Village of Belcarra

Drainage Study

Final Report

December 18, 2017

OPUS

Village of Belcarra

Drainage Study

Prepared By

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18/12/2017

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Previous Version(s): Draft Report – November 16, 2017

Third Party Disclaimer

Executive Summary

The Village of Belcarra (Village) retained Opus International Consultants (Canada) Ltd. (Opus) to conduct a Drainage Study of the area in the southern portion of the Village with a total drainage area of approximately 160 hectares. The study area's drainage system is predominantly open channel (ditches ~4 km; and, culverts ~2 km) with some stormwater sewers (~1.1 km). Collectively, they service the study area's 280 rural residential lots and the Village Hall.

As part of the study, a hydraulic model of the drainage system is developed. To reinforce the accuracy of the model, field surveys were conducted to obtain culvert, manhole, and catch basin invert elevations for most of the system east of Kelly Road. Further, drainage sub-catchments were delineated (to less than 4 ha mostly) and the Rational Method, as per the Village's Bylaw, was applied to determine their runoffs. In-lieu of flow monitoring data, anecdotal information provided by Village staff was used to validate model predictions.

The drainage system was assessed under the 5-year and 100-year return period storms, with and without climate change considerations. The IDF curve, with climate change considerations to the year of 2100, developed by the neighbouring municipality of the District of North Vancouver was considered for this Drainage Study. Subsequently, the model predicts one main corridor in Belcarra where culverts and stormwater sewers are deficient: along the entire alignment of Kelly Road. These deficiencies are caused by inadequate capacities in the pipes.

A prioritized list of improvement works, consisting of upsizing of culverts and stormwater sewers, is prepared with a total Class 'D' cost estimate of **$499,300** (2017 Canadian dollar). A total of nine (9) culverts (~134 m) and 265 m of stormwater sewers are recommended for upsizing. Most of the culverts requiring upsizing are part of the major system and are sized for the 100-year return period storm. They are situated at outfalls to the system, discharging directly to either the Belcarra/Bedwell Bays, or the Sasamat Lake. The stormwater sewers requiring upsizing are situated along Kelly Road and are part of the minor system, they are sized for the 5-year return period storm.

Finally, Opus estimated an approximate replacement value of the Village's drainage assets to be **$4.5 million** (2017 Canadian dollar), of which $2.1 million is for culverts and $2.4 million is for stormwater sewers. The asset value includes the improvement works to be implemented along with same-size replacements for those that do not require upsizing.

The reader should note that the absence of flow monitoring data precluded detailed calibration of the model and hence only preliminary model validation was possible using anecdotal information. This limits the use of the model to only high-level planning investigations, such as this drainage study.

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2 Study Area Overview

The Village of Belcarra is a municipality in British Columbia (BC) with a population of 643 (2016 Census). It is a member municipality of Metro Vancouver, located on the eastern shore of the Indian Arm, a side inlet extending north from the Burrard Inlet. An overview of the study area is shown in **Figure 2-1**.

2.1 Topography & Drainage

The study area is situated on steep terrains, typical of areas located on the side of a hill/mountain. The drainage in the study area is provided by way of surface drainage, roadside ditches, culverts, local creeks, and a limited number of stormwater sewers in the developed areas. The stormwater runoffs in the study area can be broken down into the following sources/types: developed rural residential lots (280 of them), the Village Hall, road surfaces, and the forested areas in the uplands (part of the Belcarra Regional Park) that contribute runoffs to the study area.

Runoffs from the roads and developed lots are captured and conveyed by the network of ditches and culverts, and stormwater sewers to the numerous outfalls into either Bedwell Bay or Belcarra Bay. Some parts of the study area (east) discharges to Sasamat Creek, which also conveys water from Sasamat Lake to Bedwell Bay.

Runoffs originating from the uplands are intercepted by the Village's road network and local creeks before being conveyed by the open channel system in the developed areas to the outfalls. Runoffs from the uplands south of the developed area (Woodhaven) are intercepted by Bedwell Bay Road and Main Avenue, and Rae Creek. Runoffs from the uplands east of the Coombe area are intercepted mainly by Belcarra Bay Road and Dutchman Creek.

2.2 Climate

Meteorological data were referenced from the nearest long-term climate station (Port Moody Glenayre), located in the City of Port Moody, approximately 6 km south of the Village. There is a closer climate station (Indian Arm Woodlands) to the Village, however its data is limited. The Port Moody Glenayre climate station's historical data indicates a total average annual precipitation of just over 163 cm, with approximately 5 cm comprising snow and approximately 158 cm falling as rain. Average monthly air temperature ranges from approximately 0◦C in January to over 22◦C in July.

2.3 Geology & Soils

According to the BC Soil geodatabase procured from BC Soils Information System, Ministry of Environment, the Village is underlaid with predominantly "BUNTZEN" soil with some portions of "STEELHEAD" soil, which are both Sandy Loam in texture. The surrounding forested areas of the Belcarra Regional Park to the south of the Village and on the west shore of Bedwell Bay consist of "CANNELL", "EUNICE", and "BUNTZEN" soils, which have a texture of Loam, Loamy Sand, and Sandy Loam, respectively. Overall, the majority of the soils within the study area consist of Sandy Loam soils which have fair to poor drainage characteristics.

- Develop cost estimates for the replacement of the Village's culverts and stormwater sewers; and,
- Comment and provide recommendations for the process of converting from an open ditch system to a piped network.

1.3 Background Data Collection

This section lists the existing data collected and reviewed by Opus for developing the Drainage Study. The information was mainly collected in electronic format, and consists of geospatial data, drawings and reports of previous relevant studies. The procured data, as summarized in Table 3-1, was used as background information, model construction, and development of the Drainage Study.

Table 1-1 – Data Collection Summary

Description	Data Type	Source
Background/Base Map		
Village Parcels	CAD files	Village
Street Centerlines		
Village Boundary		
0.5 m Elevation Contours		
Satellite Imagery and Street Views*	Raster/Images	Google Earth
Model Development		
Culverts, Ditches, Stormwater Sewers, Catch Basins, Manholes, and Outfalls	Cad Files PDF Documents	Village
BC Soil Information	ESRI Geodatabase	Ministry of Environment
Village Drainage Asset Inventory	PDF Document	Village
Reference Documents		
Proposed City Works Village of Belcarra BC – HY Engineering Ltd., January 2015	PDF Document/ Reports	Village
Drainage Study and Geotechnical Assessment – Associated Engineering Services Ltd., March 1984		
Village of Belcarra Subdivision and Development Bylaw No. 492, 2015		

*for reference only

1.4 Acknowledgements

Opus acknowledges the support and cooperation of the Village of Belcarra and extends its appreciation to Bernie Serné, Superintendent of Public Works at the Village, and Ron Beesley, Senior Project Engineer at HY Engineering for their assistance to the project team at Opus in preparing this report and completing this project.

The model development and analyses, and report were prepared by Nima Najafi, P.Eng., Fofo Deng Ke Fan, E.I.T., and Michael Levin, E.I.T., with field services from Brad Geib, C.E.T., AScT., with supervision and direction from Paramjeet Mankoo, C.Eng.

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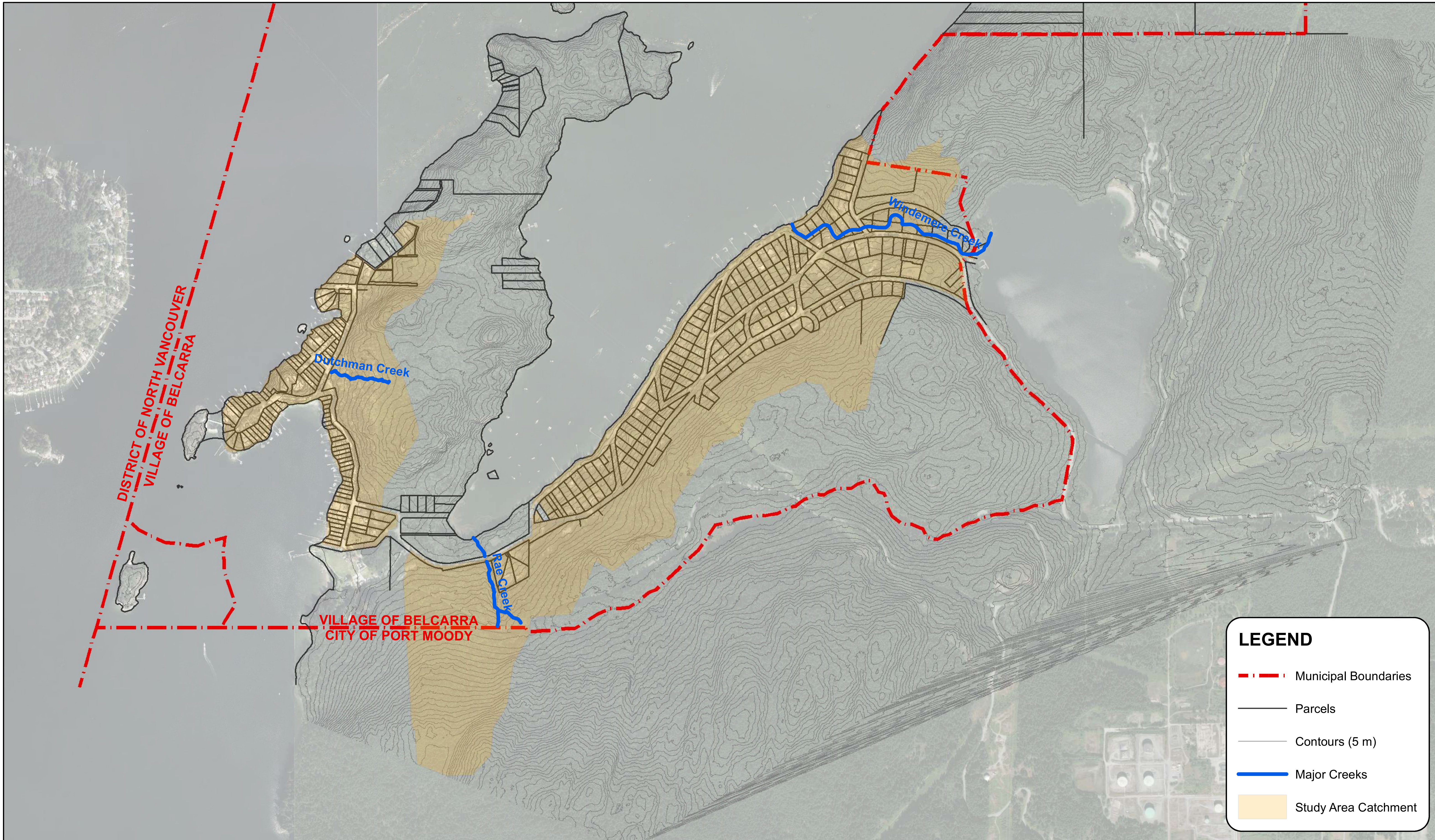

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BELCARRA 1979

VILLAGE OF BELCARRA DRAINAGE STUDY

STUDY AREA OVERVIEW

FIGURE 2-1

SCALE	PROJECT NO	
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	PREPARED BY	APPROVED BY
	ML	**PM**

Path: G:\opus_dk\municipal\269 Village of Belcarra\gis\D-26913 (Drainage Study)\Fig 2-1 Study_Area_Overview.mxd

3 Existing Drainage System

The Village's drainage network consists mainly of open channel drainage (ditches and culverts) with a limited number of stormwater sewers. The entire drainage network eventually discharges into Bedwell Bay and Belcarra Bay through numerous outfalls and creeks.

