drainage areas less than 10 ha, the 10-year return period storm can be used

[2] Design shall be in accordance with BC MoT Bridge Standards and Procedures Manual

The design standards for hydraulic structures anticipates that there will be storms, or flood events, that exceed the capacity of the structures. Such an event will lead to flooding with the associated risk to people and property.

In developed areas more generally accepted practice is to adopt a standard that includes a minor and major drainage components. The minor system is designed to accommodate a smaller return period such as a 5 year event. Any flood events, or storms, in excess of this would be routed through a major drainage system. In an urban area the minor system would typically be the storm sewer while the major system would be overland flow routes along the roads. In a rural area the ditches would be sized to contain the 5 year event and the 100 year event would overflow the ditch and follow the roadway. In all cases the subdivision design must include both the minor and major system to minimize the potential risk to people and property.

I recommend adoption of a standard that would minimize the risk to people and property during flood events, or storms, of up to the 100 year return period. This recommendation would comply with the intent as expressed by MOTI in point 4 above. Adoption of this standard is consistent with the criteria used by the City of Nanaimo in their *Manual of Engineering Standards and Specifications, Edition No. 11* of November 2016 and those proposed for the City of Courtenay in their draft *Subdivision and Development Servicing Bylaw 2919*.

2.2 Groundwater Studies

Two studies have been undertaken for the CVRD to investigate groundwater conditions within the immediate area. These include:

1. Black Creek/Oyster Bay groundwater asset characterization, and
2. 2015 Saratoga Beach – Puntledge Black Creek (Area ‘C’) – Groundwater Monitoring Program.

2.2.1 Black Creek/Oyster Bay Groundwater Asset Characterization

A study was undertaken to establish the potential ground water supply for future developments within the area due to observed declines in the production of water from the existing water supply wells. The water levels associated with the aquifers was reported to be approximately 5.0 m below the ground surface (page 6 of 28 of that report).

The study determined that the producing aquifer was not directly connected to the Oyster River, rather the pump yield and recovery of the aquifer were only slightly affected by the discharge in the river. This leads us to conclude that the aquifer is largely independent of the surface water in the watershed and that interflow, rather than aquifer discharge, is a largest contributor in sustaining stream flow in the small headwater streams within the study area. A description of these processes is included in **Section 2.7**.

2.2.2 2015 Saratoga Beach – Puntledge Black Creek (Area 'C') – Groundwater Monitoring Program.

A study was undertaken to evaluate the performance of onsite treatment systems in the Saratoga Beach settlement node based on the quality of the groundwater. Currently, wastewater in the Saratoga Beach area is managed by onsite sewerage systems, including residential septic systems and a few communal or cluster sewage systems.

The study found the surficial geology is dominated by a sandy glacio-marine deposits overlying glacial till at higher elevations. Shallow test holes were used to observe the water table at levels approximately 0.35 to 1.40 m below ground surface. The study concluded that failure of on-site sewage treatment systems are probably linked to higher density, shallow groundwater levels and age of the system. The recommendations included options to manage future sewage system while accommodating increased development, smaller lots, and shallow groundwater. This leads us to conclude that the water supply aquifer is independent of the shallow groundwater that would be impacted by onsite treatment systems in the watershed.

2.3 Stormwater Management

There are multiple risks to the CVRD that result from development, these include:

1. **Increased flood risks** in downstream reaches;
2. **Aquatic habitat damage** and the loss of fisheries resources;
3. **Increased stream erosion** and property damage; and
4. **Costs** associated with flood damage and repairs to eroded streams.

Rainwater management in a mixed rural and urban area must include the goal of mitigating adverse impacts which would result from drainage improvements and urban development. Achieving this goal involves application of **standard engineering analysis and methodologies** combined with **typical design techniques** in an **innovative manner**. Therefore all the assessments, analyses, and recommendations are a result of well documented standards of engineering practice.

2.3.1 Increased Downstream Flooding

As rural land is undergoing development, drainage works are created which direct any surface runoff more quickly to the receiving stream. Additionally there is an increase in impervious areas such as roads, buildings, driveways, sidewalks, etc., and in the number of directly connected methods of drainage, such as ditches, sewers and roadways which results in an increase in runoff. These factors combine to yield higher volumes of surface runoff volumes and greater flow rates as compared to predevelopment conditions.

In a conventional drainage system either the downstream system is enlarged to accommodate additional discharges, or new systems to convey the stormwater runoff are constructed to accommodate development. As an alternative, storage in the form of stormwater detention facilities, are frequently utilized to control the rate of stormwater runoff so that the peak flows discharging from the development do not exceed acceptable predevelopment flow rates in the downstream receiving drainage system for a given return period event.

If the post development discharge rates are not restricted then there is an increase in the risk of flooding and its associated damages to properties in a downstream direction from the development. This increased risk is attributable to both property and life of people in the affected areas. It is critical that the predevelopment rates of discharge be maintained to prevent increases in flooding. The generally accepted flood protection in British Columbia includes:

- for streams and rivers the 1 in 200 year return period event (Q_{200}); or
- the 1 in 100 year return period event (Q_{100}) in urban areas.

The standard design practice in municipal infrastructure design in British Columbia utilizes a somewhat different standard for drainage system design with a primary intent to prevent post development discharges from exceeding predevelopment rates over a wider range of return periods from a 2 to 100 year events (Q_2 to Q_{100}).

The MOTI design guidelines indicate that consideration must be given to the potential of increases in the magnitude of downstream floods and the potential to increase downstream erosion. Every development must adequately address these issues as part of the planning and design of the project.

2.3.2 Aquatic Habitat Damage

A portion of the following section has been previously included within the document "Establish Water Balance Targets for Water Balance Express, May 2, 2016" as prepared for the CVRD. I understand that the previous report it not readily available to the public so some of the contents are reproduced herein.

Research presented in "*Watershed Determinants in Ecosystem Functioning*", Horner, et, al, 1996 documented the impacts of urban development upon the aquatic environment with some very interesting findings. They reported that the impacts from urban development fell into four different categories with the effects from highest to lowest being:

1. Changes in hydrology;
2. Disturbance to riparian corridor;

3. Degradation of in-stream habitat; and
4. Deterioration of water quality.

The importance of the total imperviousness of a watershed was identified as shown on **Figure 2-1** which indicates an impact with as little as 10% impervious area. The impact increased significantly beyond that value with an identified critical value of 30% being the upper limit to support a population of cold water fish species.

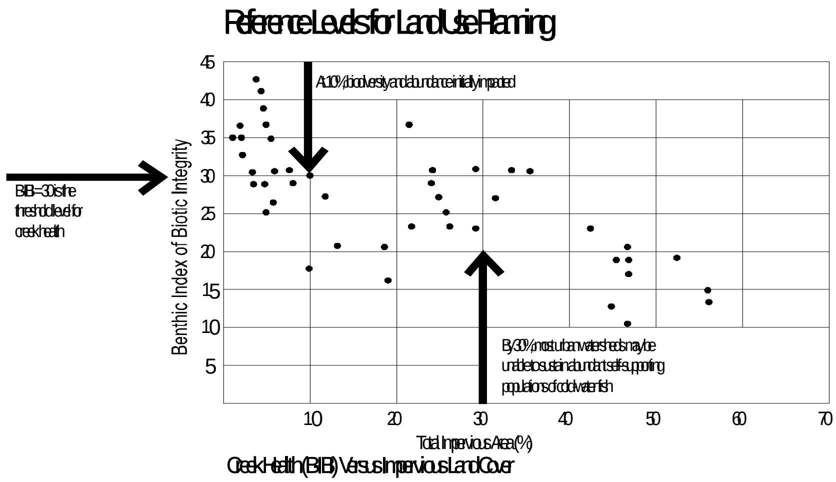


Figure 2-1 Stream Health versus Impervious Cover

The next findings that were presented included the impacts upon water quality that derive from urban development as shown on **Figure 2-2**. The acute and chronic toxicity levels of pollutants in the stream becomes a factor for cold water fish species only after an imperviousness of 60% is reached. Therefore water quality would only be an issue long after the other effects of development had eliminated the cold water fish species from the stream.

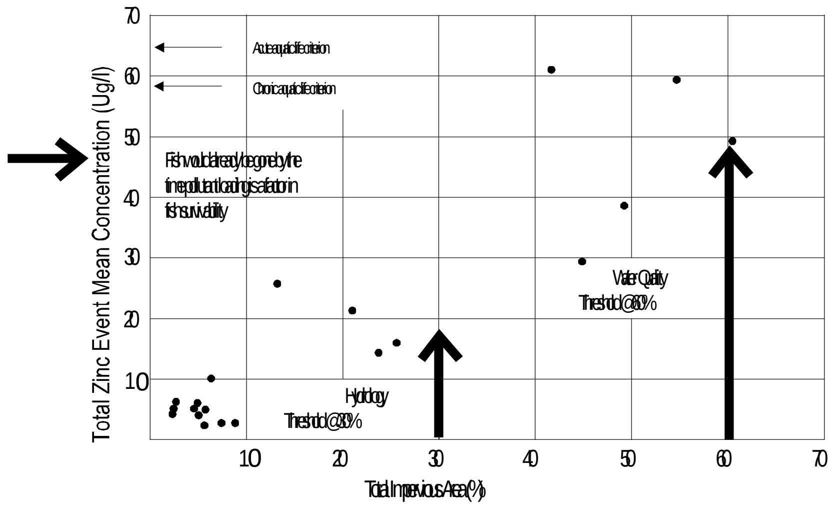


Figure 2-2 Water Quality versus Impervious Cover

The conclusion of this information is that the impacts to the stream hydrology and aquatic habitat of development must be mitigated in order to allow healthy populations of cold water fish species which include all species of salmonids.

2.3.3 Increased Erosion

The increased erosion in the streams is an impact of development that relates to the changes in hydrology which include greater rates and volumes of discharge in the stream. A traditional engineering approach to prevent increased stream erosion has been to limit post development discharge rates to those occurring from predevelopment conditions. That approach also generally assumes that a 2 or 5 year return period event (Q_2 or a Q_5) rate of discharge would not result in stream erosion. Both of these assumptions can be shown to be incorrect. Both the discharge rates and the flow durations when combined are the critical factors in stream erosion. Two excellent references include:

- "*Experience from Morphological Research on Canadian Streams*" MacRae, ASCE, 1997"
- "*Vulnerability of Natural Watercourses to Erosion Due to Different Flow Rates*", Lorent, Ministry of Natural Resources of Ontario, 1982

The erosion in streams has been found to be a related to the duration of discharge above critical threshold values rather than simply the discharge rate. Further the threshold discharges are less than commonly accepted Q_2 or Q_5 events. Therefore an increase in erosion can be avoided if both the duration and flow and the rates of discharge are maintained following urban development.

2.3.4 Increased Costs

Increased costs associated with stream erosion induced by development have long been documented. A very recent example can be found in the Town of Comox where Brooklyn Creek has experienced increased erosion due to upstream development. The eroded material accumulated in the lower reaches of the stream with the result being a reduced stream capacity and increases in flood levels. An extensive and very expensive rehabilitation program has been undertaken to protect properties from eroding stream banks and increased flood damages. These high costs of the stream rehabilitation were unexpected.

2.4 Advances in Rainwater Management

Over the past decades the understanding of stormwater management has evolved to address unanticipated impacts. The evolution of stormwater management techniques has not been universally applied in all regions with some jurisdictions adopting advances while other jurisdictions have not participated in the adoption of the evolving methods of managing stormwater. The east coast of Vancouver Island and the CVRD specifically has been one of the regions where stormwater management has been largely ignored.

The evolution of stormwater management has taken many steps. For example prior to the 1970’s the drainage objective was to quickly dispose of stormwater to prevent local flooding and to allow the local area to dry and become usable. The unintended consequences has resulted in flooding of other properties in downstream areas and the increased risk to people and property. To address that measurable impact detention ponds were created to attenuate the rate of post development discharge to predevelopment rates so as to reduce the increases in downstream flooding. Most of the design standards applied within British Columbia now include a requirement for managing discharge rates through the construction of detention ponds.

During the 1980’s and 1990’s observation and research indicated that while the creation of detention ponds could reduce the risk of flooding an unintended consequence was that they actually increased stream erosion and led to the destruction of aquatic habitat. Where erosion increased then property was lost and in areas where sediment was deposited flooding was increased. An example of this can be seen in Brooklyn Creek which drains a portion of the CVRD, City of Courtenay, and the Town of Comox.

Since approximately 2000 the evolution of stormwater management has focussed upon reducing the volume of discharge so as to reduce the duration of discharges that result in the increases in stream erosion.

The following discussion provides a description of the evolution of the concept of stormwater volume control as it has evolved. This will allow the CVRD to take advantage of the latest scientific knowledge and practices when creating the requirements for stormwater management within the CVRD.

In **2002** the Province published the **Stormwater Planning a Guidebook for British Columbia** in which the principles retain, detain, and convey were introduced. Rainwater is to be retained on site, any excess would be detained to provide flood protection and for very large storms a safe conveyance system is required. The details of the concept for retention included the volume of rainfall representing one half (½) of a Mean Annual Storm (MAS) with infiltration of this volume over a period of twenty-four (24) hours. The basis for these recommendations was a qualitative assessment linking stream health to the volume of runoff as a proportion of total precipitation. No quantitative analyses of streams or watersheds were undertaken to support the assumption linking retention volumes and stream health.

In **2012** MetroVancouver published the **Stormwater Source Control Design Guidelines** which built upon the assumptions of the Guidebook. The Guideline recommended increasing the retention volume to 0.72 MAS up from the ½ MAS of the Guidebook however no quantitative analyses of stream discharge or condition were provided. Included within the Guideline document were a series of charts (beginning with Figure B-4 within that document) that indicate where subsurface conditions include soils with infiltration rates less than 5 millimetres per hour (mm/hr) there may be difficulty in achieving the disposal requirements and that a baseflow discharge with a rate of 0.25 L/s/ha would be required to drain the constructed infiltration systems within the required 24 hour period. This was due to the insufficient infiltration capacity that would require an infiltration area larger than the project site as water does not infiltrate that quickly in these soils. With hindsight it is obvious that the infiltration capacity is a function of the watershed and that physical constraints must be balanced with requirement to retain rainwater on site. An extension of that observation is that the rainwater management targets should be based upon the conditions within the watershed and not directly tied to a prescriptive approach to retaining a fixed quantity of precipitation.

In **2015** MetroVancouver published the **Options for a Region-Wide Baseline for On-Site Rainwater Management** which was intended to provide guidance for areas that were not included in the Integrated Stormwater Management Plans (ISMP's) within the region. This Baseline document expanded upon the work completed in the Guideline and through analysis of rainwater retention. The site retention volume was revised back to 0.5 MAS and the retention volume drain time was increased to 48 hours. The baseflow release was formalized for all areas and set at a rate of 0.25 L/s/ha. Again no quantitative analyses of streams or watersheds were undertaken to support the assumption linking retention volumes and stream health.

