

## Appendix A – Hydrology Report

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TRILOGY PROPERTIES VI CORPORATION

# CAYET PRE-DEVELOPMENT HYDROLOGY ASSESSMENT – FINAL REPORT



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## 1. INTRODUCTION

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The following report provides a hydrologic assessment of the lands proposed for development under the name Cayet by Trilogy Properties VI Corporation (Trilogy). These properties are currently zoned in four parcels (Master Parcels), and Trilogy has filed a development permit application (DPA) to have these parcels rezoned into smaller lots for further development. The Master Parcels and the resulting lots are shown in Table 1.1. The resulting lot locations and boundaries are shown in the attached Map 1.

**Table 1.1: Master Parcels for Re-Zoning and Resulting Lot Designations**

| Master Parcel No. | Resulting Lot Designations |
|-------------------|----------------------------|
| 1                 | Lots 4, 6, 10b, and 11     |
| 2                 | Lots 8a and 8b             |
| 3                 | Lots 7, 9a, 9b, 10a.       |
| 4                 | Lots 3 a, b, c             |

The focus of this assessment is on the present conditions of the lands which are proposed for comprehensive development. In general, the lands are fully within the Village of Cumberland's boundary, and surround the interchange between Highway 19 and the Comox Valley Parkway. The intent of the assessment is to describe the hydrologic features of the individual parcels under consideration and determine the predevelopment conditions.

Ultimately, this study will assist Trilogy with the re-zoning process for the subject lands, determining the base line conditions prior to development. This will inform the development planning function for the area, serving to guide future decisions related to the management of storm water in the area. The following vision statement encapsulates the intent of this study:



*This study is intended to be a comprehensive hydrology report describing the hydrological features of the overall Trilogy properties (Cayet) – including water shedding, collecting and conveyance areas.*

On this basis, this report provides a high level assessment of existing conditions, while providing guidance for the potential future development of the Cayet area. The emphasis of the report is on providing a perspective for the management of rain water, and not on dictating what level of development the lands could realize. The overall goal is establishing the requirements for stormwater management for the proposed development that would require a development permit as required by the Village's OCP.

## 1.1 The Study Area and Geographic Setting

The Cayet development lies within the eastern portion of the Village of Cumberland municipal boundary, straddling the Inland Island Highway (Hwy 19) near the Comox Valley Parkway and Cumberland Road (see **Map 1**). It is characterized as undeveloped, with minimal commercial and industrial development present.

The topography in the study area consists of relatively flat to rolling terrain sloping gently toward the ocean. Highway 19 transects the Cayet lands running north-south along the entire length of the proposed development. All major creeks, streams and ditches cross this major thoroughfare, and these crossings are important controls for the management of stormwater.

## 1.2 Current Bylaws for the Village of Cumberland

The Village of Cumberland currently has only 1 specific bylaw relating to stormwater management and conveyance. The purpose of this bylaw was to regulate the connection, use and extension to the municipal stormwater system and to impose fees for associated services. It states that all



works within Village rights-of-way shall be designed and built in accordance with the MMCD design guideline, but does not specifically describe any post-development runoff performance targets. However, the bylaw does include a 'Green Alternatives' section, which highlights the following water quantity objective:

*"In an effort to maintain pre-development groundwater flow regimes, stormwater should be infiltrated as close as practicable to the initial source"*

To this end, the goal of the stormwater management plan is to achieve a "Low Impact Development", which is generally defined as an engineering design approach to manage stormwater runoff as part of green infrastructure. "Low Impact Development" stresses conservation and use of onsite natural features to protect water quality.

This report, in reference to other hydrological efforts previously completed in the surrounding area, documents these pre-development flow regimes.



## **2. THE WATERSHED**

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### **2.1. Available Information on the Watershed**

A number of references were utilized in support of this project. They include the following:

- Village of Cumberland Official Community Plan Bylaw (2014)
- Village of Cumberland Stormwater System Regulation and Fees Bylaw (2015)
- Village of Cumberland Liquid Waste Management Plan Phase 2 - Stormwater Drainage Master Plan (2010)
- Area 'D' Stormwater Management Plan (2015)
- NE Comox Neighbourhood Stormwater Management Plan – (2016)
- Previous Hydrologic Studies completed by McElhanney (2007 and 2008)
- Soils of Vancouver Island Maps (1985)
- Air-photos of the study area
- GIS shape files for:
  - o Aquifer
  - o Cadastre
  - o Contours
  - o Ditches
  - o Streams
  - o Trim Water Bodies
  - o Watersheds



## 2.2. Streams, Watershed and Wetlands Characteristics

Individual watersheds throughout the study area were assessed using a comparison of the topographic contours, and the groundwater protection map from the Village's OCP bylaw document.