Figure 3-1 shows an overview of the drainage system components. The following subsections provide a detailed description of the Village's existing drainage system based on the background data provided and the findings from Opus field survey.

3.1 Field Data Collection

Based on Opus' initial review of the drainage asset inventory provided by the Village at the RFP stage, 141 culverts were identified with the majority of them listing associated size. However, other critical data, namely the upstream and downstream invert elevations, were not available.

Opus conducted a field survey to determine upstream and downstream invert elevations, size, material, and headwall/tailwall details (if any) for the critical culverts selected for the survey program. Culverts prioritized for the field inspection program were determined based on their criticality and location – larger culverts at the downstream end of the system were given priority to smaller culverts at the upstream end.

The field survey covered 64 culverts and 32 catch basins located in the study area. The culverts were field surveyed for location confirmation and invert elevations. The catch basins were field surveyed for location confirmation and rim elevations. Of the 32 catch basins surveyed, 22 were later surveyed again to obtain invert elevations by opening the catch basins and measuring depths of all incoming and outgoing mains. Refer to Appendix A for further details (location and size) of the surveyed assets.

In addition, during the model development stage of the study, we identified a number of locations with unknown network connectivity. The Village staff conducted a field investigation to confirm these connectivity questions – refer to Appendix A for more details.

3.2 Drainage System Components

3.2.1 Creeks

The main creeks within the study area include Sasamat Creek, Rae Creek, and Dutchman Creek.

A portion of the Village's drainage system in the northeast discharges into Sasamat Creek which also conveys flows from Sasamat Lake to Bedwell Bay. This Sasamat Creek (downstream of Sasamat Lake) is bounded by Bowser Avenue to the north and Bedwell Bay Road and Watson Road to the south. There are sections of Sasamat Creek upstream of Sasamat Lake that captures and conveys runoffs from the uplands south of the study area to Sasamat Lake, these sections of the Sasamat Creek and its drainage catchments are outside the scope of this study.

Rae Creek, which starts in the uplands at the south end of the study area in the Belcarra Regional Park, conveys runoffs from the uplands, as well as discharges from the ditches along Bedwell Bay Road, to cross Bedwell Bay Road via a culvert ("BD-75") to discharge into Bedwell Bay.

Dutchman Creek, which starts in the uplands in the Coombe area, conveys runoffs from the uplands and discharge into the open channel system at Belcarra Road and Salish Road. The flows are then conveyed via ditches and culverts to an outfall discharging into Belcarra Bay.

3.2.2 Culverts

According to the Village's asset inventory and Opus' site investigation, the total length of culverts is estimated at 2 km. As per the Village's asset inventory and Opus' site investigation, there are approximately 141 culverts within the Village, ranging in size from 100 mm to 1,200 mm. The majority of the culverts have been found to be 300 mm and 450 mm in diameter (55% and 18% by total length, respectively). The culverts in the Village are named with a two-letter prefix, denoting the road it is on, followed by two numbers.

3.2.3 Stormwater Mains

The stormwater mains receive surface runoff through catch basins. According to the Village's asset inventory, the total length of stormwater mains is estimated at 1.1 km. As per the Village's asset inventory, there are approximately 65 storm sewers within the Village, ranging in size from 100 mm to 750 mm. The majority of the mains have been found to be 300 mm, 450 mm, and 600 mm in diameter (18%, 23%, and 25% by total length, respectively).

3.2.4 Ditches

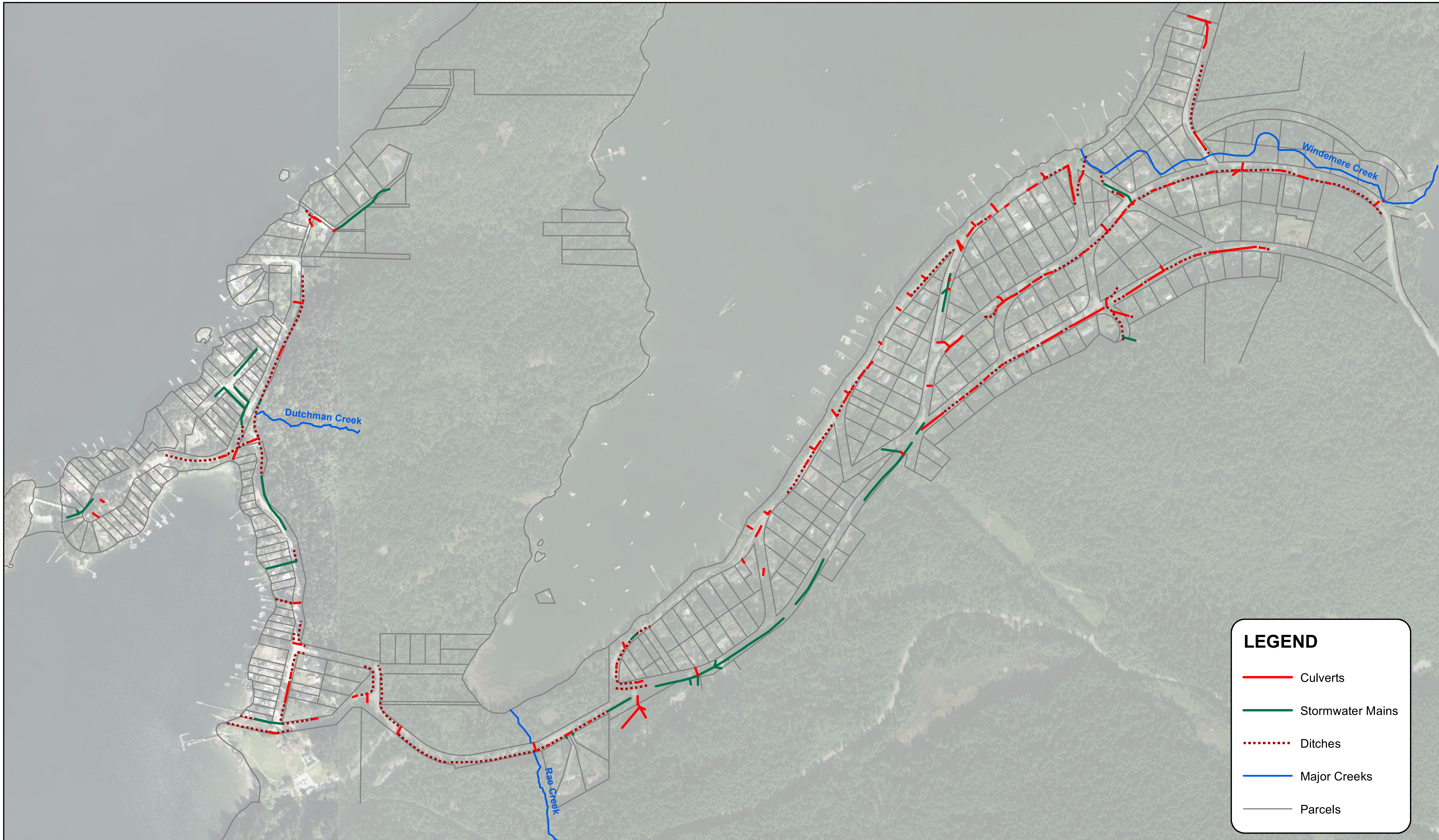
According to the Village's CAD files, the length of roadside ditches is estimated at approximately 4 km. Very limited information is available for the ditches and assumptions for their cross-sections had to be made for the purpose of hydraulic modelling (see Section 4.1.2).

3.2.5 Catch Basins and Inlets

Catch basins and inlets receive the surface runoff from the paved areas and discharge into ditches, culverts, and stormwater mains. As per the Village's CAD files, there are approximately 51 catch basins in the study area.

3.2.6 Outfalls

The Village's drainage system discharges into Bedwell Bay and Belcarra Bay through outfalls at various locations. In total, 41 outfalls identified and subsequently modelled in the study area's drainage model.



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VILLAGE OF BELCARRA DRAINAGE STUDY

EXISTING DRAINAGE SYSTEM

FIGURE 3-1

SCALE 1:7,000 @ TABLOID
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Path: G:\opus_dk\municipal\269 Village of Belcarra\gis\D-26913 (Drainage Study)\Fig 3-1 Existing_Drainage_System.mxd

4 Model Development

As part of this drainage study, Opus developed a hydraulic model to represent the study area's drainage system. The model was developed in the Computational Hydraulic International's PCSWMM software suite. The software offers comprehensive hydrologic and hydraulic modelling capabilities and is used internationally for stormwater, sanitary sewer, and watershed modelling.

The following sections provide an overview of our model development processes as well as its limitations, the key one being the model confidence as model calibration has not been completed (outside the scope of work).

4.1 Hydraulic Model Overview

The first task was to construct the physical network of the drainage system which includes assets such as culverts, ditches, stormwater mains, stormwater manholes, catch basins, and outfalls. Various modelling elements in PCSWMM were used to represent these drainage assets in the model and are summarized in Table 4-1. They are spatially shown in **Figure 4-1**.