In a separate process the **City of Surrey** undertook the **Fergus Creek ISMP** and in **2004** the analytic methods of assessing the watershed using stream flow duration to provide a measure of stream erosion, habitat degradation, and sediment transport was initiated. This was an extension of the designs of the initial phases of development in the **East Clayton Neighbourhood** in

2001 where it was found that the retention of a prescriptive quantity of rainfall would not provide a benefit to the receiving stream. The Fergus Creek ISMP provided a quantitative link between retention volumes, stream habitat, erosion potential, water quality, and flood prevention which resulted in establishing the size and operating parameters for stormwater retention systems within the watershed. The leap in understanding the analyses needed to define the hydrologic functions of a watershed ultimately led to the **Water Balance Methodology**.

The Water Balance Methodology was showcased in **2014** in the Partnership for Water Sustainability in BC publication **Primer on Water Balance Methodology for Protecting Watershed Health** provided details on the analytical methods which were established to demonstrate the impacts of urban development upon a stream and to demonstrate the effectiveness of alternative mitigation methods. The Methodology includes a stream flow duration which directly links to aquatic habitat, potential stream erosion and sediment transport. Key components of the Water Balance Methodology include precipitation, infiltration, interflow and aquifer flows combined with the duration of flow in a stream to manage aquatic habitat, stream erosion, reduction of flood risks and improvement of water quality. The calibrated continuous simulation models can assess the imposition of urban development and establish the size of mitigation methods to provide the most cost effective tools to manage stream and watershed health. The results of applying the Water Balance Methodology has led us to conclude that the impacts to a stream increase with imperviousness in a watershed and that the sizing of mitigation works should also increase with imperviousness. Further, development greatly impairs the function of the subsurface interflow system and directing extra water to the aquifers can lead to unintended consequences. This has led to establishing a set of three watershed targets that will allow streamflow to be maintained while not increasing flood risks. These watershed targets include a **volume** to be retained and detained, a **baseflow** release rate to augment streamflow without increasing flood risks, and an **area** of infiltration so as to maintain the natural rate of aquifer recharge.

In an interesting parallel process the **Washington Department of Ecology** introduced the Western Washington Hydrologic Model (WWHM) in **2001**. This model was applicable to the detailed analysis of watersheds and streams using the development and watershed flow duration as a measure in defining the works necessary to mitigate the impacts of urban development. In **2012** the Western Washington Stormwater Manual was released which **mandates the use of the WWHM for new developments** as a requirement of meeting the commitments under the National Pollutant Discharge Elimination System (NPDES) permitting process. The specific requirement is stated as "*Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow*." In Washington the developer and their engineer use the WWHM to establish the required mitigation works and how they would be utilized within the development.

In 2008 the **Oregon Department of Transportation** adopted a flow duration criteria for their projects. They stated: "*ODOT re-evaluated the water quantity design storm that had been used for hydrologic modification of highway runoff. Approaches based solely on peak discharge control (e.g., using detention facilities) are not adequate to address the range of impacts associated with urban runoff, including stream channel stability, because detention ponds can discharge at flow rates near the peak discharge for much longer times than in the predevelopment state. Regardless of a detention facility's ability to limit or reduce the peak discharge runoff from a given site, the overall runoff volume will more than likely increase compared to pre-project conditions, no matter the size of the project (impervious area). This increased volume released over a longer period of time may contribute to stream bed and bank impacts to the receiving stream. Therefore, the new ODOT water quantity design storm performance standard is for no increase in sediment transporting flows over a defined range of flows. That is, the performance standard would meet the goal of matching pre-project hydrology from a defined low discharge, high-frequency event to a defined high discharge, low-frequency event*".

The **California State Water Resources Board** has initiated in **2015**, a program to halt stream degradation. They have made the following statement "*Changes in flow and sediment loads to streams and other watercourses can result in significant and long-standing impacts to beneficial uses of our waters. These changes are collectively referred to as "hydromodification." The Water Boards have teamed with some of the nation's top scientists to devise ground breaking ways to effectively and efficiently measure and control the impacts associated with hydromodification.*" To mitigate the effects of hydromodification they now mandate a flow duration analysis and require developments to meet stringent standards to demonstrate no adverse changes occur as a result of development as part of the NDPES Permitting process. The state has created a computer model that will be applied by developers and their engineers to design the required mitigation works and how they would be utilized within the development. The use of flow duration is fundamental to the analyses and in measuring the success of the proposed on-site mitigation works within each development.

2.5 Watershed Hydrology

When assessing and creating a drainage plan an understanding of the hydrologic operation of a watershed is essential. The ideal situation would occur when there are records of both streamflow and climate within the watershed. As there are no climate or streamflow recording stations within the study area examination of available data is necessary to establish an expectation as to the hydrologic operation of the study area and to validate any hydrologic calculations completed as part of any design.

2.5.1 Climate Records

Evaluation of the hydrologic response of different watersheds, particularly on a regional basis assumes that the climate across the regions is relatively uniform. To verify climate uniformity and specifically the precipitation component a comparison of climate station records has been undertaken. A short list of acceptable climate stations was established using this following selection criteria:

- Located on the eastern side of southern Vancouver Island;
- included in the Environment Canada Climate Normals summaries;
- published Environment Canada Intensity Duration Frequency (IDF) data; and
- minimum of 20 years of Environment Canada archived hourly records for rainfall and temperature and daily precipitation used to derive snowfall contribution.

The location of the four Environment Canada climate stations shown on **Figure 2-3** were found which met the selection criteria, these being:

- Campbell River Airport;
- Comox Airport;
- Nanaimo Airport; and
- Victoria International Airport.

A comparison of the annual normal precipitation and the 24 hour rainfall volumes for a range of return periods is provided in **Table 2.1**.

Table 2.2 – Precipitation Data (mm)

Climate Station	24 Hour Rainfall Volume (mm) Return Period (Years)						Average Annual Precipitation (mm)
	100	50	25	10	5	2	
Campbell River	101.9	94.7	87.5	77.7	70.0	58.3	1,451.5
Comox	117.2	107.6	97.9	84.8	74.4	58.8	1,179.0
Nanaimo	113.0	104.0	94.8	82.5	72.7	57.9	1,162.7
Victoria	120.2	109.1	98.0	83.0	71.2	53.2	883.3

As can be seen the all of the climate stations have similar 24 hour rainfall volumes for the respective return periods. The Comox and the Nanaimo climate stations have very similar annual precipitation volumes. While Campbell River sees greater annual volumes and Victoria has less annual precipitation. The variability in the IDF Curve amounts of rainfall is relatively small, however the annual total precipitation for Victoria significantly less. Given the recorded data the precipitation across the region extending from Nanaimo through Comox is relatively uniform and the response of similar watersheds within that region can be expected to be relatively uniform.

Comox Valley
REGIONAL DISTRICT

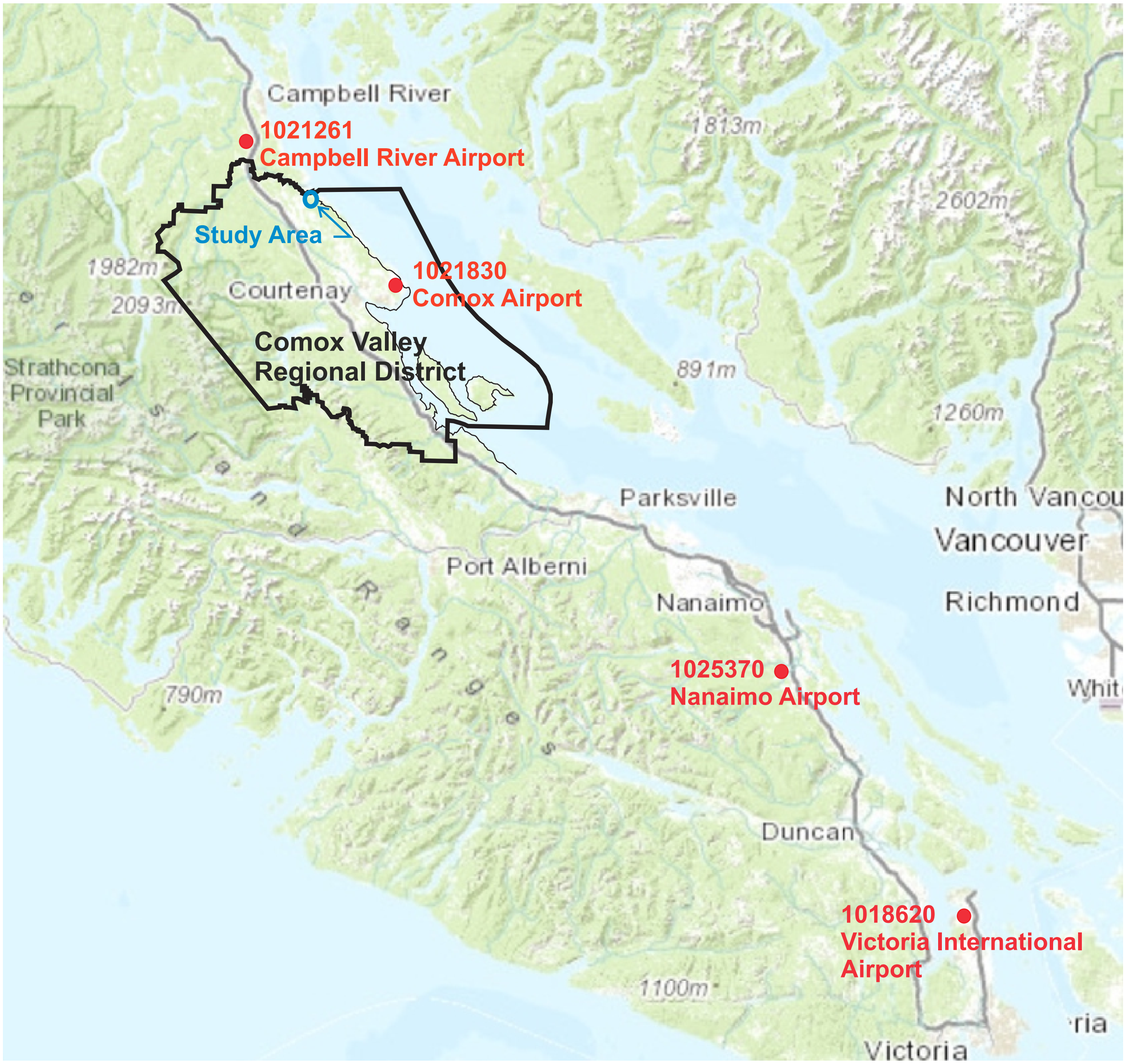


Figure 2-3
Climate Stations
Saratoga Miracle Beach Area
Master Drainage Plan

In this region there is a variation of precipitation with elevation with greater precipitation amounts occurring at higher elevations. The climate stations are located in the lower portions of the region and climate records would be representative of settled portions of the region. As discussed in the Section 2.5 the elevation of 400 m appears to be critical in differentiating climatic zones and differentiating watersheds.

2.5.2 Streamflow Records

Recorded streamflow is absent from the study area and therefore suitable streams with recorded flows must be identified. The selection of a potential list of streams for consideration a selection criteria has been established which includes the following:

- Located on the eastern side of southern Vancouver Island;
- Minimum of 10 years of continuous records which include annual maximum of both mean daily and peak daily discharges;
- Unregulated discharges; and
- Watersheds did not contain lakes which could attenuate peak discharges.

A total of nine (9) streams were found which met these criteria and a comparison of their recorded stream flow records was undertaken to identify watersheds which may be representative of the study area. The location of the watersheds for which a suitable duration of stream flow records with both daily and instantaneous discharge measurements and that had a recording period which overlapped the climate data were available are shown on **Figure 2-4**. The results of the statistical analysis of the flood magnitutes are shown in **Table 2.2**.

Table 2.3 – Flood Discharges (L/s/ha)

Stream Gauging Station		Return Period Years								Area (km^2)
		200	100	50	25	10	5	3	2	
08HD011	Oyster River	12.1	11.9	11.5	11.1	10.2	9.2	8.2	7.0	302
08HB075	Dove Creek	16.7	16.5	16.3	15.9	15.0	14.0	12.7	11.2	41
08HA016	Bings Creek	17.1	16.3	15.4	14.3	12.4	10.7	9.0	7.4	16
08HA003	Koksilah River	18.0	17.7	17.1	16.5	15.2	13.7	12.1	10.4	209
08HA001	Chemainus River	22.3	21.0	19.5	17.9	15.5	13.4	11.5	9.6	355
08HB074	Cruickshank River	22.4	22.0	21.5	20.8	19.2	17.4	15.3	13.0	213
08HB002	Englishman River	23.3	22.0	20.5	18.8	16.3	13.9	11.8	9.8	319
08HB025	Browns River	41.1	36.7	32.5	28.5	23.2	19.2	16.1	13.4	88
08HB024	Tsable River	51.3	47.5	43.9	39.2	32.9	27.5	23.0	18.8	113

As indicated in the discussion on climate records the amount of precipitation increases with elevation and may have an effect on the stream discharges where watersheds have a larger proportion of area at higher elevations.

Comox Valley REGIONAL DISTRICT

Figure 2-4
East Vancouver Island Watersheds
Saratoga Miracle Beach Area
Master Drainage Plan

Examination of the results of the flood frequency analysis indicates that there is a range of values with a trend to greater discharge rates for flood events when the watershed has a greater proportion of area at high elevation. For example the Cruickshank, Tsable, and Englishman Rivers have a high proportion of area at high elevations and have a relatively larger flood discharge. As discussed in the next section the elevation of 400 m appears to be critical in differentiating climatic zones and differentiating watersheds.

Another observation is that for watersheds that are primarily at lower elevations the smaller flood events are relatively smaller. For example the Bings Creek, Oyster River and Chemainus Rivers have relatively reduced flood discharges for smaller events.

Given the relative size and location of the study are it would be appropriate to utilize the results of Dove Creek as being representative of the expected hydrologic operation of the watershed within the study area.

2.6 Vegetation Zonation

Information in this section of this report has been derived from the *Soils of Southern Vancouver Island*, MOE Technical Report 17, J.R. Jungen, P.Ag., B.C. Ministry of Environment, August 1985. The study area corresponds to the area examined in that report. I have extracted and summarized the following technical information directly from that report.

The major characteristic of the vegetation region is that it is dominated by the rain shadow effect of descending air on the leeward side of the Vancouver Island Range. The vegetation in the area has a vertical sequence of climax vegetation communities. The Saratoga Miracle Beach Area lies in the **Coastal Grand Fir - Western Red Cedar Zone** which occurs from sea level to about 300 m elevation and is restricted to a narrow strip along the east coast of Vancouver Island. It is characterized by a forest of grand fir and western red cedar on deep, well drained sites. In response to frequent disturbance, coast Douglas-fir is the predominant seral species found on most sites. Broad-leaved tree species such as Pacific madronne, Garry oak, and bigleaf maple are also common on some sites.

2.7 Groundwater Flow

Provision of this information is important in this context as the information provided by the two hydrogeology reports noted earlier in **Section 2.2** provided different information as to the levels of the groundwater table.

The first report indicated the groundwater levels of the aquifer used for the potable water supply was approximately 5.0 m below ground surface. The second report examining he effects of sanitary sewage disposal identified a shallow aquifer in the order of 1.0 m below ground surface. I believe that the reports are describing two separate groundwater flow regimes which can be interpreted to be the deeper aquifer flow and the shallow interflow as described by the United States Geological Service (USGS) and the Soil Conservation Service (SCS).

In 2005 the United States Geological Service (USGS) identified a need to revaluate the flow of water beneath the ground surface so as to address the issues associated with accurately describing the flow path and routing of the water. This led to a calculation system which separated the groundwater into interflow and groundwater flow as shown in **Figure 2-5**.

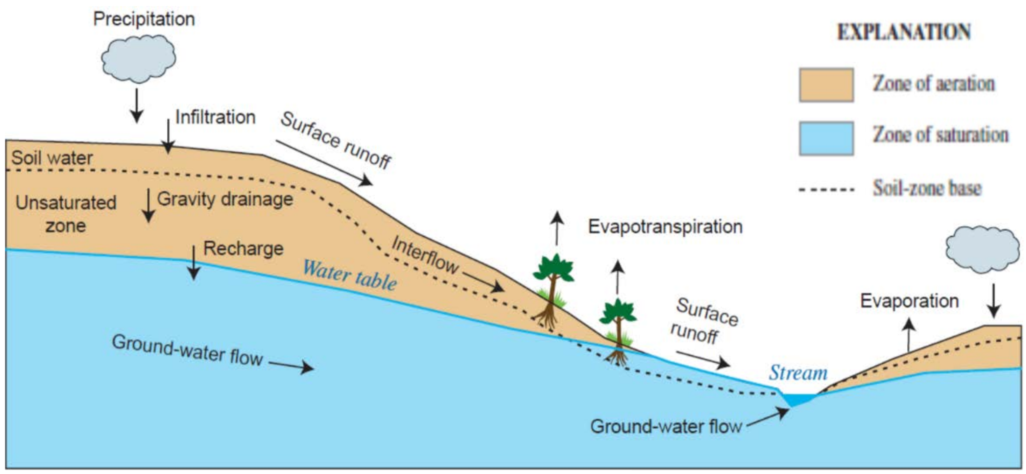


Figure 2-5 Groundwater Flows

This development of by the USGS is documented in their report "*GSFLOW—Coupled Ground-Water and Surface-Water Flow Model Based on the Integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005), U.S. Geological Survey, Reston, Virginia: 2008*".

A further confirmation of subsurface flow paths can be found in documents prepared by the Soil Conservation Service (SCS). The SCS has developed and continues to update the hydrologic methodology used by practitioners and have created a number of training resources on the subject. The document *Engineering Hydrology Training Series Module 203 Runoff Concepts, USDA Natural Resources Conservation Service National Employee Development Center*, July 1999 defines Surface Flow as "*Surface flow is water that has remained on the surface of the ground and moves as overland flow, shallow concentrated flow or channel flow*." It offers these statements regarding interflow "*Interflow is water that infiltrates the upper soil profile and then moves laterally through the soil profile and, eventually, reappears as surface flow at a downstream point. Lateral flow is caused by a relatively impervious zone that prevents or restricts downward movement of water. Interflow may be a significant part of the total direct runoff under certain soil, geological, or land use conditions. It is common in forested areas on moderate or steep slopes with permeable soils over bedrock. Forest and* *ground litter provide high infiltration for water to enter the soil, and slopes provides energy for lateral flow.*

Significant amounts of interflow are not common in cultivated soils on small watersheds and are not usually considered in SCS methods of estimating runoff. Interflow may return to the surface so quickly that it is not possible to separate surface flow and interflow. Interflow may have an impact on wetlands and water quality."

The comment regarding the lack of interflow in cultivated soils is telling as the SCS drainage methods were originally created to estimate drainage in agricultural areas. When the SCS methods were adopted for use in developing areas the agricultural biases were retained. This particular bias must be given consideration and analysis methods used in forested areas and areas that are not actively cultivated must be modified to include descriptions of the actual physical hydrologic processes.

2.8 Surface Soils

Examination of surface soils is critical to understanding the hydrology of an area particularly when considering interflow and groundwater interactions to stream discharges. The shallow (less than 1 m in depth) soils are most affected and altered by the interaction of both rainwater and biological activity are commonly referred to as "top soil". The surface soils are modified over time by these factors and their physical and chemical characteristics will be altered from those of the original geological materials.

Information in this section of this report has been derived from the *Soils of Southern• Vancouver Island*, MOE Technical Report 17, J.R. Jungen, P.Ag., B.C. Ministry of Environment, August 1985. I have extracted and summarized the following technical information which corresponds to the study area.

The surficial soils develop as a result of combined physical characteristics of the geological materials, topography, biological activity and climate. Our past experience leads us to believe that these processes and the resulting soil properties are not well understood by many practitioners in the area of water resources. Understanding the nature of the shallow soils allows us to view how they interact with rainwater and determine how they alter the flow path to the stream. A brief description of the soil formation processes and the soil types that are present within the Saratoga Miracle Beach Area are included below.

The colours of the soils beneath the layer of forest litter range from reddish brown to yellowish brown. The reddish brown colour due to unhydrated iron oxide (hematite) is most distinct when exposed during cultivation or excavation. The entire weathered layer soils seldom extends beyond a depth of 600 mm or 750 mm.

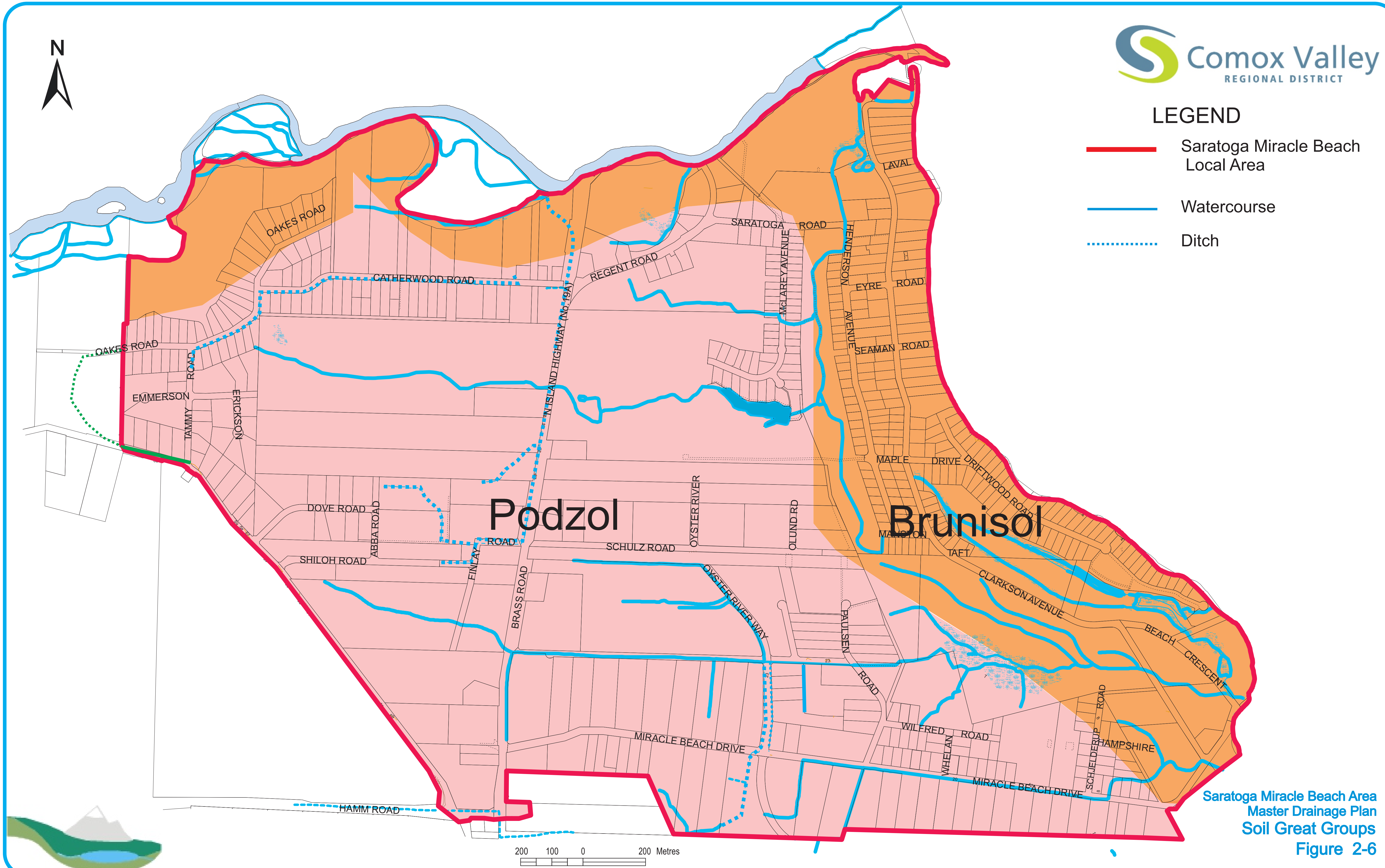
Soli classifications seek to group similar soils in order to organize our knowledge of soils and enable prediction of their behavior. In The System of

Soil Classification for Canada, soil groupings are based on properties' that indicate a similar mode of origin. The soil order is the highest level of generalization in this system. Of the nine orders, only two occur in the area:

1. Solis of the humid forested regions containing significant amounts of amorphous aluminum, iron, and/or organic matter (**Podzolic** order}; and
2. Soils with weakly developed horizons (**Brunisolic** order).

For a vast majority of the area the soils have developed under a coniferous forest. A major factor in soil genesis is the midsummer drought in July and August, which brings about dehydration and chemical precipitation processes in the soil. The location and distribution of the Soil Orders can be seen on **Figure 2-6**.

In general, Podzollc soils are difficult to distinguish in the field from Brunisolic soils for both have similar colour. Podzolic soils are due mainly to the maritime climate which is characterized by high precipitation, low moisture deficits and cool to moderately cold soil temperature regimes. These factors act on the soil parent material to form bright, reddish-coloured, deeply weathered soils which are strongly leached. Brunisolic soils occur on relatively young fluvial and fine textured parent materials where the climate is characterized by warm, dry summers with high moisture deficits and relatively low total precipitation. Compared to the Podzols, the Brunisolic soils are less acid and leached, have lighter colors.



Saratoga Miracle Beach Area Master Drainage Plan
Soil Great Groups
Figure 2-6

2.9 Development

Development within the study area is comprised of man-made alterations to the natural environment. The current and proposed alterations will provide the regions with the additional capability of economic growth while planning is undertaken to minimize the associated adverse impacts to the natural environment.

The current developments have significantly altered the hydrology of the study and future developments will continue that trend unless mitigation measures are implemented to protect the important natural features.

The current planning for the study area is being examined and will be defined in due course. The study area is designated as a development node and any protection of landscape features for ecological reasons will reduce the footprint of the land available for development.

2.9.1 Impacts and Mitigation

As development proceeds there is a very drastic disruption to the shallow soils as building foundations and underground infrastructure is constructed. These disruptions result in large alteration of the shallow surficial soils and the interflow system with the greatest impacts occurring in the denser developments where the ground disturbances are contiguous.

Development almost universally results in drainage improvements, a greater area of imperviousness, less pervious area and a corresponding reduction in vegetation. These alterations to the landscape will increase the volume of surface runoff and reduce the volumes lost to the air through evaporation and transpiration. If the runoff volume is to be maintained then a larger volume must be infiltrated into the ground. Where the terrain is steep constraints soil stability may be adversely affected which would result in an increased risk to people and property. In areas located on clays, bedrock, or high groundwater levels infiltration rates may not be sufficient to allow large rates of infiltration. In these locations the only acceptable method of managing the extra volumes is to discharge to the stream through the drainage system but at rates that are sufficiently small and will not increase stream erosion. The flow duration assessment which is part of the Water Balance Methodology is used to demonstrate that stream erosion can be controlled to predevelopment rates, or reduced if this is a desirable outcome of mitigating the impacts of development.

3. NATURAL ASSETS

Natural assets are assets of the natural environment. These consist of biological assets (produced or wild), land and water areas with their ecosystems, subsoil assets and air. For the purposes of this study we will confine the scope to include the landscape features that provide a benefit to the residents of the study area, the CVRD and to our society as a whole.

Natural assets within the study area include, but are not limited to, streams, wetlands, riparian areas, and terrestrial habitat. Natural assets are often found intertwined and inseparable in terms of function and derived benefits. For instance streams always have a riparian area, whether it is natural or highly modified by man. Wetlands will have riparian areas although the nature of a wetland can vary from one that is permanently wet and readily identifiable to areas that flood seasonally with the associated flora that is adapted to this hydrologic process. Wetlands are often fed or drained by streams. Often a riparian area may form on the flat verge of a stream and be comprise wetlands that are both permanently and seasonally wet. The areas that are in direct contact with, or nearby, water will form aquatic habitat whereas areas that are exposed only to water in the form of precipitation are terrestrial habitat. For more information regarding the environmental findings refer to the report Saratoga-Miracle Beach Local Area Brief Environmental Inventory, Current Environmental, October 31, 2017

Function of the natural assets are often overlooked or the value of that function can be discounted to such an extent that the value is overlooked. The degradation of the function and hence the value of the natural asset will occur as the landscape is altered for development.

3.1 Streams

The natural function of a stream is complex: however in the simplest of terms the stream provides engineering, recreational, and environmental functions. Streams in the study area have been generally identified in the CVRD GIS system as shown on **Figure 3.1.**

3.1.1 Engineering Function

Streams provide a complex function in drainage as both a conveyor and retainer or water. Conveying water from upstream areas to downstream areas allows safe human use of the upstream areas for development, farming, recreation, and business. The counter to this is that the stream also retains and limits the drainage which will reduce the flooding of downstream areas unless the channel is modified. These two engineering functions are opposed where the flood discharge reduction is overlooked in favor if channel modification and increased discharge capacity.

Increasing a channel discharge either by increasing the capacity, or by increasing the discharge will adversely affect the stability of the channel and increase costs associated with maintenance.