Table 4-1 – Summary of Model Elements

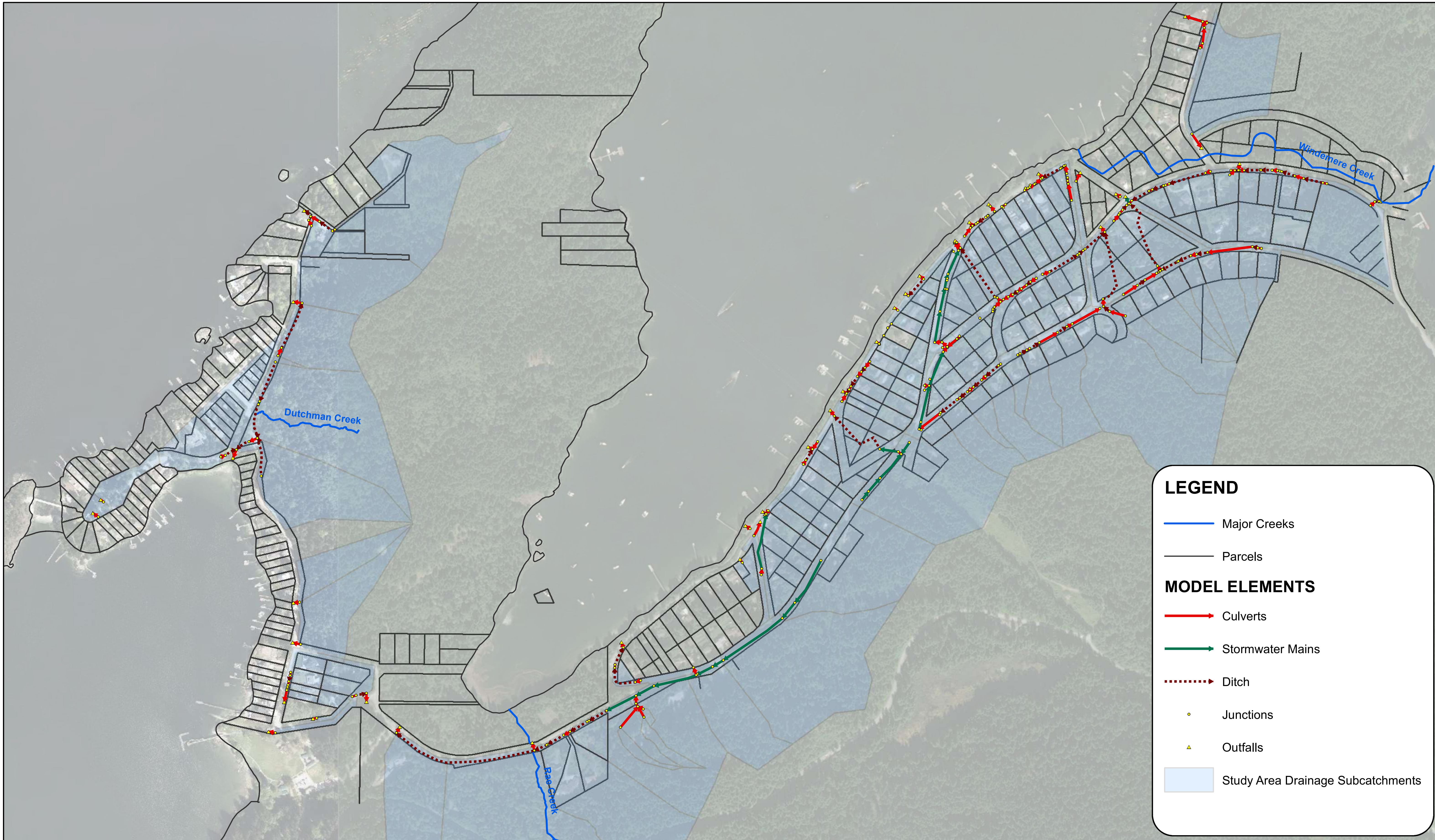
PCSWMM Model Element	Used to Represent	Count
Junction	• Manhole • Catch Basin • Nodes for connecting Ditch sections	345
Conduit	• Culvert • Ditch • Stormwater Sewer	242
Outfall	• Discharge location to creeks or open water (e.g. Bedwell or Belcarra Bay)	42

Each modelling element has a specific set of input data requirements, most of the data are available from the Village's CAD files, which are the primary input for developing the drainage model. The CAD files were converted into GIS shapefiles for review and formatting in ESRI ArcGIS 10.4 prior to import into PCSWMM. Field survey data, record drawings, and previous reports were used as supplementary sources of data to develop the model.

The following subsections provide further descriptions of the approach used and assumptions applied to each of the modelling elements.

4.1.1 Junctions

In a conveyance system, junctions are the nodes where links (conduits) join. Drainage manholes GIS shapefile was imported to PCSWMM to create the model junctions. Furthermore, a number of "dummy" junctions were created to ensure logical network connectivity. The principal input parameters for junctions are invert and rim elevations. The primary sources for the input parameter were field survey, contour data, and Village stormwater network drawings, where available.



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BELCARRA 1979

VILLAGE OF BELCARRA DRAINAGE STUDY

MODELLED DRAINAGE SYSTEM

FIGURE 4-1

SCALE 1:7,000 @ TABLOID — 0 0.075 0.15 KILOMETERS

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PREPARED BY	APPROVED BY
ML	PM

Path: G:\opus_dk\municipal\269 Village of Belcarra\gis\D-26913 (Drainage Study)\Fig 4-1 Modelled Drainage System.mxd

Opus included a total of 386 junctions (manholes, catch basins, and model connectivity nodes) in the model, of which 214 junctions (55%) were identified with unknown rim and/or invert elevations. 0.5 m contour data was used to estimate the rim elevation for junctions with missing rim elevations. The invert elevations were estimated by assuming a minimum pipe cover of half their diameter. In some cases, this was adjusted to allow for appropriate pipe slope.

4.1.2 Conduits

Culverts, stormwater mains, and ditches were modelled as conduits in the drainage hydraulic model. A number of "dummy" conduits were added to the model to ensure logical network connectivity. A total of 2 km of culverts were modelled. In addition, over 3.7 km of stormwater mains and ditches were modelled to ensure network connectivity. The principal input parameters for conduits are diameter, inlet/outlet elevations, length, and Manning's roughness coefficient (n).

Approximately 11% of the modelled culverts and approximately 40% of the modelled stormwater mains were missing diameter information. For these conduits, the immediate upstream or downstream conduit diameters were applied – smaller diameters were conservatively taken in the case of size differences upstream and downstream, where applicable.

Refer to Appendix B for a list and a figure of culverts and stormwater sewers with assumed sizes. It also identifies culverts assumed to be abandoned or replaced with a piped network. We would recommend Village staff field investigate these assets as a next-step and leverage the available funding for **"Data Collection and Reporting" through the new Federation of Canadian Municipalities' (FCM) Municipal Asset Management Program (MAMP)** – refer to Section 7.1 for more details.

Approximately 2.4 km of ditches were modelled. However, no drawings or field survey data was available for open channel cross sections. They were assumed to be trapezoidal based on the design standards in the Village's Subdivision and Development Bylaw No. 492, 2015, which also suggests a maximum depth of 1 m, maximum side slopes of 1.5 H: 1 V, a minimum bottom width of 0.3 m, and a minimum grade of 0.5% for ditches. These initial parameters were further refined based on available contour data and Google Earth Pro street views (where available).

Finally, the manning's roughness coefficient used for pipes (culverts and stormwater mains) is 0.013, which is the industry average for closed conduits. For ditches, a coefficient of 0.05 is applied as is typical for natural channels with regular section.

4.1.3 Outfalls

Terminal nodes within the drainage system were modelled as outfalls in the drainage model. They represent outfall discharges into creeks, rivers, and large waterbodies. The invert elevations and rim elevations are principal input parameters for outfalls. Note that it was beyond the scope of work to consider tidal or surcharging influence at the outfall, and as such, a "free" outfall condition is assumed for all modelled outfalls.

4.2 Hydrological Model

Typically, the hydrologic component of the model is responsible for runoff generation and flow routing from the drainage sub-catchment to the receiving drainage system (culverts, ditches, stormwater mains). For this Drainage Study, the Rational Method is used for runoff generation with the flow routing component captured in the time of concentration calculations completed for each sub-catchment. The runoff is then applied directly to the receiving culvert or ditch or stormwater main.

The following describes our approach to delineating the drainage sub-catchments in the study area as well as the runoff calculations completed for each of the sub-catchments.

4.2.1 Sub-catchment Delineation

Sub-catchments are hydrologic units of land whose topology and drainage system elements direct surface runoff to a single discharge point. To achieve higher resolution in the model, the study area was divided and delineated into numerous sub-catchments based on contour data, location of catch basins and service lines, Village parcels, and aerial photographs. The rural undeveloped sub-catchments, whose runoffs flow into the study area's drainage system, were also delineated and included in the model. Each of the sub-catchments were assigned a culvert or stormwater sewer that it discharges to. The sub-catchments are illustrated in **Figure 4-1**.

4.2.2 Runoff Calculation

Once all the sub-catchments have been delineated and a discharging conduit assigned, the Rational Method was used to determine their runoff rates. The runoff is then applied directly to the discharging conduit in the model for hydraulic capacity assessment. The following summarizes our approach to calculating runoffs. Refer to Appendix D for the complete calculations for each sub-catchment.

According to the Village's Bylaw, the following Rational Method formula is used:

> Q = RAIN, where:
>
> **Q** = Flow in m^3/s; **R** = Product of runoff coefficient and adjustment factor; **A** = Drainage area in hectares; **I** = Rainfall Intensity in mm/hr; and, **N** = 0.00278.

Out of the four input parameters, two are readily available ("A" and "N"). For the other two ("R" and "I"), the following approach was adopted to determine their values for each sub-catchment.

4.2.2.1 Runoff Coefficient ("R")

Opus reviewed the aerial photograph (Google Maps) of the study area and determined, for each sub-catchment, the percentage of area that is residential, parks/green area, or roads. By applying the Bylaw-suggested runoff coefficients and adjustment factors, an area-weighted average "R" was then determined for each sub-catchment. Refer to Appendix D for the detailed calculation of "R".