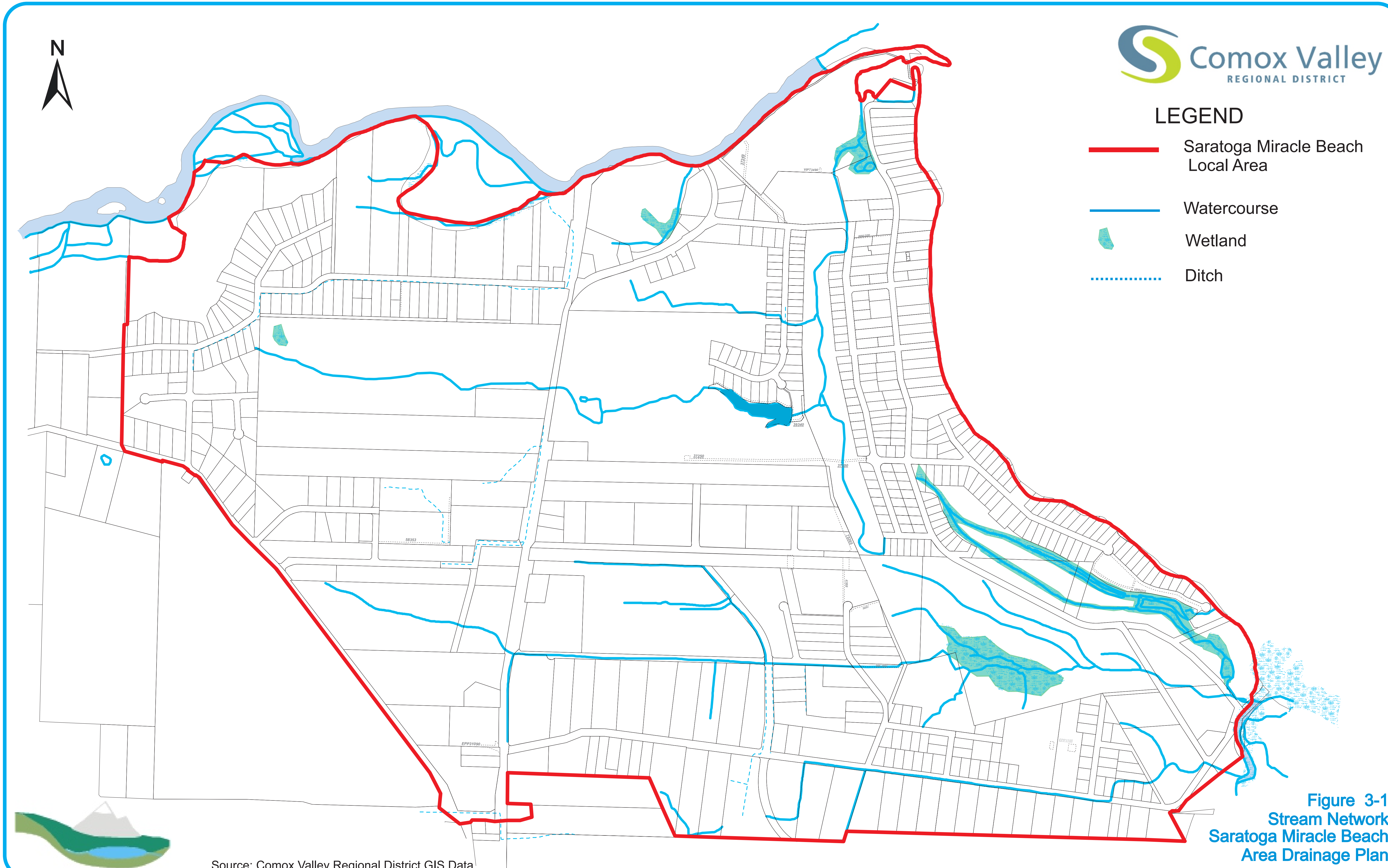


Figure 3-1
Stream Network
Saratoga Miracle Beach
Area Drainage Plan

3.1.2 Environmental Function

Streams in the study area are described in the Saratoga-Miracle Beach Local Area Brief Environmental Inventory, by Current Environmental.

Black Creek is a highly productive fish-bearing stream originating in wetland complexes on the east side of Highway 19, and flowing into Elma Bay. Fish species known to inhabit Black Creek include chum and coho salmon, resident and anadromous cutthroat trout, rainbow trout and steelhead. The creek is identified in the Fisheries Information Summary System as being sensitive coho habitat and one of the best coho-producing streams for its size on Vancouver Island.

The Oyster River is a high-value recreational fishing river. It is one of the most popular steelhead rivers on Vancouver Island, and has the best anadromous cutthroat run on eastern Vancouver Island. The Oyster River also has runs of chinook, chum, coho, and pink salmon, rainbow trout, Dolly varden, and provincially blue-listed coastal cutthroat trout.

3.2 Wetlands

Current Environmental report indicates that Wetland ecosystems are rare and account for only 1.7% of the total sensitive ecosystems inventory on the eastern side of Vancouver Island and the Gulf Islands. The wetland complexes identified within in the study area are comprised of slough-sedge dominated wetland area and a drier areas dominated by hardhack and Pacific crabapple. The environmental descriptions listed below are extracted from the Current Environmental report, which should be consulted for additional detail.

3.2.1 Engineering Function

The wetlands within the study area provide a wide range of functions that are important in their impacts upon properties and the potential of risk to the residents of the area. The wetlands are areas with a relatively large surface area, very small longitudinal slopes. These areas act as barriers to flow and detain large volumes of water with two important functions. The first physical function is to reduce the discharges through flow attenuation and thus provides flood protection to downstream areas. Increasing the conveyance capacity by ditching or enlarging the channel will reduce the local area that experiences occasional flooding and transfer the risk of flooding on to downstream areas. The second function is to improve the quality of the discharges through two processes of filtration and nutrient uptake. The wetland vegetation will filter the water to reduce solids such as sediment and floating debris. The vegetation will also absorb and utilize nutrients and other dissolved material in the water.

3.2.2 Environmental Function

The study area contains two high-value wetland complexes; the Saratoga (Clarkson) wetlands bounded by Miracle Beach Drive, Paulsen Road, and Clarkson Ave (the southeast corner of the SMB area), and the wetlands surrounding the Black Creek slough bounded by Maple Drive, Driftwood Road, and Clarkson Ave. These areas provide habitat for avians, amphibians, fish, and other species. Other ecological functions include supplying vital nutrients to downstream habitats and flow regulation. Some of these wetland areas have been identified by the Comox Valley Land Trust (CVLT) as priority lands for conservation efforts.

The wetland areas provide wildlife habitat to a diverse number of avian species, amphibian forage and rearing habitat, fish habitat (food production, winter refuge/rearing, and migration to upstream areas), and numerous wildlife trees (snags). There are patches of mature (~110 years old) forest in sections surrounding the central swamp wetland – these areas have very high wildlife and recreational/esthetic value.

3.3 Riparian Areas

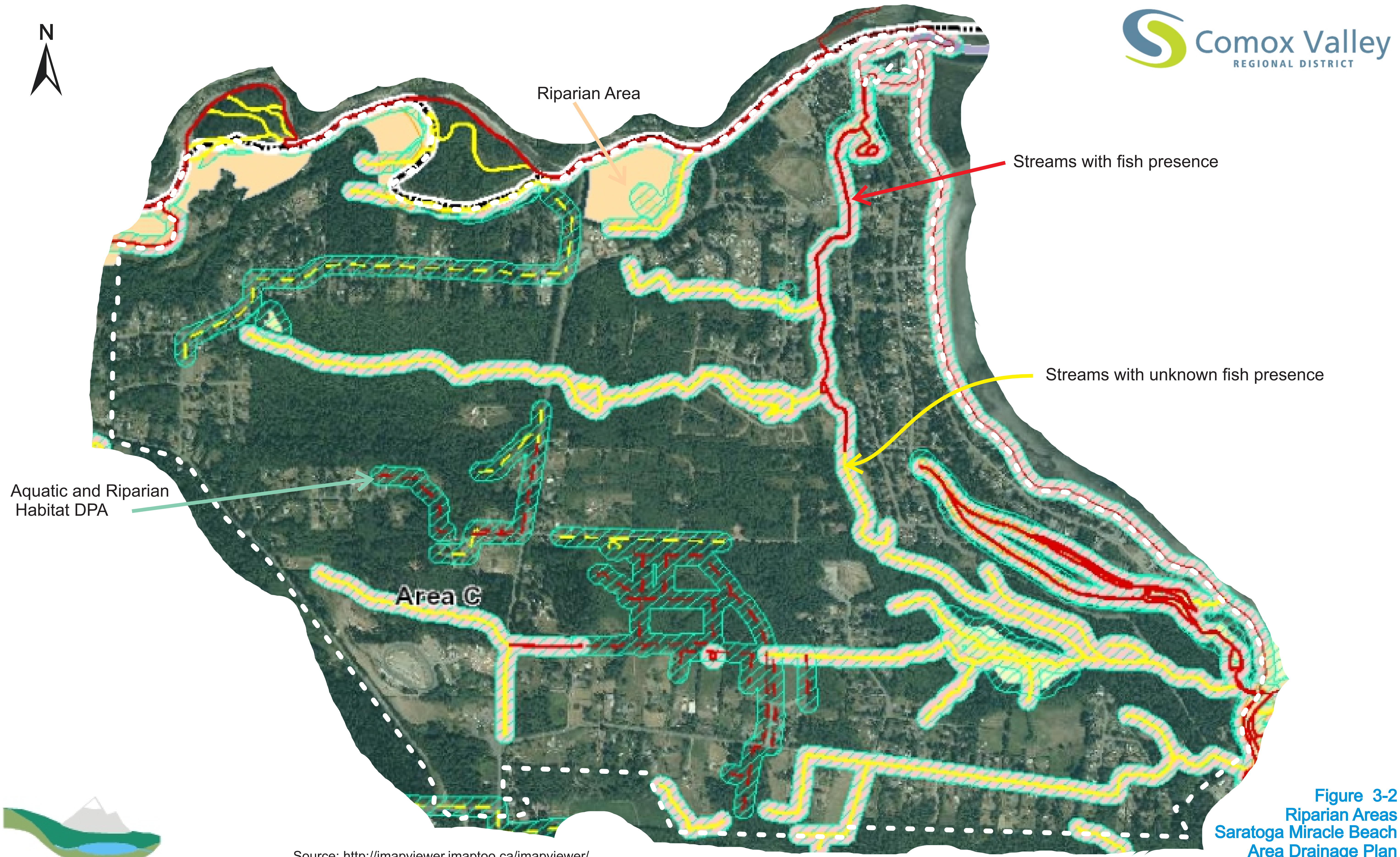
Riparian areas can include wetlands and other areas adjacent to streams, whether flowing or ephemeral. The riparian areas are shown on **Figure 3.2**.

3.3.1 Engineering Function

Riparian areas can provide additional flood discharge capability however their extent may not correspond directly to the floodplain. Each stream has a floodplain that is defined by the extent of the area necessary to convey the design flood. The floodplain is often different than the riparian area defined by the environmental function.

3.3.2 Environmental Function

The riparian areas have a function similar to that of wetlands in providing habitat and food sources for wildlife while sheltering the streams from sunlight and warming of the water which would be harmful to the fish populations.



Source: http://imapviewer.imaptoo.ca/imapviewer/

Figure 3-2
Riparian Areas
Saratoga Miracle Beach
Area Drainage Plan

3.4 Terrestrial Areas

The terrestrial areas are all areas that are not counted as wetlands or riparian areas.

3.4.1 Engineering Function

The engineering function of the terrestrial areas as it relates to drainage is one of conflicts. The first is a source of surface discharge that can be utilized as a water supply benefiting flora, fauna and people within the area. The second is a sponge that absorbs rainfall and which then attenuates the discharges to reduce peak floods while providing extended discharges during periods when there is no rainfall.

The two functions can be altered dramatically by human intervention in the watershed through deforestation, drainage improvements with ditching, agriculture, increasing imperviousness, and water diversions. The result is always greater peak flood discharges and smaller dry period discharges.

3.4.2 Environmental Function

The environmental function of the terrestrial areas is to provide habitat for flora and fauna. Changes in the watershed such as deforestation and drainage improvements alter the value of the habitat and the diversity and numbers of both the flora and fauna.

3.5 Drainage Patterns

The drainage within the study area is determined by the topography with surface water flowing perpendicular to the contours, except where ditching has been used to redirect the natural flow path of the water as shown on **Figure 3.3**. There are several obvious stream relocations that have occurred and these include:

1. South of Schulz Road and west of Oyster Way where the drainage pattern is now formed by manmade ditches;
2. A topographic low point which would have been a wetland located to the north of Schulz Road and west of Oyster River Way has been drained by the ditches created during the construction of Schulz Road;
3. The ditch immediately to the north of the properties on the north side of Miracle Beach Drive west of Oyster River Way;
4. Redirection of the drainage to follow the ditches created by road construction; and
5. Several ditches that follow property lines.

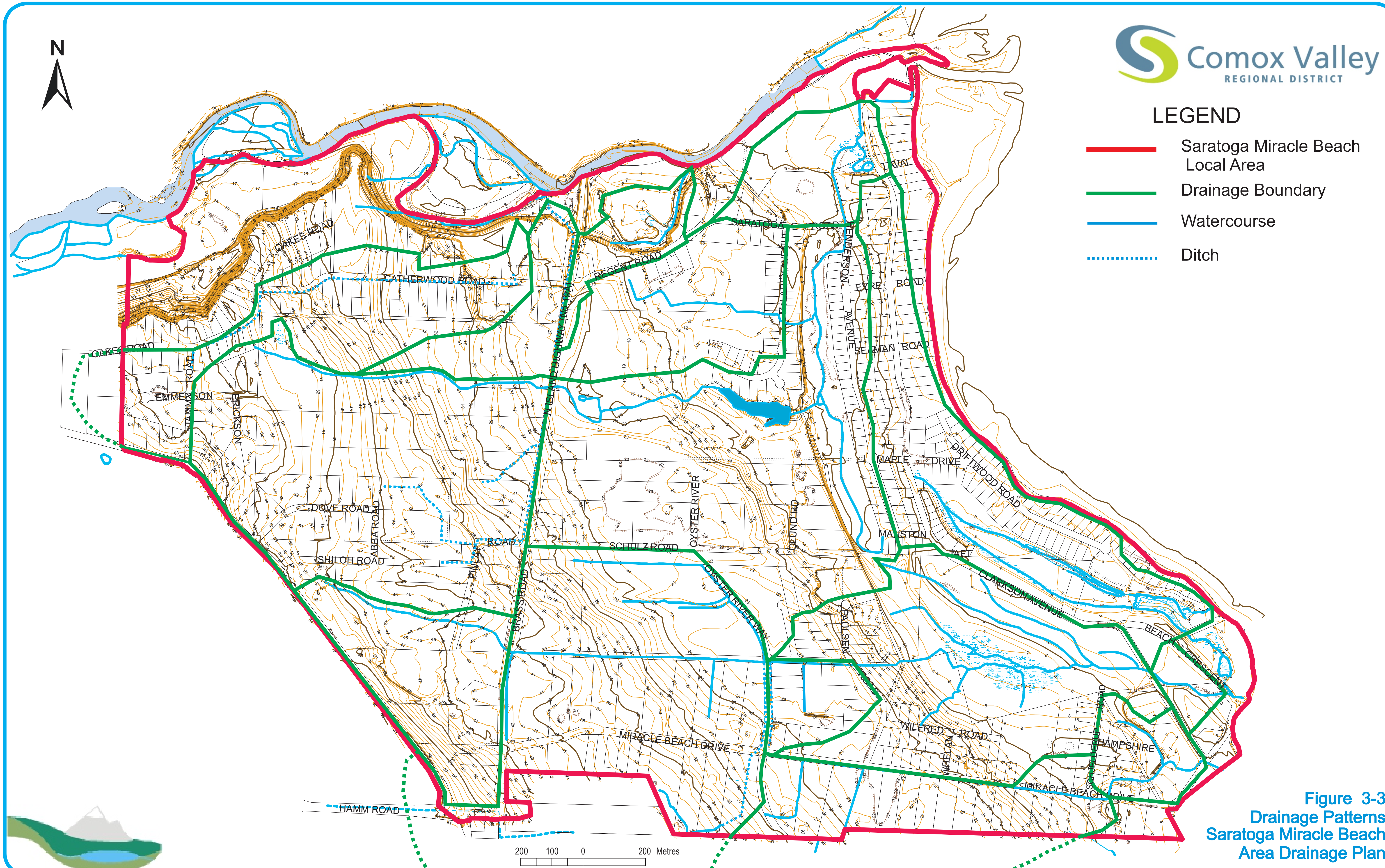


Figure 3-3
Drainage Patterns
Saratoga Miracle Beach
Area Drainage Plan

The drainage in the area corresponds roughly to the bounds of the Saratoga Miracle Beach Area. The construction of Macaulay Road has effectively formed a drainage boundary on the west, the Oyster River forms the northern drainage boundary with the Strait of Georgia to the east. The southern drainage boundary lies a small distance to the south of the area.

The study area can has been divided into a series of smaller catchments which contribute to streams and flow under the roadways at identified points as shown on **Figure 3.4**.

An estimate of the design discharges for predevelopment conditions, a natural forested state, is shown in **Table 3.1**.

Table 3.1 – Stream Crossing Predevelopment Discharges (L/s)

Stream Crossing	Return Period Years					Area (ha)
	100	25	10	5	2	
1	2,858	2,754	2,598	2,425	1,940	173.2
2	1,980	1,908	1,800	1,680	1,344	120.0
3	1,848	1,781	1,680	1,568	1,254	112.0
4	475	458	432	403	323	28.8
5	1,251	1,206	1,138	1,062	849	75.8
6	86	83	79	73	235	21.0
7	3,115	3,002	2,832	2,643	2,115	188.8
8	3,381	3,258	3,073	2,868	2,295	204.9
9	191	184	174	162	130	11.6

An estimate of the potential post development discharge rates at each of the crossings is shown in **Table 3.2**. The assumed post development conditions included are typical of the future land use zoning being given consideration and with minimal efforts to constrain future stormwater discharges. As can be seen when comparing the pre and post development discharge rates there is a considerable potential increase in discharges at the crossing and in the streams within the area. This confirms the need to reduce development discharge rates to prevent increases in flood risks.

Table 3.2 – Stream Crossing Potential Development Discharges (L/s)

Stream Crossing	Return Period Years					Area (ha)
	100	25	10	5	2	
1	11,604	9,734	8,210	6,772	4,053	173.2
2	8,040	6,744	5,688	4,692	2,808	120.0
3	7,504	6,294	5,309	4,379	2,621	112.0
4	1,930	1,619	1,365	1,126	674	28.8
5	5,081	4,262	3,595	2,965	1,775	75.8
6	1,404	1,178	994	820	490	21.0
7	12,650	10,611	8,949	7,382	4,418	188.8
8	13,727	11,514	9,711	8,011	4,794	204.9
9	777	652	550	454	271	11.6

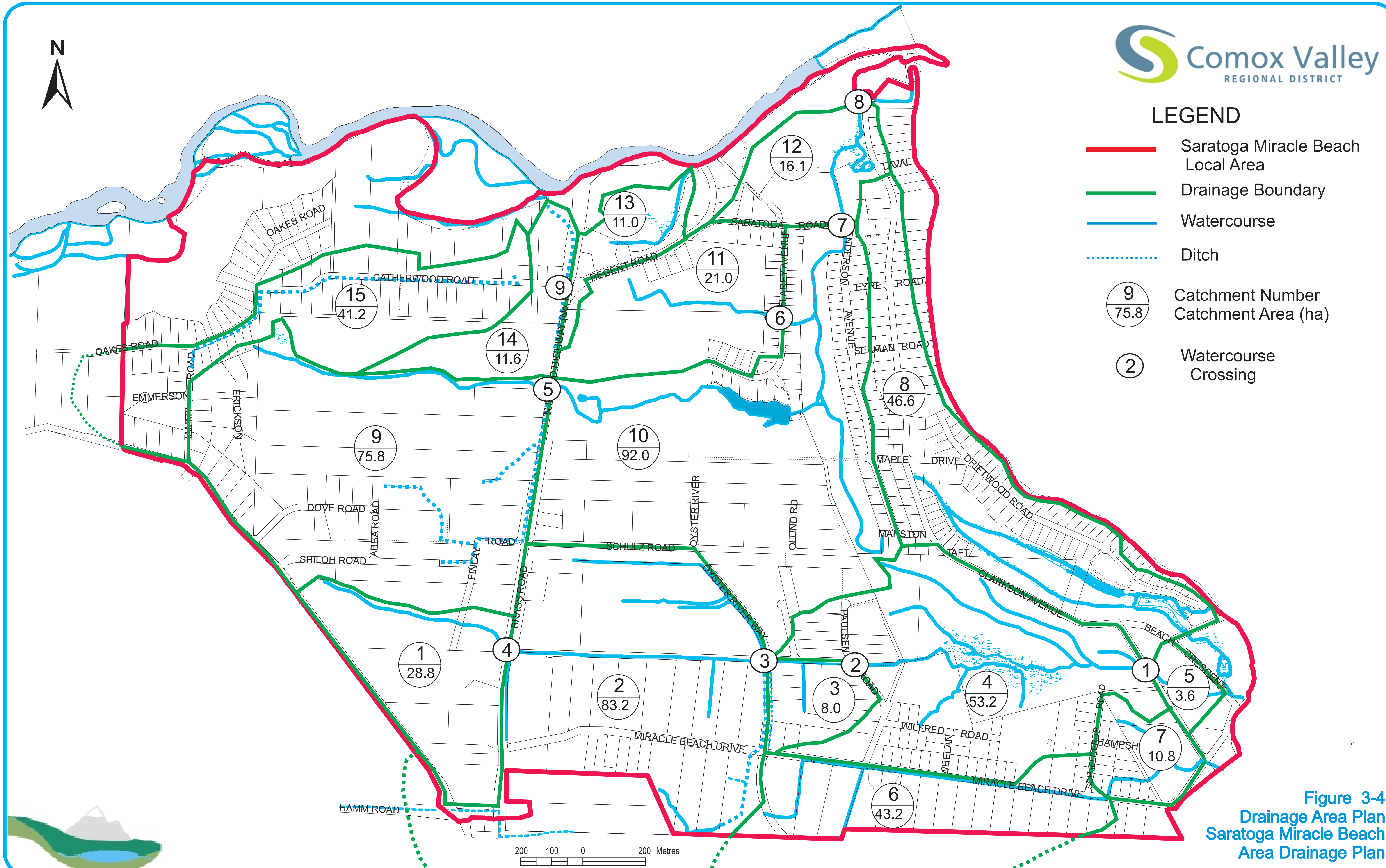


Figure 3-4
Drainage Area Plan
Saratoga Miracle Beach
Area Drainage Plan

3.5.1 Stream Crossing 1

Stream crossing 1 is located on Clarkson Avenue and is comprised of two CSP culverts; one is an 1,150 by 820 mm pipe arch and the second is a 600 mm diameter round pipe. They have a combined capacity, assuming inlet control while upstream depths is 1,100 L/s, and when water is just overtopping the road there is a total capacity of 2,000 L/s. This capacity is approximately a 2 year predevelopment discharge rate and much less than 2 year capacity under potential development conditions when flowing full.

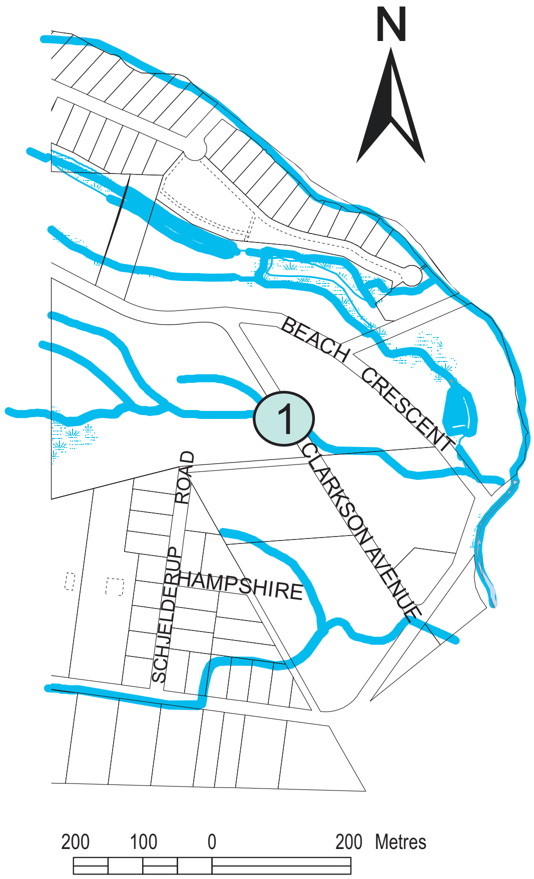
The crossing shown on **Figure 3.5** exhibits a corroded and failing pipe invert combined with erosion beneath the pipe indicating this crossing will require replacement in the near future.

At the time of the field reconnaissance on June 27, 2017 there was:

- no flow in at the crossing,
- the stream upstream and downstream were not well defined and they exhibited characteristics of an ephemeral stream with extensive vegetation.
- flow with levels to the top of the culvert would flood over a wide area upstream and downstream of the culverts, and
- the inlet and outlet were obscured by vegetation and were partially blocked, and thus had an actual capacity less than estimated above.

3.5.2 Stream Crossing 2

Stream crossing 2 is located on Paulsen Road and is shown on **Figure 3.6.** At the time of the field reconnaissance on June 27, 2017 the culvert inlet and outlets were overgrown with vegetation and were not accessible. The capacity and condition of this crossing and channel has not been assessed.



1 - Crossing of Clarkson Avenue

Culvert Inlet

Interior of the culvert from the outlet

Channel upstream of culvert

Figure 3-5
Crossing 1
Saratoga Miracle Beach
Area Drainage Plan

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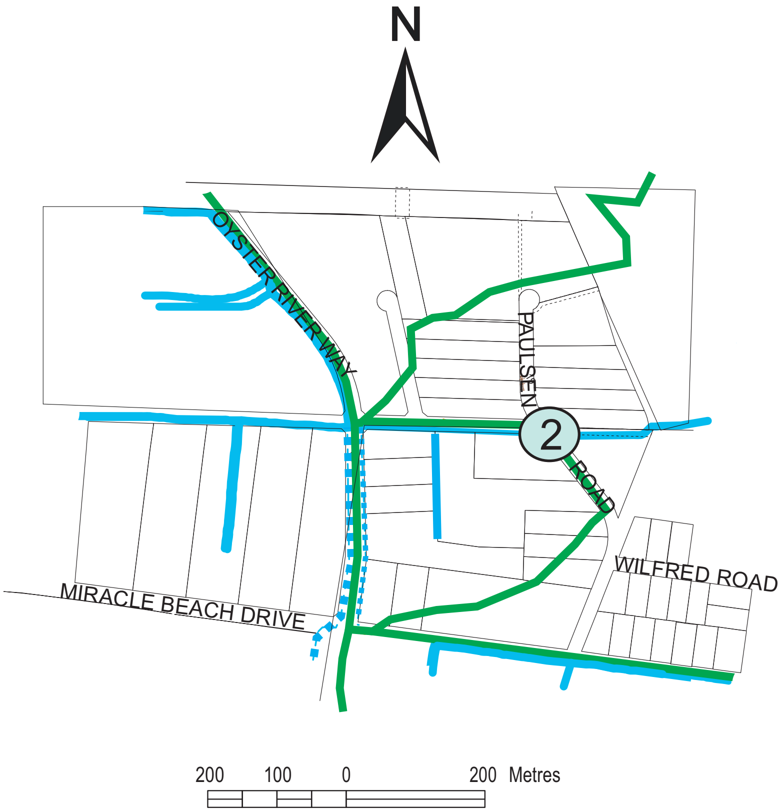

Channel upstream of culvert

Channel downstream of culvert

Figure 3-6
Crossing 2
Saratoga Miracle Beach
Area Drainage Plan

3.5.3 Stream Crossing 3

Stream crossing 3 is located at the limit of the constructed portion of Oyster River Way at the Right-of-Way of the unconstructed Smooth Road north of Miracle Beach Drive. The crossing has one 1,000 mm diameter round pipe with a capacity, assuming inlet control while upstream depths is to the top of the highest pipe is 1,300 L/s and a total capacity when just overtopping the road of 2,200 L/s. This capacity is greater than the 100 year predevelopment discharge rate less than a 2 year capacity under potential development conditions when flowing full.

The crossing shown on **Figure 3.7** shown a recent installation with a trickle of flow at the time of the field reconnaissance on June 27, 2017.

3.5.4 Stream Crossing 4

Stream crossing 4 is located on Brass Road, or North Island Highway (19A) north of Miracle Beach Drive as shown on **Figure 3.8**. At the time of the field reconnaissance on June 27, 2017 the culvert inlet and outlets were overgrown with vegetation and were not accessible. The capacity and condition of this crossing and channel has not been assessed.

3.5.5 Stream Crossing 5

Stream crossing 5 is located on Brass Road, or North Island Highway (19A) south of Regent Road as shown on **Figure 3.9**. At the time of the field reconnaissance on June 27, 2017 the culvert inlet and outlets were overgrown with vegetation and were not accessible. The capacity and condition of this crossing and channel has not been assessed.

3.5.6 Stream Crossing 6

Stream crossing 6 is located on McLarey Avenue and has a 1,050 mm diameter round pipe. Under ideal conditions it would have a capacity, assuming inlet control while upstream depths is to the top of the highest pipe of 1,300 L/s and a total capacity when just overtopping the road of 2,200 L/s. This capacity is greater than the 100 year predevelopment and potential post development when flowing full.

The crossing shown on **Figure 3.10** exhibits a corroded and failing pipe invert combined with erosion beneath the pipe indicating this crossing will require replacement in the near future. In addition, there are other steel pipes partially obstructing the pipe and reducing the capacity of the crossing.

At the time of the field reconnaissance on June 27, 2017 there was no flow in at the crossing and the stream upstream and downstream were not well defined. Flow with levels to the top of the culvert would flood over a wide area upstream of the culvert.

3.5.7 Stream Crossing 7

Stream crossing 7 is located on Saratoga Road at Henderson Avenue and is comprised of two 1,550 by 1,1200 CSP pipe arches They have a combined capacity, assuming inlet control while upstream depths is to the top of the highest pipe is 4,000 L/s and a total capacity when just overtopping the road of 6,400 L/s. This capacity is greater than the 100 year predevelopment and approximately a 2 year discharge under the potential development conditions discharge rate when flowing full.

The crossing shown on **Figure 3.11** shows pipes in functioning condition. At the time of the field reconnaissance on June 27, 2017 there was a trickle of flow in at the crossing. The upstream and downstream channels were well defined, however the flow with levels to the top of the culvert would flood over a wide area upstream of the culverts. The downstream channel was filled with vegetation and may not have the capacity to convey the design flows without overtopping the stream banks.

3.5.8 Stream Crossing 8

Stream crossing 8 is located under an internal access road in the Pacific Playgrounds resort and has a single 1,200 mm CSP pipe. It has a capacity, assuming inlet control while upstream depths is to the top of the highest pipe is 1,800 L/s and a total capacity when just overtopping the road of 3,000 L/s. This capacity is approximately a 5 year predevelopment conditions discharge rate when flowing full. The capacity is less than a 2 year flow under potential development when just flowing full.