The runoff coefficient "C" is a key component in the application of Rational Method. It is reasonable to assume that "C" is independent of rainfall intensity or volume in impervious areas, such as streets, rooftops and parking lots. For pervious areas, the fraction of runoff varies with rainfall intensity and the accumulated volume of rainfall. Thus, it is crucial in the application of the Rational Method to select a runoff coefficient that is appropriate for the storm, soil and land use conditions. For the purpose of this study, a weighted “C” factor was estimated using the Village Bylaw recommendation for the various lands uses, which are eventually multiplied by the adjustment factors, also proposed by the Bylaw. The percentages of different land use types in each sub-catchment were determined through a high-level visual review of the current (2017) ortho photos and did not involve field reviews or delineation of land use polygons. Assessment of the future land use conditions are beyond the scope of this study.

4.2.2.2 Rainfall Intensity (“I”)

The rainfall intensity (“I”) is determined using two input parameters: Intensity-Duration-Frequency (IDF) curves and Time of Concentration (“T_c”).

IDF Curves

In the 1984 Drainage Study Report, there were no IDF curves presented. However, there were mentions of using 20-minute duration storm intensities of 30.5 mm/hr and 45.7 mm/hr for the 5-year and 100-year storms. The 20-minute duration was determined based on the Time of Concentration calculation, which was applied commonly to all sub-catchments. Based on our review of all currently available IDF curves of Environment Canada rain gauges in the area, the one in North Vancouver at Lynn Creek (Station # 1105660) has IDF curves that closely match the intensities cited in the 1984 report. The rain gauge is located at an elevation and environment (e.g. surrounded by mountains) similar to that of the study area. These IDF curves were assumed for assessing existing scenarios without climate change.

It is also within the scope of this study to account for climate change in our assessments. The neighbouring municipality of the District of North Vancouver (DNV) has completed an update to their Bylaw (DNV Development Servicing Bylaw 8145, 2017) and it includes IDF curves that incorporate future climate change scenarios to the year 2100. It was agreed upon with the Village that the IDF curves corresponding to the “Lower Zone” be used for this Drainage Study, more specifically, to assess the existing system’s hydraulic capacities and to help size upgrades to the system.

Table 4-2 illustrates the range of rainfall volumes for various durations of the 5-year and 100-year return period design storms. Refer to Appendix C for the IDF curves used in this study.

Table 4-2 – Range of Design Rainfall Volumes

Duration	5-Year (mm)		100-Year (mm)	
	Existing	Climate Change	Existing	Climate Change
15-min	8.3	12.1	12.5	22.3
30-min	11.9	15.9	17.7	28.5
1-hour	17.6	21.0	26.0	36.0
24-hour	156.5	146.4	255.8	234.6

Time of Concentration

In order to calculate the Time of Concentration (T_c) parameter, as per the Village Bylaw, the sub-catchment *slope, length, concentration coefficient,* and *friction factor* need to be determined. The *slope* was estimated using the Digital Elevation Model (DEM), available through Natural Resources Canada[1]. The *length* was estimated by tracing the drainage flow path from the furthest point in the sub-catchment to the discharge point. The *concentration coefficient* and *friction factor* were estimated via review of the ortho photos and factoring the length of overland flow paths, ditches, stormwater sewers, percentage of paved and natural areas.

All the above parameters are summarized in Appendix D.

4.3 Model Exclusions & Limitations

4.3.1 Model Exclusion

As the primary focus of the Drainage Study was to assess the hydraulic capacity of the Village's culverts and stormwater sewers, the ditches were modelled with assumed parameters to provide model network connectivity. In addition, it was outside the scope of the Drainage Study to model the conveyance of the major system including overland flow, road drainage, and creeks. Finally, tidal impacts of Bedwell Bay and Belcarra Bay on the study area's outfalls have not been considered.

4.3.2 Model Confidence

It was beyond the scope of this study to calibrate the model to observe flows. In addition, cross sections of the ditches were not surveyed, instead they were modelled based on contour data, aerial imagery review, and using typical geometry as per the Village's subdivision bylaw. This limits the model's ability to capture the actual cross section of the ditches, and will only provide an approximation to capacity. All the above have limited the use of this model to planning level studies and conceptual recommendations only. Considering that the Village has no recorded hydraulic and flooding issues in the past, the current model is adequate.

[1] http://open.canada.ca/data/en/dataset/7f245e4d-76c2-4caa-951a-45d1d2051333

4.3.3 Hydrology Limitations

The Village's Bylaw stipulates using the Rational Method for tributary areas up to 4.0 hectares. Over 95% of the catchments delineated in the study area are less than 4.0 hectares and as such, the Rational Method was used in this study. One key characteristic of the Rational Method is that the rate of runoff resulting from any rainfall intensity is a maximum when the rainfall intensity lasts as long or longer than the time of concentration. Specifically, the entire drainage area does not contribute to the peak discharge until the time of concentration has elapsed. This assumption limits the size of the drainage basin that can be evaluated by this method and will typically result in overestimated peak flows. This is adequate for this study in-lieu of flow monitoring data to compare model predictions against.

5 Conveyance Capacity Assessment

This section presents the findings from our conveyance capacity assessment, identifying those culverts and stormwater sewers that are deficient under the existing and climate change scenarios. We have also outlined the evaluation criteria used to assess the culverts and stormwater sewers in the study area.

5.1 Evaluation Criteria

As per the Village Bylaw, the minor system and the major system are to be designed to convey 5-year and 100-year flows, respectively. The minor system includes the stormwater sewers and the driveway culverts while the major system includes the road culverts, ditches, and the roads.

Although a detailed assessment of the major system is beyond the scope of this drainage study, especially the review of ditch capacities and major flow routes, we have included critical road culverts in our capacity assessments. These culverts are typically located downhill and are outfalls to the system. The purpose of reviewing these critical culverts is to ensure that they are adequately sized to convey major system flows out of the system into the bays or creeks.

In general, a culvert or a stormwater sewer's inadequate capacity are predicted in the hydraulic model in the form of a flow restriction that causes flooding in the upstream system.

5.2 Assessment Results

The drainage system in the study area was assessed under three flow conditions:

- 5-year Storm without Climate Change
- 5-year Storm with Climate Change
- 100-year Storm with Climate Change

5.2.1 5-Year Storm – Validation Scenario

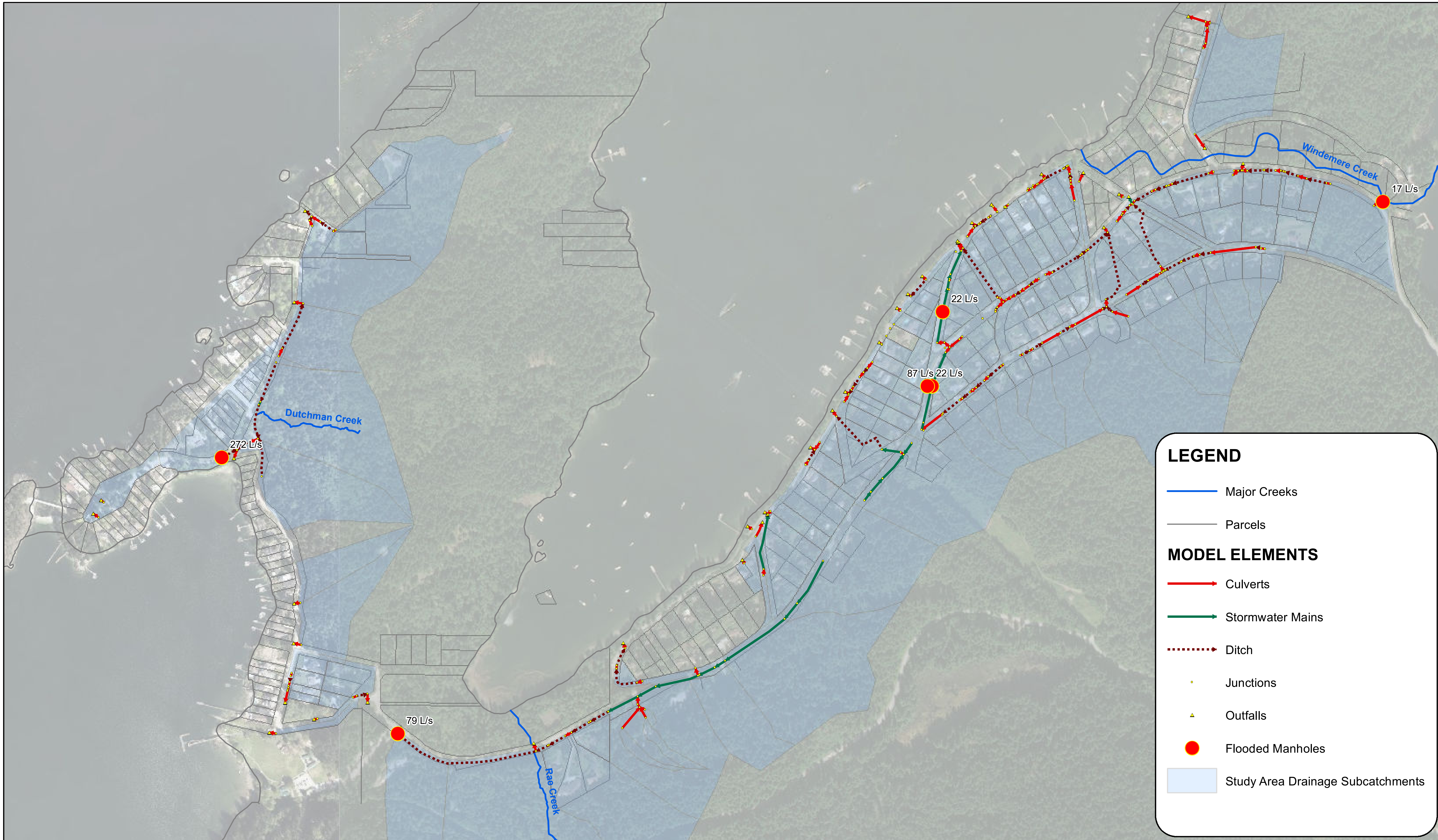
According to Village staff, the study area has not experienced significant flooding or ponding issues, which is indicative of adequate conveyance capacity in the existing drainage system for rainfall events up to the "minor" system's design criteria of 5-year return period flows. In lieu of measured flow data and model calibration, Opus used the above observation as anecdotal information to validate the model. The hydraulic model is not predicting flooding in the study area under the 5-year storm event.

5.2.2 5-Year Storm with Climate Change – Assessment Scenario

Under the 5-year design flows with climate change, the model predicts a total of six (6) flooding locations in the study area as shown in Figure 5-1. Three out of the six flooding occurrences are caused directly by inadequate downstream culvert capacities, namely "BD-76", "BD-01A", and "TU-02". The other flooding occurrences are caused by the inadequate capacities in stormwater sewers along Kelly Road.

5.2.3 100-Year Storm with Climate Change – Assessment Scenario

Under the 100-year design flows with climate change, the model predicts a total of 24 flooding occurrences in the study area as shown in Figure 5-2. The majority of the flooding is caused by the insufficient capacity in the minor system (i.e. driveway culverts and stormwater sewers) to convey the 100-year flows (i.e. major system flows).



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VILLAGE OF BELCARRA DRAINAGE STUDY

CULVERT CAPACITY ASSESSMENT 5-YEAR STORM WITH CLIMATE CHANGE

FIGURE 5-1

SCALE
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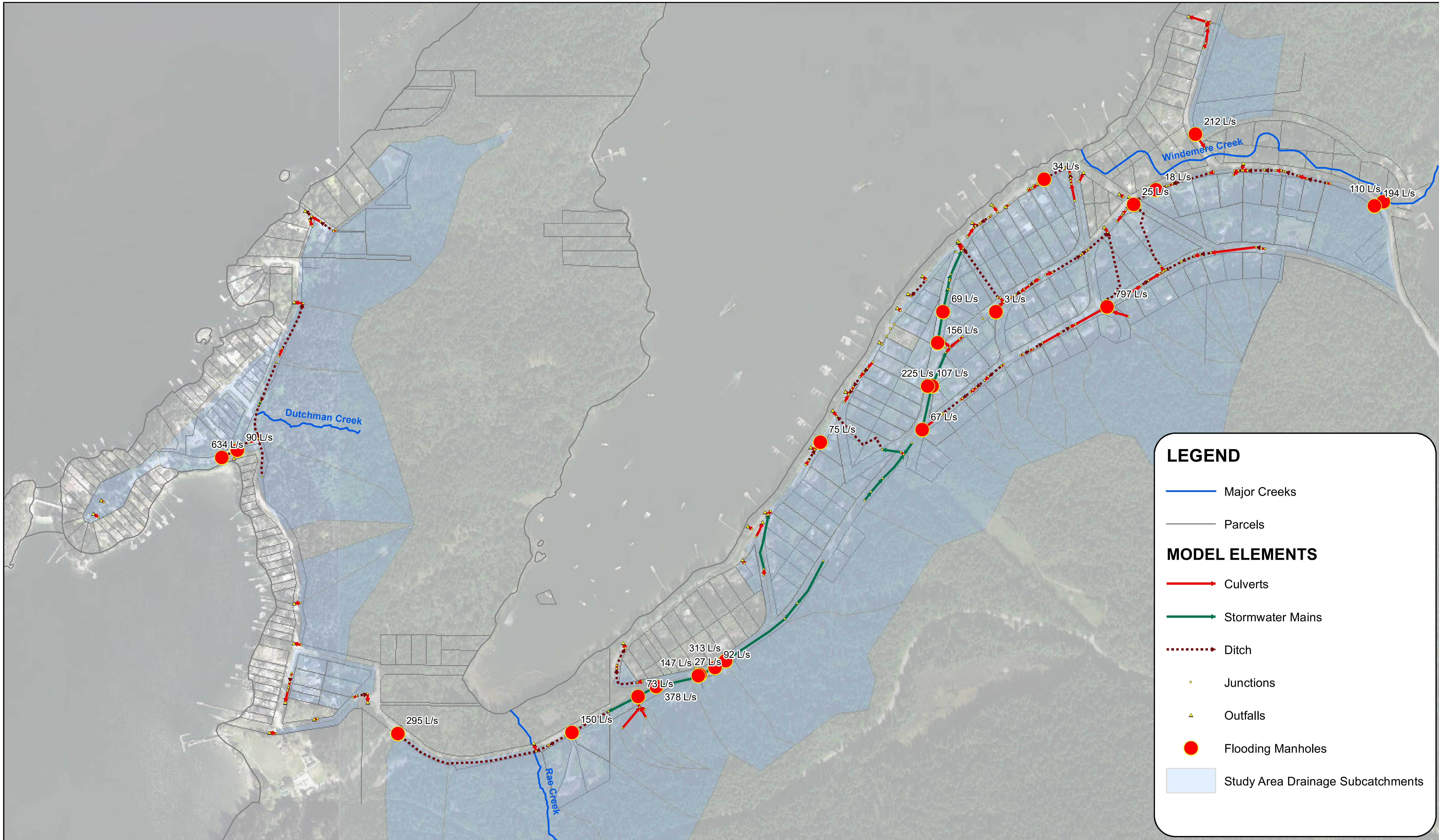
PROJECT NO
D-26913.00

DATE
NOV 2017

PREPARED BY	APPROVED BY
ML	**PM**

Path: G:\opus_dk\municipal\269 Village of Belcarra\gis\D-26913 (Drainage Study)\Fig 5-1 Culvert Capacity Assessment - 5-Year Storm with Climate Change.mxd



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VILLAGE OF BELCARRA DRAINAGE STUDY

CULVERT CAPACITY ASSESSMENT 100-YEAR STORM WITH CLIMATE CHANGE

FIGURE 5-2	PROJECT NO D-26913.00	
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	PREPARED BY ML	APPROVED BY PM

Path: G:\opus_dk\municipal\1269 Village of Belcarra\gis\D-26913 (Drainage Study)\Fig 5-2 Culvert Capacity Assessment - 100-Year Storm with Climate Change.mxd

6 Drainage System Improvement Works

This section summarizes the upsizing requirements for the deficient culverts and stormwater sewers, as identified in the previous section of this report, to meet design flows under the 5-year and 100-year climate change scenarios for the minor and major systems, respectively. This section also provides Class "D" cost estimates for not only the upsizing of deficient pipes, but also the replacement (same-size) of the other culverts and stormwater sewers with the purpose of incorporating the estimated value of the Village's drainage assets into the Tangible Capital Assets (TCA) list.

6.1 Cost Estimate Basis

Table 6-1 below summarizes the unit rates used to provide a Class "D" cost estimate for upsizing and replacement of culverts and stormwater sewers. Also included is the lump sum costs associated with headwall and tailwall structures, in the case of culverts.

These unit rates and costs include only supply and installation, road/pavement restoration, and an allowance of 40% for engineering fees and contingency. They are developed based on relevant past projects within BC municipalities and Opus' internal cost database, adjusted to 2017 Canadian dollars.

Table 6-1 – Unit Costs for Culvert & Stormwater Sewer Replacement (2017 Canadian Dollars)

Item	Size	Unit Cost ($) (Culvert/Storm Sewer)	Unit
Culverts / Stormwater Sewers	100	$350 / $500	/m
	150	$400 / $600	/m
	200	$450 / $700	/m
	250	$500 / $800	/m
	300	$550 / $900	/m
	350	$600 / $1,000	/m
	375	$650 / $1,050	/m
	400	$700 / $1,100	/m
	450	$750 / $1,175	/m
	500	$800 / $1,275	/m
	525	$850 / $1,300	/m
	600	$900 / $1,475	/m
	700	$950 / $1,700	/m
	750	$1,000 / $1,800	/m
	900	$1,050 / $2,000	/m
	1,200	$1,100 / $2,650	/m
Headwall and Road Restoration		$20,000	Lump Sum

The reader should note that the above unit rates are Class "D" cost estimates adequate for budgetary planning only. A more accurate cost estimate will require site investigation and be determined on a case-by-case basis, which is outside the scope of this Drainage Study.

6.2 Culvert & Stormwater Sewer Upsize

We are recommending a total of nine (9) culverts (approximately 134 metres) and 265 m of stormwater sewers for upsizing. The estimated cost (Class 'D') for such improvement works is **$499,300** (2017 Canadian dollar). Of which, $187,400 is attributed to the upsizing of culverts and $311.900 to the upsizing of stormwater sewers.

Most of the culverts requiring upsizing are part of the major system and are sized for the 100-year flows. They are situated at outfalls to the system, discharging directly to either the Belcarra/Bedwell Bays, or the Sasamat Lake. The stormwater sewers requiring upsizing are situated along Kelly Road and are part of the minor system, they are sized for the 5-year return period storm. Their locations and recommended sizes are shown in Figure 6-1.

6.3 Drainage Asset Value

The review of pipe age, condition, remaining useful life, and the development of a replacement schedule for the existing culverts and stormwater sewers are outside the scope of this Drainage Study. However, it is the intent of this study to estimate the replacement value of the Village's drainage asset such that it can be incorporated into the TCA list.

Table 6-2 provides an inventory of the study area's drainage assets, namely the culverts and stormwater sewers, and their respective replacement cost estimates. For culverts with known upstream or downstream headwall material, their replacements include the costs associated with a new head/tailwall as well.

Based on our unit costs described in Section 6.1, the total value of the drainage assets is estimated at **$4.5 million** (2017 Canadian dollar). Of which, $2.1 million is attributed to culverts and $2.4 million to stormwater sewers. These include the costs of the necessary upsizing of culverts and stormwater sewers (i.e. the improvement works). For those assets not requiring upsizing, the cost of replacement (same-size) was considered.