The crossing shown on **Figure 3.12** shows pipes in functioning condition. At the time of the field reconnaissance on June 27, 2017 there was a trickle of flow in at the crossing. The upstream and downstream channels were well defined and may have the capacity to convey the flows up to the capacity of the culvert without overtopping the stream banks.

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3 - Crossing of Oyster River Way

Channel upstream of culvert

Outlet of culvert

Inlet of culvert

Figure 3-7
Crossing 3
Saratoga Miracle Beach
Area Drainage Plan

Comox Valley
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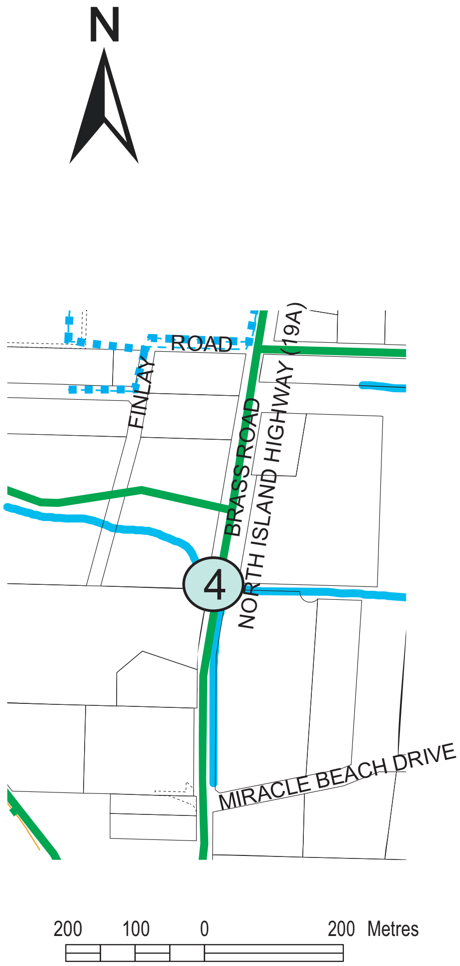
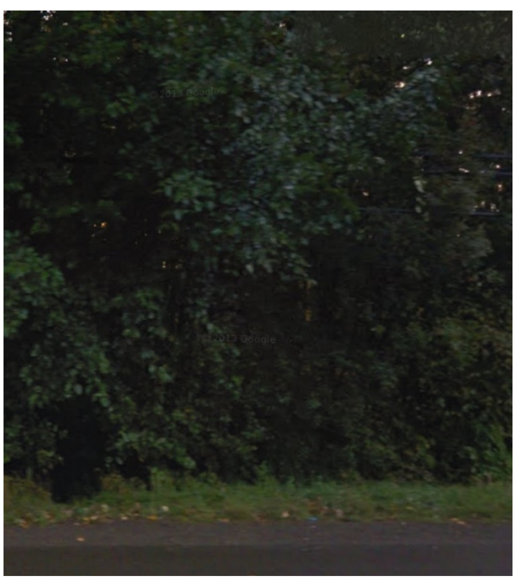


Channel upstream of culvert



Channel downstream of culvert

Figure 3-8
Crossing 4
Saratoga Miracle Beach
Area Drainage Plan

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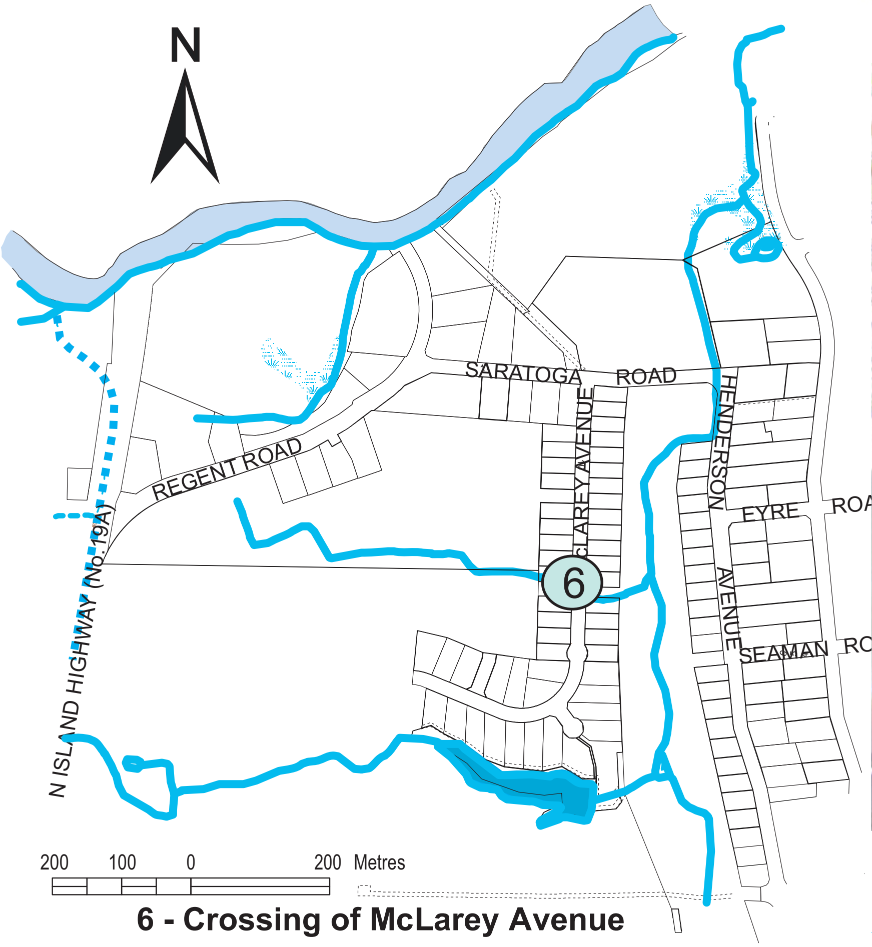
5 - Crossing of North Island Highway

Channel upstream of culvert

Channel downstream of culvert

Figure 3-9
Crossing 5
Saratoga Miracle Beach
Area Drainage Plan

Comox Valley
REGIONAL DISTRICT



6 - Crossing of McLarey Avenue

View of interior from upstream

Culvert Inlet

Channel upstream of culvert

Figure 3-10_
Crossing 6
Saratoga Miracle Beach
Area Drainage Plan

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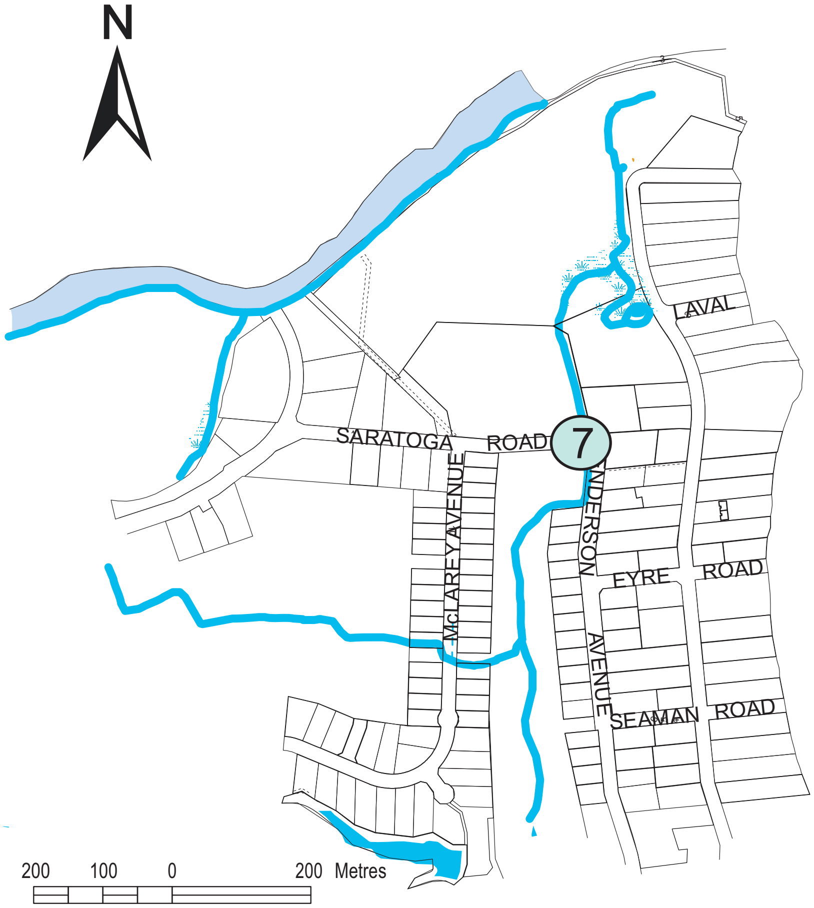

7 - Crossing of Saratoga Road at Henderson Avenue

Culvert inlets

Channel upstream of culverts

Figure 3-11
Crossing 7
Saratoga Miracle Beach Area Drainage Plan

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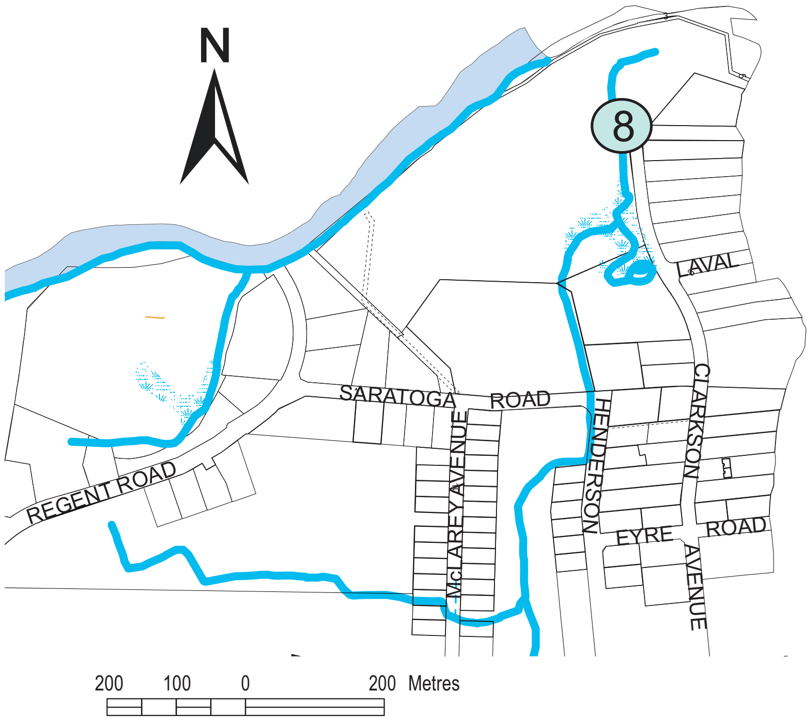
REGIONAL DISTRICT



8 - Crossing under Campground access beside the Clarkson Avenue


Culvert inlet


Channel upstream of culvert

Figure 3-12
Crossing 8
Saratoga Miracle Beach Area Drainage Plan

3.5.9 Stream Crossing 9

Stream crossing 9 is located on Catherwood Road at North Island Highway (19A) and is comprised of two round CSP pipes of 600 and 750 mm diameters They have a combined capacity, assuming inlet control while upstream depths is to the top of the highest pipe is 800 L/s and a total capacity when just overtopping the road of 1,500 L/s. This capacity is greater than the 100 year predevelopment and the potential development conditions discharge rate when flowing full.

The crossing shown on **Figure 3.12** shows pipes in functioning condition. At the time of the field reconnaissance on June 27, 2017 there was no flow at the crossing. The upstream and downstream channels were well defined and may have the capacity to convey the design discharges

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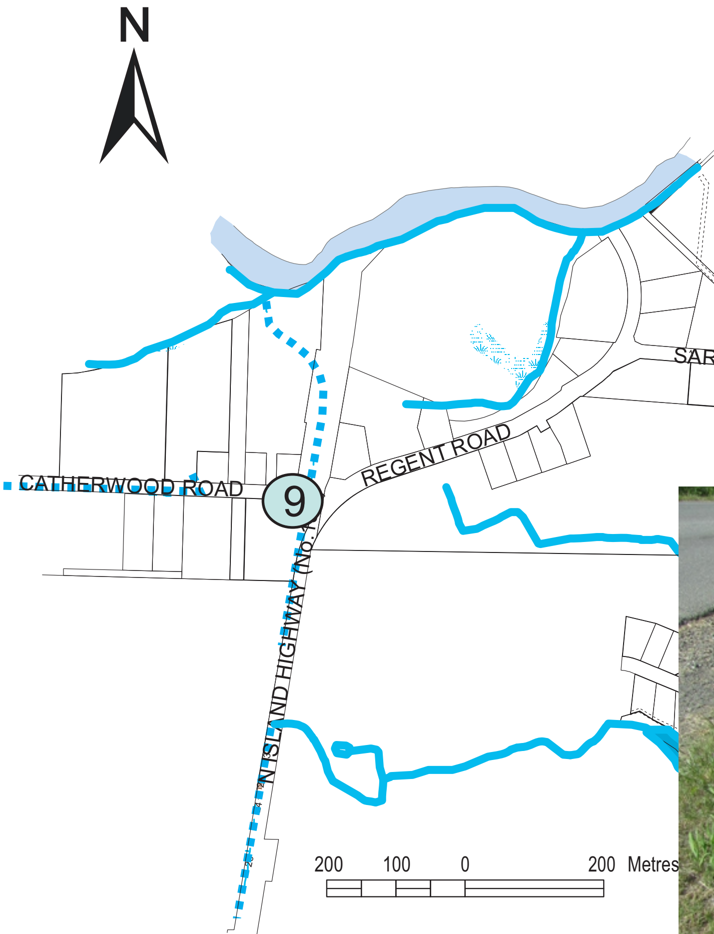

9 - Crossing Catherwood Road beside the North Island Highway

Outlet of culverts

Ditch downstream of culverts

Figure 3-13
Crossing 9
Saratoga Miracle Beach
Area Drainage Plan

3.6 Impacts of Development

As indicated in previous sections of this report there are numerous impacts that result from development and human intervention in the landscape within the area. These include an increase in flooding, increased risk to people along the stream corridors and wetland areas, damage to the aquatic, riparian and terrestrial habitat occupied by the flora and fauna of the area.

3.6.1 Increased Flooding

Development which can vary from deforestation, conversion of the land to agricultural use, and on to land use changes for subdivision development of residential, commercial, industrial, and institutional purposes. All of these activities will increase the peak discharge rates when compared to the predevelopment land forms. The increases of peak discharge rates will increase the depth of flooding and the extent of the flood across the land. Of particular concern would be the relatively flat wetland areas that are subject to occasional flooding. The depths of flood levels will increase the extent of flooding will increase to include areas that did not previously experience flooding.

The increase in flooding will result in additional flood damages to land and properties within the active flood zone. Where people have contact with the flood waters they will experience increase risk of injury and possibly death. Adoption of design standards as discussed in **Section 2.1** would minimize the potential risks to people and property.

The existing drainage infrastructure within the study area was constructed with a limited capacity by applying criteria as described in **Table 2.1**. Application of those criteria accepts that the capacity of culverts would eventually be exceeded and that flooding would occur. The results of an assessment of the stream crossings and the nearby conveyance channels is shown in **Table 3.3**. As can be seen, most of the crossings and channels do not have sufficient capacity to convey the 100 year return period flood event, or storm.