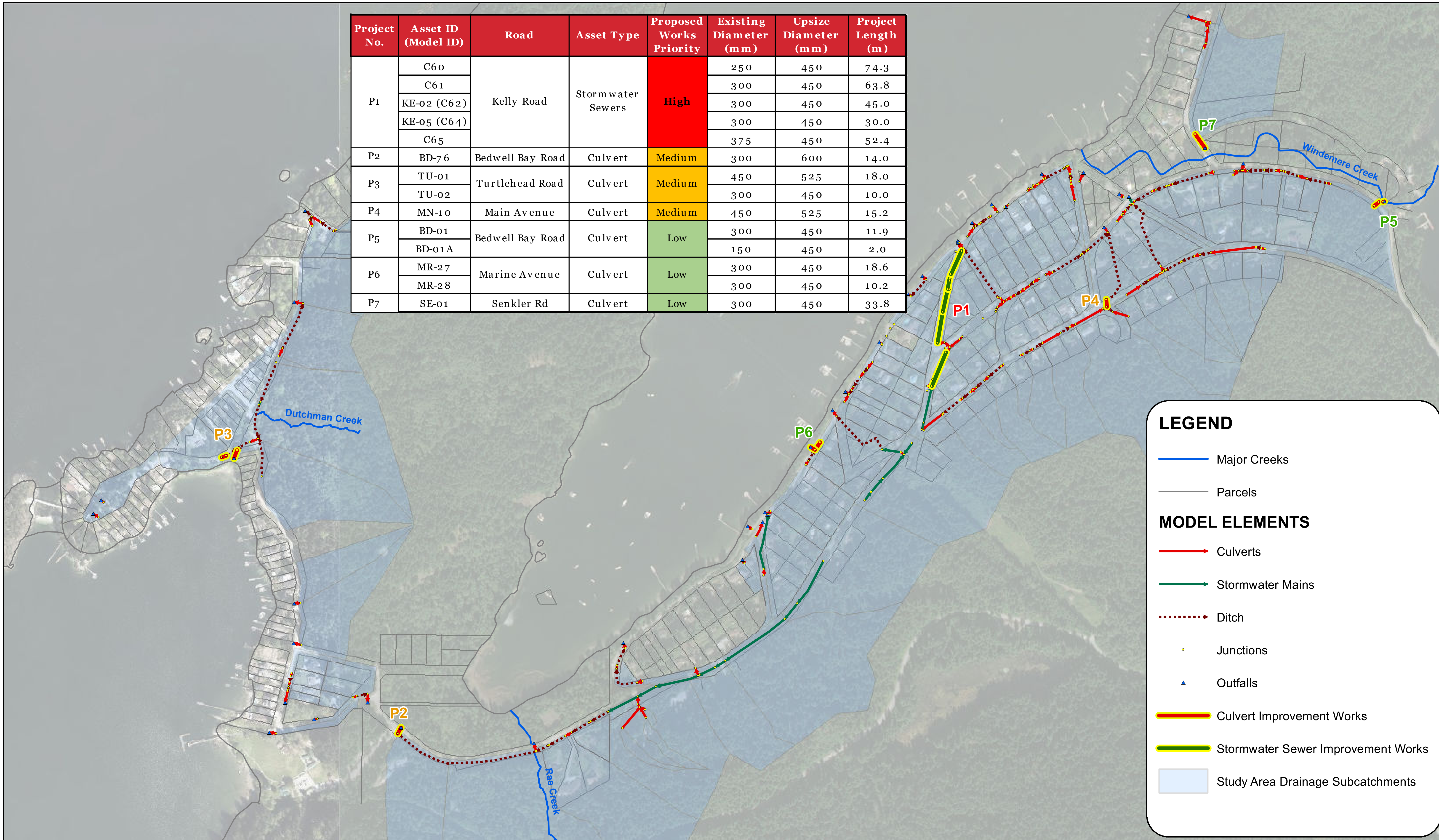
6.4 Next Steps

Typically, for modelling studies, we would recommend clients to improve the confidence of the model by way of flow monitoring and model calibration. However, considering that the Village is not experiencing significant flooding issues, these modelling improvements may not be a priority.

Opus included a total of 386 junctions (manholes, catch basins, and model connectivity nodes) in the model, of which 214 junctions (55%) were identified with unknown rim and/or invert elevations. Approximately 11% of the modelled culverts and approximately 40% of the modelled stormwater mains were missing diameter information. The Village may wish to, as a next-step, consider completing data collection for its drainage (and potentially other) assets including its ageing culverts. There are funds available through the FCM's Municipal Asset Management Program (see next section for more details) for "Data Collection and Reporting". The intent of this exercise is to enhance the Village's asset management practices.

With a better understanding of its assets, the Village can better prioritize investment decisions such as the design and implementation of a piped network to replace the open channel system in Belcarra. Refer to the next section for relevant funding availabilities.

Project No.	Asset ID (Model ID)	Road	Asset Type	Proposed Works Priority	Existing Diameter (mm)	Upsize Diameter (mm)	Project Length (m)
P1	C60	Kelly Road	Stormwater Sewers	High	250	450	74.3
	C61				300	450	63.8
	KE-02 (C62)				300	450	45.0
	KE-05 (C64)				300	450	30.0
	C65				375	450	52.4
P2	BD-76	Bedwell Bay Road	Culvert	Medium	300	600	14.0
P3	TU-01	Turtlehead Road	Culvert	Medium	450	525	18.0
	TU-02				300	450	10.0
P4	MN-10	Main Avenue	Culvert	Medium	450	525	15.2
P5	BD-01	Bedwell Bay Road	Culvert	Low	300	450	11.9
	BD-01A				150	450	2.0
P6	MR-27	Marine Avenue	Culvert	Low	300	450	18.6
	MR-28				300	450	10.2
P7	SE-01	Senkler Rd	Culvert	Low	300	450	33.8



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VILLAGE OF BELCARRA DRAINAGE STUDY

STORMWATER SEWER & CULVERT UPSIZING REQUIREMENTS

FIGURE 6-1

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PROJECT NO D-26913.00

DATE NOV 2017

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Path: G:\opus_dk\municipal\269 Village of Belcarra\gis\D-26913 (Drainage Study)\Fig 6-1 Stormwater Sewer & Culvert Upsizing Requirements.mxd

Table 6-2 - Drainage Asset Value - Replacement Cost

Road Name	Pipe ID	Asset Type	Diameter (mm)	Pipe Material	GIS/Modelled Length (m)	Upstream Headwall Material	Downstream Headwall Material	Proposed Works Priority	Proposed Upsize Diameter	Improvement/ Replacement Cost
Bedwell Bay Rd	BD-01	Culvert	300	Unknown	11.9	Rock	Cement Bag	Low	450	$28,910
	BD-01A	Culvert	150	Unknown	2.0	Wood	Wood	Low	450	$21,510
	BD-02	Culvert	200	Unknown	8.0	None	None			$3,582
	BD-03	Culvert	450	Unknown	18.6	None	Rock			$33,973
	BD-04	Culvert	450	Unknown	3.7	Cement Bag	Cement Bag			$22,745
	BD-05	Culvert	450	Unknown	11.0	None	Cement Bag			$28,270
	BD-05A	Culvert	450	Unknown	1.9	Cement Bag	Cement Bag			$21,455
	BD-06	Culvert	450	Unknown	11.5	None	N/A			$8,610
	BD-07	Culvert	600	Unknown	14.2	N/A	Cast Concrete			$32,745
	BD-08	Culvert	300	Unknown	8.0	None	None			$4,404
	BD-09	Culvert	450	Unknown	14.0	Rock	Rock			$30,466
	BD-10	Culvert	300	Unknown	10.4	Cast Concrete	Cast Concrete			$25,742
	BD-11	Culvert	300	Unknown	7.5	Rock	Rock			$24,145
	BD-11A	Culvert	300	Concrete	1.5	None	None			$825
	BD-12	Culvert	300	Unknown	7.5	Cast Concrete	Cast Concrete			$24,133
	BD-13	Culvert	600	Concrete	7.9	Cement Bag	N/A			$27,124
	BD-14	Culvert	750	Unknown	2.8	Cement Bag	N/A			$22,793
	BD-16	Culvert	600	Unknown	6.1	Cement Bag	N/A			$25,489
	BD-17	Culvert	300	Unknown	8.4	None	None			$4,617
	BD-18	Culvert	300	Unknown	15.7	None	Cement Bag			$28,621
	BD-19	Culvert	900	Unknown	13.6	Unknown	Rock			$34,252
	BD-20	Culvert	300	Unknown	5.0	None	None			$2,771
	BD-21	Culvert	300	Concrete	4.6	None	None			$2,514
	BD-22	Culvert	300	Concrete	15.2	None	None			$8,333
	BD-23	Culvert	300	Concrete	13.8	None	None			$7,563
	BD-24	Culvert	300	Concrete	22.5	Wood	None			$32,375
	BD-25	Culvert	300	Concrete	21.6	None	None			$11,865
	BD-26	Culvert	300	Concrete	7.7	None	None			$4,228
	BD-27	Culvert	300	Unknown	10.5	Plastic	Cast Concrete			$25,782
	BD-28	Culvert	250	PVC	16.2	None	None			$8,100
	BD-29	Culvert	100	PVC	4.6	None	None			$1,600
	BD-30	Culvert	300	Concrete	7.9	None	None			$4,340
	BD-31	Culvert	300	Concrete	25.3	None	None			$13,901
	BD-32	Culvert	500	Concrete	14.3	Cast Concrete	Rock			$31,474
	BD-33	Culvert	450	PVC	13.2	None	None			$9,867
	BD-34	Culvert	250	Unknown	9.1	None	None			$4,540
	BD-37	Culvert	450	Concrete	7.6	None	None			$5,731
	BD-58	Culvert	150	PVC	3.2	None	None			$1,271
	BD-59	Culvert	200	PVC	16.5	None	None			$7,425
	BD-64	Culvert	300	Concrete	16.0	None	None			$8,800
	BD-65	Culvert	350	Galvanized Pipe	7.0	None	None			$4,200
	BD-66	Culvert	250	Concrete	12.0	None	None			$6,000
	BD-67	Culvert	250	Concrete	25.0	None	None			$12,500
	BD-68	Culvert	300	Concrete	55.0	None	None			$30,250
	BD-70	Culvert	600	Concrete	4.5	Cast Concrete	Cast Concrete			$24,050
	BD-71	Culvert	600	Concrete	14.9	Cement Bag	Cement Bag			$33,410
	BD-74	Culvert	600	Concrete	2.4	Cement Bag	Cement Bag			$22,160
	BD-75	Culvert	1200	Concrete	16.8	Cast Concrete	Rock			$38,436
	BD-76	Culvert	300	Unknown	14.0	PVC?	Cast Concrete	Medium	600	$32,618
	BD-15	Stormwater Sewer	750	Unknown	16.0	N/A	N/A			$28,800
	BD-35	Stormwater Sewer	300	Unknown	26.0	None	None			$23,400
	BD-36	Stormwater Sewer	300	Concrete	29.0	None	None			$26,100
	BD-38	Stormwater Sewer	450	Concrete	21.0	None	None			$24,675
	BD-39	Stormwater Sewer	450	Concrete	9.0	None	None			$10,575
	BD-40	Stormwater Sewer	450	Concrete	33.0	None	None			$38,775
	BD-41	Stormwater Sewer	300	Concrete	27.0	None	None			$24,300
	BD-42	Stormwater Sewer	300	Concrete	12.0	None	None			$10,800
	BD-43	Stormwater Sewer	150	PVC	22.0	None	None			$13,200
	BD-46	Stormwater Sewer	600	Unknown	39.0	None	None			$57,525
	BD-45	Stormwater Sewer	600	Unknown	44.0	None	None			$64,900
	BD-44	Stormwater Sewer	600	PVC	23.0	None	None			$33,925
	BD-47	Stormwater Sewer	600	Concrete	40.0	None	None			$59,000
	BD-48	Stormwater Sewer	150	PVC	0.5	None	None			$288
	BD-49	Stormwater Sewer	600	Concrete	52.0	None	None			$76,700
	BD-50	Stormwater Sewer	150	PVC	1.0	None	None			$600
	BD-51	Stormwater Sewer	600	Concrete	57.0	None	None			$84,075
	BD-52	Stormwater Sewer	150	PVC	0.5	None	None			$270
	BD-53	Stormwater Sewer	150	PVC	1.0	None	None			$600
	BD-55	Stormwater Sewer	300	Concrete	12.0	None	None			$10,800
	BD-54	Stormwater Sewer	600	Concrete	24.0	None	None			$35,400
	BD-61	Stormwater Sewer	450	Concrete	18.0	None	None			$21,150
	BD-57	Stormwater Sewer	600	Concrete-PVC?	37.0	None	None			$54,575
	BD-56	Stormwater Sewer	100	PVC	15.0	None	None			$7,500
	BD-63	Stormwater Sewer	450	Concrete	71.0	None	None			$83,425
	BD-60	Stormwater Sewer	300	Galvanized Pipe	19.0	None	None			$17,100
	BD-62	Stormwater Sewer	150	PVC	12.0	None	None			$7,200
	BD-69	Stormwater Sewer	450	CPP	52.0	Unknown	Unknown			$61,100
	BD-72	Stormwater Sewer	300	Concrete	6.0	None	None			$5,400
	BD-73	Stormwater Sewer	200	PVC	6.0	None	None			$4,200
	C59	Stormwater Sewer	300	-	90.6	-	-			$81,498
	C60	Stormwater Sewer	250	-	74.3	-	-	High	450	$87,253
	C69	Stormwater Sewer	600	-	40.5	-	-			$59,776
	C75	Stormwater Sewer	450	-	41.7	-	-			$48,994
Belcarra Bay Rd	BL-01	Culvert	450	Concrete	24.4	Cement Bag	Unknown			$38,287
	BL-03	Culvert	300	Unknown	7.3	Cement Bag	Cement Bag			$24,021
	BL-04	Culvert	300	Concrete	6.4	Wood	Wood			$23,509
	BL-05	Culvert	450	Concrete	16.8	Steel Cage	None			$32,573
	BL-06	Culvert	300	Concrete	12.8	Unknown	Unknown			$7,040
	BL-13	Culvert	600	Metal	18.4	Unknown	Unknown			$16,582
	BL-14C	Culvert	600	DNE	18.3	DNE	DNE			$16,457
	BL-18	Culvert	250	Unknown	17.4	Unknown	Unknown			$8,718
	BL-2	Culvert	350	DNE	4.0	DNE	DNE			$2,384
	BL-07	Stormwater Sewer	300	Concrete	10.0	Unknown	Unknown			$9,000
	BL-08	Stormwater Sewer	450	CPP	52.0	Unknown	Unknown			$61,100
	BL-09	Stormwater Sewer	100	PVC	24.0	Unknown	Unknown			$12,000
	BL-10	Stormwater Sewer	150	Big-O	30.0	Unknown	Unknown			$18,000
	BL-11	Stormwater Sewer	300	Concrete	29.0	Unknown	Unknown			$26,100
	BL-12	Stormwater Sewer	300	Concrete	38.0	Unknown	Unknown			$34,200
	BL-14P	Stormwater Sewer	600	DNE	12.0	DNE	DNE			$17,700
	BL-15	Stormwater Sewer	500	Metal	22.0	None	None			$28,050
	BL-16	Stormwater Sewer	450	Metal	15.0	None	None			$17,625
	BL-17	Stormwater Sewer	300	Concrete	6.0	Dirt	Dirt			$5,400
Bostock Rd	BS-01	Stormwater Sewer	450	Galvanized Pipe	38.0	None	None			$44,650
Coombe Ln	CO-01	Culvert	600	DNE	12.4	DNE	DNE			$11,187
	CO-02	Culvert	600	DNE	20.4	DNE	DNE			$18,360
	CO-03	Culvert	600	DNE	5.7	DNE	DNE			$5,114
	CO-04	Stormwater Sewer	600	DNE	16.0	DNE	DNE			$23,600
	CO-05	Stormwater Sewer	600	DNE	25.0	DNE	DNE			$36,875
	CO-06	Stormwater Sewer	600	DNE	52.0	DNE	DNE			$76,700
	CO-07	Stormwater Sewer	600	DNE	20.0	DNE	DNE			$29,500
	CO-08	Stormwater Sewer	600	DNE	11.0	DNE	DNE			$16,225
	CO-09	Stormwater Sewer	600	DNE	14.0	DNE	DNE			$20,650
Kelly Rd	KE-01	Culvert	700	CPP	14.8	None	None			$14,043
	KE-04	Culvert	100	Unknown	3.8	None	None			$1,320
	KE-06	Culvert	100	Unknown	4.0	None	None			$1,415
	KE-03	Stormwater Sewer	600	Unknown	15.0	None	None			$22,125
	KE-02	Stormwater Sewer	300	Perforated Pipe	45.0	None	None	High	450	$52,875
	KE-05	Stormwater Sewer	300	Perforated Pipe	30.0	None	None	High	450	$35,250
	C61	Stormwater Sewer	300	-	63.8	-	-	High	450	$74,997
	C65	Stormwater Sewer	375	-	52.4	-	-	High	450	$61,523
Madison Rd	MD-01	Culvert	400	Wood	17.4	Unknown	Unknown			$12,159
	MD-02	Culvert	300	Concrete	8.2	Rock	Rock			$24,510
	MD-03	Culvert	300	Concrete	7.6	Unknown	Unknown			$4,191
	MD-04	Culvert	300	Concrete	14.3	Unknown	Unknown			$7,865
	MD-05	Stormwater Sewer	400	Wood	25.0	Unknown	Unknown			$27,500
	MD-06	Stormwater Sewer	400	Concrete	30.0	Unknown	Unknown			$33,000