Table 3.3 – Stream Flood Potential

Stream Crossing	Adequate 100 Year Flood Capacity at the Crossing		
	Crossing	Channel Immediately Upstream	Channel Immediately Downstream
1	No	No	No
2	Unknown	Unknown	Unknown
3	No	No	No
4	Unknown	Unknown	Unknown
5	Unknown	Unknown	Unknown
6	Yes	Yes	Yes
7	No	No	No
8	No	No	No
9	Yes	Yes	Yes

Further development within the study area should protect the public and property from flood risks by applying the accepted standards as described in **Section 2.1**.

The capacity of the channels located beyond the immediate vicinity of the road crossings have not been determined. As development proceeds there is a need to establish the design flood levels and extents, or the floodplain, which is associated with a channel in order to provide flood protection to both people and property. Establishing the floodplain and Flood Construction Levels can occur during the design of the subdivision and development or prior to the development as part of the planning process for the study area. It is essential that the floodplain and flood construction levels be established prior to subdivision to protect people and property within the study area from the risks of flooding. Documents describing the process of delineating and protecting the floodplain areas include:

- *Flood Hazard Area Land Use Management Guidelines, Amended by Ministry of Forests, Lands, Natural Resource Operations and Rural Development, January 1, 2018,*
- *Professional Practice Guidelines - Legislated Flood Assessments in BC were commissioned by the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), June 2012, and*
- *Flood Hazard Map User Guide. September, Ministry of Water, Land and Air Protection (MWLAP), 2004.*

The potentially designated floodplain setbacks are not the same as the setbacks required for Riparian Areas. As a result there may be two different setback requirements and the most conservative will apply to any development. The two setbacks may include:

1. Riparian Area Setback, and
2. Floodplain Setback.

3.6.2 Environmental Impacts

Along this the increase in flooding is the increase in stream erosion that will move sediment and alter the form of the bed and banks of the stream resulting in damages to the aquatic habitat along the streams. Habitat degradation can also occur when the increased volumes of discharge occur in a stream as a result of the increased impervious area and drainage improvements associated with development in the study area.

An additional impact will be a decrease in the base flow rates during dry seasons with streams that now flow continuously becoming ephemeral. A fisheries resource would be lost should this occur.

In areas that have “improved” drainage; that is a drainage system altered by human intervention the flow duration is decreased by increasing the flow rates. While this has the benefit of increasing the load bearing capacity of the soil and allows for cultivation or other human activities there is a reduction in the amount of time that the land is moist or wet. In this manner the wetland characteristics and environmental values of land become reduced. Preservation of wetland areas must include preservation of both their natural condition and the flow conditions that feed water to the wetland. Of the hydrologic functions of the watershed that contribute water to the wetland are altered then the wetland will be adversely impacted, even if their area and features are protected.

3.7 Area Specific Targets

Mitigation of the impacts caused by development would include the management of flow duration after development as documented within the report Establish Water Balance Targets for Water Balance Express, May, 2016 as prepared for the Comox Valley Regional District. I understand that the previous report it not readily available to the public so some of the contents are reproduced herein.

The watershed targets were established for development and the Water Balance Express web based computer model was created for use by homeowners. The Water Balance Express can be found at this web site http://comox.waterbalance-express.ca/. It should be noted that use of the Water Balance Express is free.

As part of the study a continuous simulation computer model was created and calibrated to a regional stream flow flood frequency analysis. The flood discharges that can be anticipated are shown in **Table 3-4** and on **Figure 3.14**.

Table 3.4 – Flood Frequency Comparison

Return Period (years)	Typical Area Discharge (L/s/ha)	Target Discharge (L/s/ha)
200	16.9	16.7
100	16.4	16.5
50	15.9	16.3
25	15.3	15.9
10	14.4	15.0
5	13.5	14.0
3	12.7	12.7
2	11.9	11.2

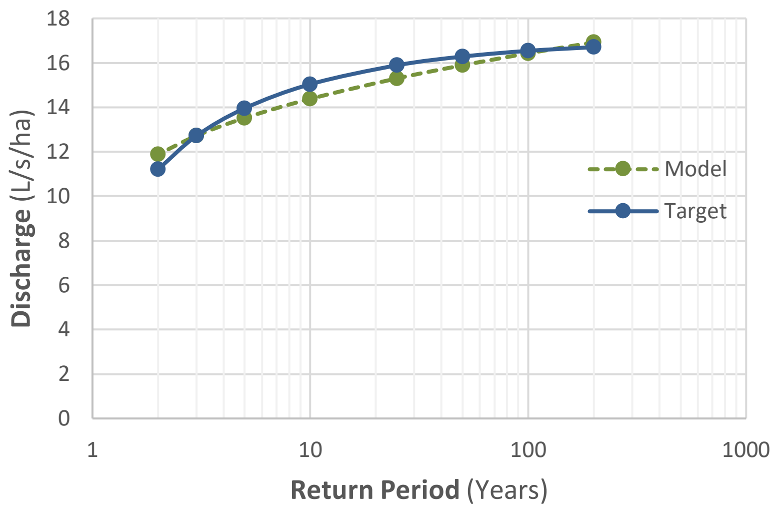

Figure 3-14 Model Calibration

The very close correlation is a demonstration that the computer model has been verified and that it will provide an accurate representation of the stream flow and watershed discharge.

Any future computer simulations of environmental impacts and flood frequency will require the use of verified continuous simulation computer models. Use of design storm models using typical input values may not provide similar results and are not recommended.

Evaluation of the water balance of the watershed indicates that the primary hydrologic function of the study area is not surface runoff as assumed by typical hydrologic models used in stormwater design. Rather the hydrology of the area is largely driven by the interflow system. The water balance for the occupied lands with the coastal area would include:

- Precipitation 100%
- Stream flow 83% comprised of direct runoff and interflow return and return of deep groundwater with a variation from 50% to 100% representing the variable annual release from groundwater.
- Surface capture and evaporation 10%
- Lost to deep groundwater 2%
- Plant transpiration 5%

The hydrogeologic reports identified in **Section 2.2** above identify two separate and distinct aquifers that are not directly connected and that there are two separate water tables. The upper aquifer can be seen to be the interflow system and is seasonally variable while the deeper aquifer is isolated from the upper aquifer by a glacial till.

Preservation of the hydrology of study area and the natural environmental assets would necessitate preservation of the interflow system and avoidance of introducing excess water into the aquifer that is the source of the potable water for the study area. The infiltration to deep groundwater should be limited to approximately 2% of the total precipitation and surface evaporation should be maximized. Limiting the increase in aquifer recharge will maintain the existing ground water elevations and will preclude adverse impacts.

The calibrated predevelopment computer model was modified to reflect the potential post development conditions where the impervious ratios could be as high as 50%. While this may initially appear to be high there are no bylaws or regulations limiting the imperviousness of properties within the study area. The results of the flood frequency analysis are shown in **Table 3.5**.

Table 3.5 – Potential Area Flood Frequency		
Return Period (years)	Natural Discharge (L/s/ha)	Uncontrolled Discharge (L/s/ha)
200	16.7	71.7
100	16.5	67.0
50	16.3	61.9
25	15.9	56.2
10	15.0	47.4
5	14.0	39.1
3	12.7	31.5
2	11.2	23.4

These numbers demonstrate the tremendous increase in the magnitude of flood discharges that occurs as a result of development where the total imperviousness of a watershed or development area increases by up to 50%.

A graphical depiction of this information is provided on **Figure 3-15**.

Figure 3-15 Flood Discharge Estimates

Mitigation within the study area requires the protection of environmental values while eliminating any potential increases in flood risks. Mitigation of the environmental impacts would provide for discharge rates and the duration of flows that would occur under natural conditions. That is the flow discharges that occur for any given number of hours over a year under natural conditions would occur following development of the study area. The flow durations are critical in protecting the wetland form and function while maintaining the aquatic habitat within the streams for the production of fish. Therefore the focus of mitigation would be to maintain the flow duration within the study area.

Given the priority for flow duration a series of mitigation targets can be established that will maintain the flow duration while controlling the flood risks within the study area. The key to properly functioning mitigation works would be to replicate the interflow system while preventing excess losses to the deep aquifer. The objective of Rainwater Management within the study area would be to mimic the amount of water that was infiltrated to groundwater under natural watershed conditions, provide the interflow connectivity to the stream and to maintain or decrease potential flood risks. This approach provides a level of assurance that:

- Excess water will not be directed to the ground and would avoid potentially adverse impacts of excessive groundwater levels;
- Summer flows will be maintained with an operating interflow system; and
- Downstream properties will not suffer an increased risk of flooding or flood damages.

A simple description of the mitigation measures would be a system that contains a volume of rainwater, has a limited area that allows water to infiltrate into the deep aquifer, and an apparatus to limit release rate to mimic interflow as seen on **Figure 3.16**.

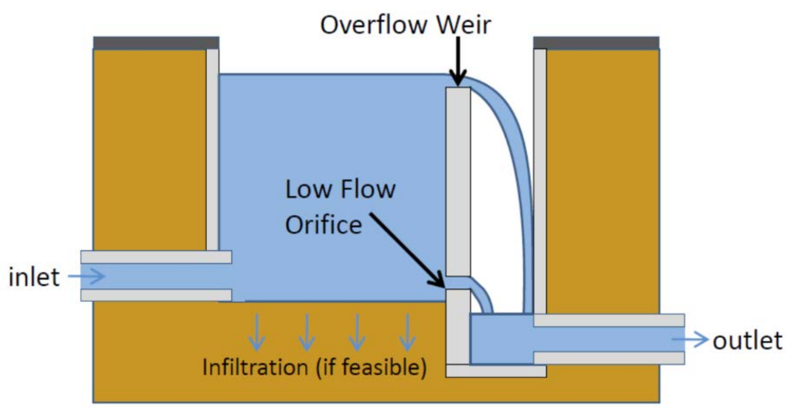

Figure 3-16 Mitigation System

The three physical characteristics include:

1. **Volume of retention** which stores rainwater for controlled release to deep groundwater / aquifer or to the stream through the municipal drainage system;

2. **Infiltration system area** in contact with the subsurface which will allow retained water volumes to infiltrate to deep groundwater / aquifer; and
3. The **base flow release rate** which can be used to augment small stream discharges through release of retained rainwater.

The analysis which is a part of the Water Balance Methodology minimizes the volume of retention and the infiltration system area while maintaining the selected base flow release. A sensitivity analysis established the minimum retention / infiltration system size while achieving the stated objectives. This allows to the least cost system to mitigate the impacts of urban development.

A series of mitigation measures were included within the post development model to provide an estimate of the potential of mitigating the increases in flood risks in the study area. The operation of the mitigation works in the model limits the increase in the duration of discharges that would raise the flood risks while increasing the duration of the small discharges that would augment the low flows to maintain the ecological values of the natural features within the study area.

The post development condition with BMP's indicated the number of hours during the simulation that the specific discharge rates were exceeded and the effect of adding mitigation works as shown in **Table 3.6**.

Table 3.6 – Area Flow Exceedance

Discharge (L/s/ha)	Discharge Exceedance (hours)		
	Natural Conditions	Uncontrolled Discharge	Controlled Discharge
0.6	16,523	12,949	17,819
0.7	14,624	12,216	14,395
0.8	13,092	11,450	11,539
0.9	11,845	10,783	9,198
1.0	10,875	10,243	7,180
1.5	7,768	7,799	5,360
2.0	6,292	6,022	4,044
3.0	4,949	3,962	2,288
4.0	3,597	2,659	1,314
6.0	1,165	1,233	451
8.0	266	605	175
10.0	55	280	85
15.0	3	46	5

The information indicates that the duration of large discharges will be greatly increased following development if mitigation and flow attenuation is not part of the development design, construction, and operations process.

The smaller discharge rates would be decreased following development which would adversely affect the aquatic environment, particularly during periods of drought. With the implementation of both retention and neighbourhood detention the loss of baseflow can be largely mitigated and the increases in the large flood discharges for up to the 100 year return period event can be eliminated.

The information shown in **Table 3.6** can be seen graphically on **Figure 3-17**.

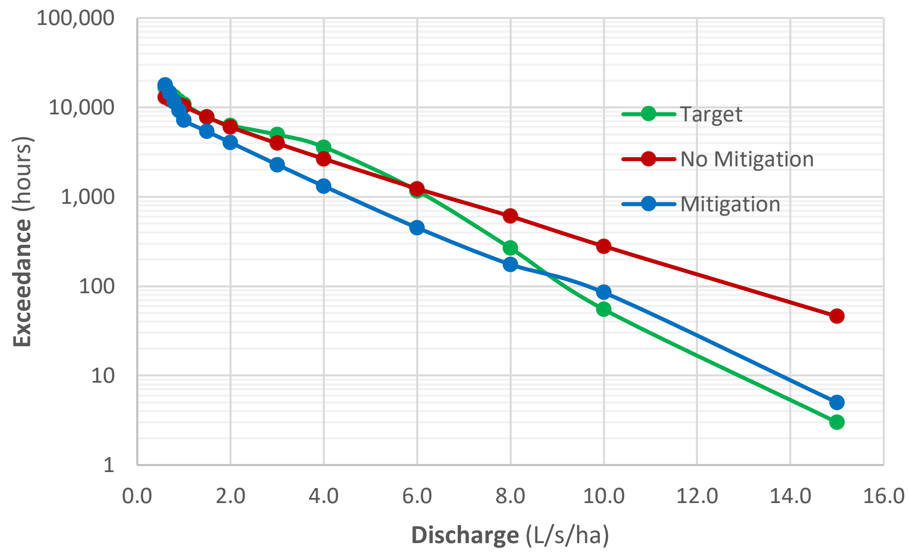

Figure 3-17 Discharge Exceedance

Due to the scale of the chart axis there is some compression of the low discharge and high duration values. These small yet almost continuous discharges represent the majority of the total volume of discharge. The total volume of discharge to the stream has been maintained and slightly increased while decreasing duration of the larger magnitude discharge events. This will reduce the potential for stream erosion in addition to providing increases to the valuable low flows that are critical to aquatic health.

The flood frequency was assessed to demonstrate that the risk of flooding would be kept the same or reduced following development with the mitigation works. The results can be seen on **Figure 3-18**.

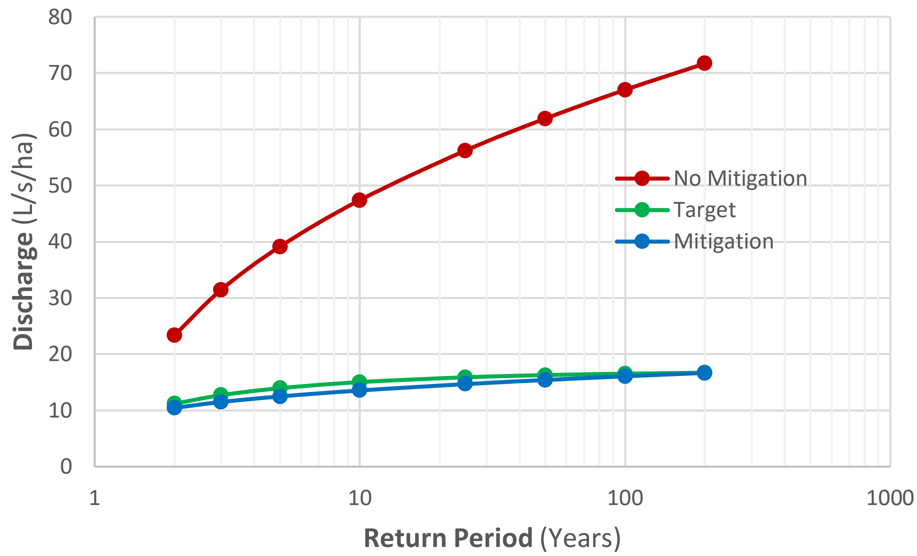

Figure 3-18 Flood Discharge Estimates

The numeric values for flood frequency can be seen in **Table 3.7**.