Table 6-2 - Drainage Asset Value - Replacement Cost

Road Name	Pipe ID	Asset Type	Diameter (mm)	Pipe Material	GIS/Modelled Length (m)	Upstream Headwall Material	Downstream Headwall Material	Proposed Works Priority	Proposed Upsize Diameter	Improvement/ Replacement Cost
Main Ave	MN-01	Culvert	300	Unknown	7.5	None	None			$4,129
	MN-02	Culvert	300	Unknown	91.9	None	None			$50,554
	MN-03	Culvert	300	Unknown	12.3	Cast Concrete	Cast Concrete			$26,773
	MN-04	Culvert	300	Unknown	2.1	Cement Bag	Cement Bag			$21,164
	MN-05	Culvert	450	Unknown	3.0	Cement Bag	Cement Bag			$22,228
	MN-06	Culvert	750	Unknown	11.4	N/A	Cement Bag			$31,350
	MN-07	Culvert	300	Unknown	5.5	Cement Bag	Cement Bag			$23,033
	MN-08	Culvert	300	Unknown	27.0	None	None			$14,869
	MN-09	Culvert	300	Unknown	33.8	None	None			$18,590
	MN-10	Culvert	450	CSP	15.2	None	None	Medium	525	$13,708
	MN-11	Culvert	450	Unknown	64.0	Rock	Cast Concrete			$68,007
	MN-12	Culvert	450	Unknown	12.6	Rock	Rock			$29,433
	MN-13	Culvert	300	Unknown	42.4	Rock	Rock			$43,341
	MN-14	Culvert	300	Unknown	6.9	None	None			$3,771
	MN-15	Culvert	300	Unknown	5.5	None	None			$3,028
	MN-16	Culvert	300	Unknown	5.4	Cement Bag	Cement Bag			$22,963
	MN-17	Culvert	300	Unknown	10.8	None	None			$5,952
	MN-18	Culvert	300	Unknown	15.7	None	None			$8,626
	MN-19	Culvert	300	Unknown	6.9	None	None			$3,809
	MN-20	Culvert	450	Unknown	54.7	Cast Concrete	N/A			$61,028
Marine Ave	MR-01	Culvert	300	Concrete	2.9	None	None			$1,602
	MR-02	Culvert	300	Concrete	2.4	None	None			$1,320
	MR-03	Culvert	375	Concrete	11.7	Cast Concrete (2.1m)	None			$27,600
	MR-04	Culvert	300	Unknown	18.3	N/A	N/A			$10,046
	MR-05	Culvert	300	Concrete	11.0	None	None			$6,034
	MR-06	Culvert	300	Concrete	8.0	None	None			$4,400
	MR-07	Culvert	300	Concrete	7.0	None	None			$3,850
	MR-08	Culvert	300	Concrete	13.4	None	None			$7,348
	MR-09	Culvert	300	Galvanized Metal	5.8	None	None			$3,191
	MR-10	Culvert	300	Concrete	5.0	None	None			$2,750
	MR-11	Culvert	300	Concrete	4.6	None	None			$2,519
	MR-12	Culvert	300	Concrete	10.1	None	None			$5,554
	MR-13	Culvert	300	Concrete	20.6	None	None			$11,306
	MR-14	Culvert	100	PVC	5.2	None	None			$1,811
	MR-15	Culvert	520	Unknown	16.0	N/A	N/A			$13,564
	MR-16	Culvert	520	Concrete	18.6	None	None			$15,813
	MR-17	Culvert	300	Unknown	10.7	None	None			$5,880
	MR-18	Culvert	300	Concrete	7.8	None	None			$4,315
	MR-19	Culvert	300	Unknown	8.8	None	None			$4,865
	MR-20	Culvert	300	Concrete	6.9	None	None			$3,788
	MR-21	Culvert	300	Unknown	16.0	None	None			$8,792
	MR-22	Culvert	300	Unknown	12.4	None	None			$6,793
	MR-23	Culvert	300	Unknown	7.4	None	None			$4,090
	MR-24	Culvert	400	Unknown	9.0	None	None			$6,290
Marine Ave	MR-25	Culvert	300	Unknown	15.9	None	None			$8,767
	MR-26	Culvert	450	Unknown	15.0	None	None			$11,258
	MR-27	Culvert	300	Unknown	18.6	None	None	Low	450	$13,935
	MR-28	Culvert	300	Unknown	10.2	None	None	Low	450	$7,668
	MR-29	Culvert	300	Unknown	10.0	None	None			$5,493
	MR-30	Culvert	300	Unknown	9.0	None	None			$4,940
	MR-31	Culvert	450	Unknown	8.7	None	None			$6,557
	MR-32	Culvert	250	Unknown	31.7	None	None			$15,840
	MR-33	Culvert	450	Unknown	11.0	None	None			$8,266
	MR-34	Culvert	150	Unknown	8.5	None	None			$3,393
	MR-36	Culvert	300	Unknown	11.2	None	None			$6,169
	MR-35	Stormwater Sewer	300	Unknown	13.0	None	None			$11,700
Robson Rd	RO-02	Stormwater Sewer	300	Concrete	20.0	None	None			$18,000
	RO-01	Stormwater Sewer	300	Concrete	5.0	None	None			$4,500
	RO-04	Stormwater Sewer	300	PVC	56.0	None	None			$50,400
	RO-03	Stormwater Sewer	300	Concrete	13.0	None	None			$11,700
Salish Rd	SA-01	Stormwater Sewer	300	0	60.0	N/A	N/A			$54,000
	SA-03	Stormwater Sewer	300	PVC?	41.0	None	None			$36,900
Senkler Rd	SE-01	Culvert	300	Concrete	33.8	Cement Bag	None	Low	450	$45,363
	SE-02	Culvert	300	PVC	10.4	Unknown	N/A			$5,746
	SE-03	Culvert	300	Unknown	31.9	N/A	N/A			$17,545
	SE-04	Culvert	300	Concrete	12.9	N/A	N/A			$7,096
	SE-05	Culvert	100	PVC	9.4	N/A	N/A			$3,281
	SE-06	Culvert	300	Concrete	37.1	N/A	Unknown			$20,417
Tatlow Rd	TT-02	Culvert	200	Unknown	33.8	Unknown	Unknown			$15,210
	TT-03	Culvert	300	PVC	47.0	None	None			$25,835
	TT-04	Culvert	300	Concrete	16.7	None	None			$9,191
	TT-05	Culvert	450	Concrete	20.1	Rock Headwall	Rock Headwall			$35,083
	TT-01	Stormwater Sewer	100	PVC	25.0	N/A	Cement Bag			$12,500
Turtlehead Rd	TU-01	Culvert	450	Unknown	18.0	Unknown	Unknown	Medium	525	$16,200
	TU-02	Culvert	300	Concrete	10.0	Unknown	Unknown	Medium	450	$7,500
	TU-03	Culvert	200	PVC	7.6	Unknown	Unknown			$3,429
	TU-04	Culvert	200	PVC	13.7	Unknown	Unknown			$6,165
	TU-07	Stormwater Sewer	150	Unknown	7.0	None	None			$4,200
	TU-08	Stormwater Sewer	200	Unknown	23.0	None	Unknown			$16,100
	TU-05	Stormwater Sewer	150	Unknown	32.0	None	None			$19,200
	TU-06	Stormwater Sewer	200	PVC	10.0	None	None			$7,000
Watson Rd	WA-02	Culvert	200	CMP	10.3	Unknown	None			$4,625
	WA-01	Stormwater Sewer	750	0	55.0	N/A	Unknown			$99,000
West Rd	WE-01	Culvert	300	Unknown	11.3	None	None			$6,201
	WE-02	Culvert	300	Unknown	6.4	None	None			$3,505
Young Rd	YO-01	Culvert	300	Unknown	12.6	N/A	N/A			$6,914
	C77	Stormwater Sewer	450	-	113.9	-	-			$133,778
SUB-TOTAL CULVERT IMPROVEMENT/REPLACEMENT COSTS										$2,091,711
SUB-TOTAL STORMWATER SEWER IMPROVEMENT/REPLACEMENT COSTS										$2,427,503
TOTAL DRAINAGE ASSET VALUE IMPROVEMENT/REPLACEMENT COSTS										**$4,519,213**

7 Potential Funding Opportunities

This section identifies and details a few funding programs, such as the Federation of Canadian Municipalities' (FCM) Green Municipal Fund (GMF) and Municipal Asset Management Program (MAMP), that the Village may wish to consider applying for. These funding programs apply to feasibility and pilot studies, and capital projects, such as the ones identified in this section. Opus has assisted many clients in the preparation of their grant funding applications for pilot and capital projects. We would be delighted to assist the Village in its grant funding applications in future work.

A description of the available funding programs is summarized in Table 7-1.

7.1 Asset Condition Assessment

A comprehensive condition assessment of the Village's asset can enhance staff's knowledge of their assets and better prioritize investment decisions, adhering to industry best practices for asset management. As a result of the condition assessment, a criticality/risk assessment can be completed, leading to the development of a prioritized replacement schedule of the assets. This would allow for better planning to meet short-term and long-term budgetary requirements.

In order to assess asset conditions, field investigations and surveys need to be completed with details of work recorded/reported. There are funding available for this activity (Data Collection and Reporting) through FCM's new MAMP - see Table 7-1 for more details.

7.2 Open Channel to Piped System Conversion

Open channel drainage system in a developed environment requires significant operation and maintenance effort. If not maintained properly, it could cause capacity issues in the conveyance due to overgrowth and sediment build-up, as well as social, environmental, and safety issues (e.g. stagnant water, foul odour, eye sore, ditch bank erosion, and flooding). It is our understanding that the Village has received requests from residents to convert these open channel systems into buried pipe systems.

For this undertaking, the Village can apply for Green Municipal Fund (GMF) grants, where a combination of funding and low-interest loans is available, the details of which are summarized in Table 7-1. Subject to funding approval, Opus can leverage the model to assist the Village in determining sizing and grading requirements for new stormwater mains in these areas.

Based on our understanding of the Village's drainage system, we would suggest, as a start, to convert the open channel systems along Bedwell Bay Road and Main Avenue east of Kelly Road. The open channel systems along these corridors service a significant portion of the residential areas in the Village. A preliminary option to be considered could be to route all flows from these corridors west towards the stormwater sewers on Kelly Road. As they are being slated for upsizing per our drainage study recommendations, the Village may wish to leverage this opportunity to review and update the sizing requirements for these sewers to accommodate the increased flows from the abovementioned option. Opus can leverage the model to assist the Village in determining sizing and grading requirements for new stormwater mains in these areas.

Table 7-1 – Grant/Funding Description

Grant Fund Name	Description	Project Examples	Funding Breakdown
FCM Green Municipal Fund	*Through the Green Municipal Fund (GMF), we provide funding for municipal environmental initiatives that improve air, water, and soil, and reduce greenhouse gas emissions. GMF funding is available to all Canadian municipal governments and their partners for eligible projects.*	Stormwater Quality: Feasibility studies, pilot projects and capital projects *Example – a low-impact development project that captures and treats stormwater runoff through permeable pavement and bio-retention planters* Stormwater Management: Feasibility studies, pilot projects and capital projects *Funding for stormwater management feasibility studies about volume of runoff is now offered through FCM's Municipalities for Climate Innovation Program.*	Feasibility studies Grants: Up to 50 per cent of eligible costs to a maximum of $175,000. Pilot projects Grants: Up to 50 per cent of eligible costs to a maximum of $350,000. Capital projects Offers low-interest loans, with competitive lending rates, usually in combination with grants. Funding is provided for up to 80 per cent of eligible project costs. The loan maximum is $5 million, and the grant amount is 15 per cent of the loan. Applicants with high-ranking projects may be eligible for a loan of up to $10 million, combined with a grant for 15 per cent of the loan amount, to a maximum of $1.5 million.

Grant Fund Name	Description	Project Examples	Funding Breakdown
FCM Municipal Asset Manageme nt	*The Municipal Asset Management Program is a 5-year, $50-million program that will help Canadian municipalities make informed decisions about infrastructure investments, such as the planning and construction of roads, recreational facilities, and water and wastewater systems.*	MAMP supports activities ranging from collecting data and analysing your asset management needs to developing policies and training staff to implement them. Eligible projects should increase your municipality's capabilities in at least one of the five competencies described in our Asset Management Readiness Scale. Read the application guide for full details. Some examples of the types of activities funded by the program are: • Asset management assessments • Asset management plans, policies and strategies • Data collection and reporting • Training and organizational development • Knowledge transfer	Provides funding for up to 80 per cent of total eligible project costs, to a maximum of $50,000. Projects must be completed within 11 months from funding approval notice.
Municipalit ies for Climate Innovation Program	*The Municipalities for Climate Innovation Program (MCIP) is a 5-year, $75-million program that helps municipalities prepare for, and adapt to, climate change, and to reduce emissions of greenhouse gases.*	<u>Feasibility studies:</u> *A feasibility study assesses the technical and financial feasibility of a specific project to reduce or avoid GHG emissions. It uses a verifiable evaluation process that leads to a recommended course of action.* <u>Operational studies:</u> *An operational study 1) assesses the actual or potential benefit of changing the way a municipal service is delivered and managed or 2) enables research to support such a change.*	Grants of up to $175,000. Funding for up to 80 per cent of eligible costs

Grant Fund Name	Description	Project Examples	Funding Breakdown
Infrastructure Planning Grant Program	*Provincial funding program for long-term plans and assessment studies to support local government infrastructure.* *The Infrastructure Planning Grant Program offers grants to support local government in projects related to the development of sustainable community infrastructure.*	The Program supports a range of initiatives related to improving water, sewer, drainage and other environmental infrastructure. Eligible projects are those that promote sustainable infrastructure including, but not limited to: Plans: • Water Conservation Plans • Water Master Plans • Asset Management Plans • Liquid Waste Management Plans • Integrated Stormwater Management Plans Studies • Infrastructure Condition Assessments • Economic Evaluations of Universal Water Demand Management Strategies • Innovative Pilot Projects and Capacity Building Programs • Wastewater Reclamation and Water Reuse Studies; Integrated Resource Recovery Water Audits and Development of Water Demand Management Strategies	Grants up to $10,000 are available to help improve or develop long-term comprehensive plans that include, but are not limited to: capital asset management plans, community energy plans, integrated stormwater management plans, water master plans and liquid waste management plans.