Table 3.7 – Potential Flood Frequency			
Return Period (years)	Natural Discharge (L/s/ha)	Uncontrolled Discharge (L/s/ha)	Controlled Discharge (L/s/ha)
200	16.7	71.7	16.7
100	16.5	67.0	16.1
50	16.3	61.9	15.4
25	15.9	56.2	14.7
10	15.0	47.4	13.6
5	14.0	39.1	12.5
3	12.7	31.5	11.5
2	11.2	23.4	10.5

As can be seen the proposed mitigation works will off-set the increased flood risks associated with development within the study area.

The size of the mitigation works can be summarized in the three target values for the study area and include:

1. **Retention Volume** on site 164 m^3/ha of development, with neighbourhood detention facilities having a 1 in 100 year volume of 420 m^3/ha of contributing area
2. **Base Flow Release Rate** 1.0 L/s/ha from on-site systems, and maximum controlled release rate of 11.2 L/s/ha of developed area for neighbourhood facilities. Overflows are allow from all facilities.
3. **Infiltration Area** 100 m^2/ha of development area for on-site facilities.

Impacts resulting from development of the off-lot areas will require mitigation that can be undertaken at the time of subdivision or development through construction of stormwater retention and detention facilities to manage both the rates and volumes of discharges from the area.

Development can proceed as there is no specific need to embark upon a costly field investigation to provide the next incremental level of detail. As additional information becomes available it can be incorporated into the models to provide updated watershed targets.

3.8 On-Site and Off-Site Standards

The rainwater management systems envisioned would provide a developed watershed provide with a hydrologic response and flood risks which would be equal to those found if no development were to have occurred.

Two basic types of physical mitigation measures can be defined by their operational characteristics. The two types include landscape features and retention systems. :

1. **Landscape surface features** that capture and contain rainwater before it has an opportunity to begin to flow over the surface. These systems can be described as rainwater absorption devices because they act to prevent surface runoff. These features can include enhanced topsoil and other absorbent features built with the intent to retain rainwater without having surface runoff.
2. **Volume retention systems** capture and store surface runoff while allowing the volume to infiltrate deeper into the ground. Where surface runoff occurs then the systems are no longer acting to absorb rainfall, rather they are containing and managing surface runoff. The retention systems would typically be connected to, and receive runoff from, an impervious surface such as a building roof or a driving surface. These retention systems must be constructed with a base flow release system to allow a portion of the drained water to flow into the drainage system so as to mimic the lost interflow system.

The key to rainwater absorption landscaping features is to have a soil texture with approximately equal proportions of sand, silt and clay. This soil texture will retain a maximum amount of soil moisture for plant use. A soil with a greater proportion of sand will only temporarily detain rainwater as a sand soil will drain and drain out quickly and the opportunity to retain soil moisture will be lost. The ideal soil will be a Silty Loam or a Clay Loam with no more than 8% organic content by weight. Excess organic matter will reduce the load carrying capacity of a wet soil and create a boggy condition when the soil is wet.

Any areas that are disturbed by a development process should be restored with no less than 150 mm and up to 300 mm of topsoil as described above. While the ideal soil is a mixture of equal parts of sand, silt, and clay the cost of finding and importing such a material may be cost prohibitive. In this case augmenting the existing soil with up to 8% organic material would be acceptable.

Volume retention systems have three physical components which include and accommodate the watershed target criteria for:

- A detained volume;
- A control to allow baseflow release; and
- A surface contact area to allow infiltration to deep groundwater.

Plants within landscaping features may be desirable in retention systems so that retained water can be utilized for transpiration.

The main components of any rain garden can be defined and measured as shown on **Figure 3-19**.

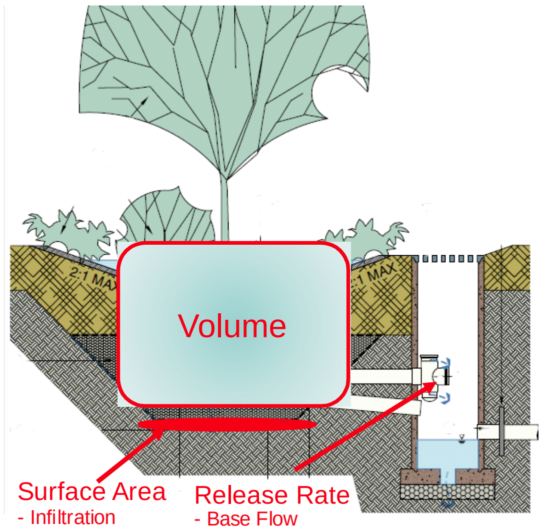

Figure 3-19 Components of a Typical Rain Garden

The potential shape and appearance of the volume retention systems is limited only by our imagination and constraints of a site and regulatory concerns. A typical on-lot rain garden can be seen on **Figure 3-20**.

Figure 3-20 On-Site Rain Garden

In rural areas there are fewer constraints available to use the ground surface. Generally rain gardens occupy small areas where the ground surface has been depressed below the surrounding surface and which will receive runoff from impervious areas. These can have natural vegetation or can be small wetland areas. The key components will include these features:

- Depressed ground surface to contain and to pond water temporarily.
- A top soil or planting media that will retain water for plant growth,

Locating the Off-site retention systems would be within the road R-O-W and could be considered a modification of the existing ditch system that provides drainage. Rather than a simple vegetated ditch the components of the new facilities would include the volume, area, and release rates required to satisfy the watershed targets. Images of linear rain gardens that can be constructed within the road R-O-W can be seen on **Figure 3-21**.

Figure 3-21 Linear Rain Garden

The off-site neighbourhood retention pond can be designed with the standard details which would be used for any neighbourhood pond. The only constrain is the maximum controlled discharge rate for up to full design depth with an overflow to allow for situations where the flood event is larger than the design would accommodate and an overflow is required.

3.8.1 Public and Private Facilities

There are opportunities for providing a mix of public and private facilities within the study area. WE can anticipate that the detention ponds within property that is ultimately owned by the CVRD. However, as seen above the volume reduction BMP's can be placed on private property and on public lands of the Rights-Of-Way. There is a choice of whether all of the BMP's are on public property or whether there is a mixture of public and private systems.

In the case of publicly owned and operated BMP's they would be constructed within the road R-O-W at the time of subdivision and would be operated and maintained by the CVRD. As the BMP's would occupy space within the R-O-W there may be a need to provide a greater width of R-O-W to accommodate all of the systems plus drainage from upstream areas. The On-lot disturbed areas would then be restored as described previously.

If there is a mixture of ownership the BMP's would be constructed in two stages during subdivision and development. The first stage would be to construct the BMP’s required to service the roadways at the time of subdivision. The BMP’s required for mitigating the on-site impacts would be authorized and constructed as part of the building permit process. In this case the BMP ownership would be both public and private with the responsibility for operation and maintenance falling upon the owner of the system.

3.9 Opportunities and Constraints

As the development occurs within the study area and as redevelopment of existing properties occur when older housing is replaced there exist opportunities to bring about changes in our use and construction standards that can have a benefit to the natural health of the watershed, wetlands and streams.

I believe that the future watershed can become a very exciting and environmentally valuable habitat and a jewel which would be an example that other municipalities would aspire to equal. This change in the watershed would occur over time as development results in subdivision and new home construction and redevelopment occurs where houses are reconstructed without the need for municipal resources on private property. As roadways are reconstructed similar facilities should be constructed to manage and enhance the hydrologic response of municipal land. The neighbourhood retention facilities will require planning to locate them, and a strategy to allow them to be constructed as part of the development process.

3.10 Implementation

Inclusion of rainwater management can be a complex regulatory issue in light of how land development occurs and the responsibilities of the individuals and firms which are a part of the process.

A vast majority of the newly created properties are sold to new owners who would then complete the development process. The building construction is the final step in overall process where the property owner applies for a building permit to construct a dwelling.

Design and construction of on-lot rainwater management systems would occur following subdivision. The two most significant reasons for this sequence are described below.

1. The first reason is to establish the building location within the building envelope to allow sufficient clearance and to avoid conflicts between the location of the building, septic system, and the various components of the rainwater management system.
2. The second reason is that subdivision creates lots without any provision for on-lot construction. The latter must meet building code provisions, and municipal staff carry out inspections at specific points during construction.

The CVRD must revise their building permit standards to include the rainwater management systems necessary to mitigate the impacts in the study area. The Water Balance Express can form one component in the building permit process in providing mitigation of on-lot development or redevelopment.

Implementing rainwater management systems is a good and environmentally sound decision in any local government. The aesthetics and livability of neighbourhoods and communities can be enhanced while allowing development and protecting the environment.

Rainwater infrastructure which is to be constructed on private property would require design review and inspections by a suitably qualified professionals and / or building inspectors as part of the building process and regulated under the building permit process.

Alternatively a new administrative process of design, review, approval and acceptance may be created by the local government. A modified process may include a qualified professional for design and certification. Inclusion of a qualified professional would necessitate modification of the Development Agreements and the legal relationships between the local government, the developer, the home builder and the engineering consultants that have been a standard part of the land development process to date in other jurisdictions.

The rainwater infrastructure constructed within Rights-Of-Way requires review and approval of the local government and MOTI in rural areas. The infrastructure could be constructed as part of the servicing of the subdivision and prior to the sale of individual lots. The design of the portions of the drainage which include conveyance capacity would be completed by using existing established methods and would be subject to the standards as applied before completion of this Master Drainage Plan. Only those part of the rainwater management system intended to provide volume and rate control would be subject to new design standards and processes.

Thus, the Land Development Process would require a balance of enforceable regulation provided through Bylaws and Administrative process that would allow a bridge to be formed between the two steps of the Land Development process which are comprised of Subdivision and Building Construction.

On-going operation and maintenance of all of the systems will be required. The on-site systems located on private property will require maintenance by the property owner and systems located within the road R-O-W or on lands dedicated to the CVRD will require operation and maintenance by the CVRD.

As development proceeds and the design of facilities occurs there will be a need to convey the information to staff. This will occur in two stages:

1. Submission of the subdivision design will be received by staff of the CVRD and MOTI. These staff will require training to understand the designs and to evaluate whether the proposed systems meet the requirements of this drainage plan.
2. The design and submission process should include the provision of Operating and Maintenance (O&M) Manuals for rainwater management systems. This will allow staff to properly operate and maintain the systems in the future.

Public acceptance of the rainwater management facilities will be required as will ongoing system maintenance of the facilities located on private property. A process of providing information to potential future and existing property owners is required. A formal program to provide initial and ongoing public education for property owners and developers should be in place to provide support to the public and to demonstrate the benefits of the systems and their maintenance.

4. LAND USE GOVERNANCE

Land Use Governance carries with it a responsibility to protect the public, their property, and the environment. Future development within the Saratoga Miracle Beach Area has the potential to adversely increase flood risks and result in the adverse damage to aquatic and riparian habitat. The potential impacts can be mitigated with the control of stormwater discharge rates and volumes combined with protection of the riparian areas along the stream and within wetlands.

Reduction of potential the potential impacts resulting from ongoing development within the study area will require a new way of managing the development process and in educating both staff and the public which includes developers and their engineers. Adopting new methods and processes is not an unusual concept as history shows us that we adapt as we acquire new knowledge. In this case knowledge is of risk and adverse impacts in the process of occupying and altering the landscape to suit new uses and for human occupation.

Stormwater management has evolved into rainwater management with new knowledge of our impacts upon the environment and of the increased flood risks associated with previous land drainage practices. The regulated requirements have been revised in the past and will continue to be revised in the future. The CVRD and MOTI have an opportunity to preserve the natural environmental assets and to prevent increased risks of flooding within the study area by adopting standards that are consistent with those of other jurisdictions and that are in compliance with the stated objectives of both organizations.

Developments would be required to comply with the design guidelines of MOTI in acting to prevent increased flood risks and stream erosion downstream of any future development. This is possible because the MOTI policy is stated to be "*In areas where a Master Drainage Plan has been developed, all subsequent drainage designs should conform to the plan.*" Therefore any future drainage designs within the Saratoga Miracle Beach Area would be required to comply with this Master Drainage Plan.

The design of the portions of the drainage which include conveyance capacity would be completed by using existing established methods and would be subject to the standards as applied before completion of this Master Drainage Plan. Only those part of the rainwater management system intended to provide volume and rate control would be subject to new design standards and processes. The rainwater volume control measures could be designed with the use of the Water Balance Express; whether they are located on-site or within the road R-O-W. Access to the tool is through a web page located at http://comox.waterbalance-express.ca/.

The neighbourhood retention ponds would be sized to contain the watershed target volume while releasing the allowable discharge rates, no additional analysis would be required. If new analysis is desired the methodology utilizing continuous hydrologic simulation for the entire period of climate record must be employed.

Mitigation of the potential impacts will result in infrastructure constructed on both private and public lands. Thus there will be both public and private infrastructure designed and constructed during future development undertaken as part of both subdivision and building permit processes. This will result in ownership, operation, and maintenance being the responsibility of both the CVRD and the private property owners. This will require new administrative processes at both the CVRD and at MOTI to ensure that the objectives of this drainage plan are achieved.

1. MOTI would enforce compliance of the design guidelines during subdivision development, and
2. The CVRD would enforce compliance during the building permit process.

Subsequent to construction the infrastructure will require operation, maintenance and possibly replacement as the systems age. A funding process will be required to ensure ongoing funding to support the operation, maintenance, and replacement activities associated with the infrastructure. This can be accomplished through creation of a Local Service Area for Stormwater and Drainage under the authority derived from the British Columbia Local Services Act. A precedent for this has been set with the establishment of the Black Creek/Oyster Bay fire protection local service area.

Establishing a Local Service Area for drainage and stormwater management would be initiated with the first development and can be expanded with each subsequent development, whether a subdivision or other type of development. The funding is through an annual parcel tax based upon the costs to operate and maintain the stormwater and drainage infrastructure. In this way any future costs can be recovered by the users of the system without affecting the budgets of the CVRD.

An initial and ongoing education and training program will needed to provide training to property owners, and the staff of both the CVRD and MOTI with regards to the details of design and requirements for operation and maintenance.

5. CORPORATE AUTHORIZATION

This document entitled:

Saratoga Miracle Beach Area
Master Drainage Plan

Client Name:

Comox Valley Regional District

Was prepared by:

J.M.K. (Jim) Dumont, P.Eng.

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Dec 17, 2019