**Map 2** shows the interpreted watershed boundaries in relation to the proposed Cayet development. Each watershed has been assigned a name for identification purposes for this study, as follows:

- Trent River/Maple Creek Watershed
- Roy Creek Watershed
- Millard Creek Watershed
- Piercy Creek Watershed
- Morrison Creek Watershed

Complementing **Map 2** is the appended figure of the mapped wetlands and riparian areas that was developed by Madrone Environmental Services (2017). These 3 maps define the watershed and wetland characteristics in the proposed development area, and the stormwater management plan must respect the current hydrologic features throughout the development process. The names are associated with the main watercourses draining that portion of the land. The topography in the area generally slopes gently from west to east towards the Strait of Georgia.

## 2.3. Surface Geology

Geological mapping was sourced directly from the Ministry of Environment mapping records. According to this surficial geology mapping, most of the area is described by the following geological units:



- South of Royston Road is characterized by the “Kye-Cassidy” geological units described as:
  - o 60% loam Sand, significant seepage, rapid draining;
  - o 40% very gravelly loam sand, rapid draining; and
  - o Moderately rolling (9-15%) with complex topography (Southern portion of Maple Creek watershed).
- Remainder of Cayet Development is characterized by the “Dashwood-Hawarth-Ronald” geological units described as:
  - o 60% very gravelly loam sand/gravelly loam sand, well draining;
  - o 20% very gravelly loam sand, rapid draining;
  - o 20% gravelly loam, well draining; and
  - o Gently rolling to moderately rolling (5-15%) with complex topography. (All identified watersheds/ north portion of Maple Creek watershed)

The general gravelly nature of the surficial soils within the Cayet development are consistent with observations made throughout the area, which include a number of gravel extraction operations, especially toward the north end of the development area. Notwithstanding this surficial condition, there are localized areas where underlying soils restrict infiltration capacity. Experience throughout the local area shows underlying dense till-like material, which restricts infiltration to deeper soil zones, and often creates wetter areas where seasonal rains exceed the storage capacity of the surficial layer. As a result, there are a number of areas on the Cayet lands that contain seasonally wet areas or wetland features as have been mapped in the TEM report.

## 2.4. Groundwater Conditions

A groundwater aquifer is located within the northern portion of the Cayet development. This aquifer is outlined in the Village’s OCP Groundwater protection map. This groundwater aquifer connects from Comox Lake to below Maple Lake and some of the surrounding areas. The approximate boundary of the groundwater protection area in relation to the proposed developmental boundary is displayed on **Map 2**.



### **3. PRE-DEVELOPMENT HYDROLOGY**

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After looking at the physical characteristics of the watersheds within the Cayet area, it is prudent to develop appropriate targets so that the development can meet suitable goals with respect to stormwater management. On this basis, the hydrology of the watershed must first be determined to define the amounts and distribution of rainfall over the study area, so that proper targets for managing the rainfall can be formulated.

The hydrology of a watershed is described by the water balance model (or hydrologic cycle). The principle of the water balance model is that each drop of precipitation interacts with the earth's surface through the following:

- Evaporation
- Transpiration
- Infiltration
  - o Interflow
  - o Groundwater recharge
- Runoff

Eventually, each drop of precipitation is returned to the atmosphere and the process repeats itself.

In a natural condition, the watershed exhibits an appropriately balanced and sustainable rainfall response. This ultimately results in healthy and sustainable stream hydrology, water quality and riparian and stream environments. However, as urbanization occurs and imperviousness of the watershed increases, the hydrology of the watersheds tends to change, resulting in a reduction in transpiration and infiltration, and an increase in surface runoff.



### 3.1. Rainfall Characteristics of Cumberland

**Figure 3.1** indicates the regional annual mean total precipitation for the mid-Vancouver Island and Discovery Islands regions.

**Figure 3.1: Regional Mean Annual Rainfall Amounts**



Source: Annual Mean Total Precipitation (Atlas of Canada)

[http://atlas.nrcan.gc.ca/site/english/maps/environment/climate/precipitation/precip?layers=pcp\\_annual&scale=42051275.911682&mapxy=-1694825.2083336664%201868243.25&mapsize=1150%201350&urlappend=](http://atlas.nrcan.gc.ca/site/english/maps/environment/climate/precipitation/precip?layers=pcp_annual&scale=42051275.911682&mapxy=-1694825.2083336664%201868243.25&mapsize=1150%201350&urlappend=)

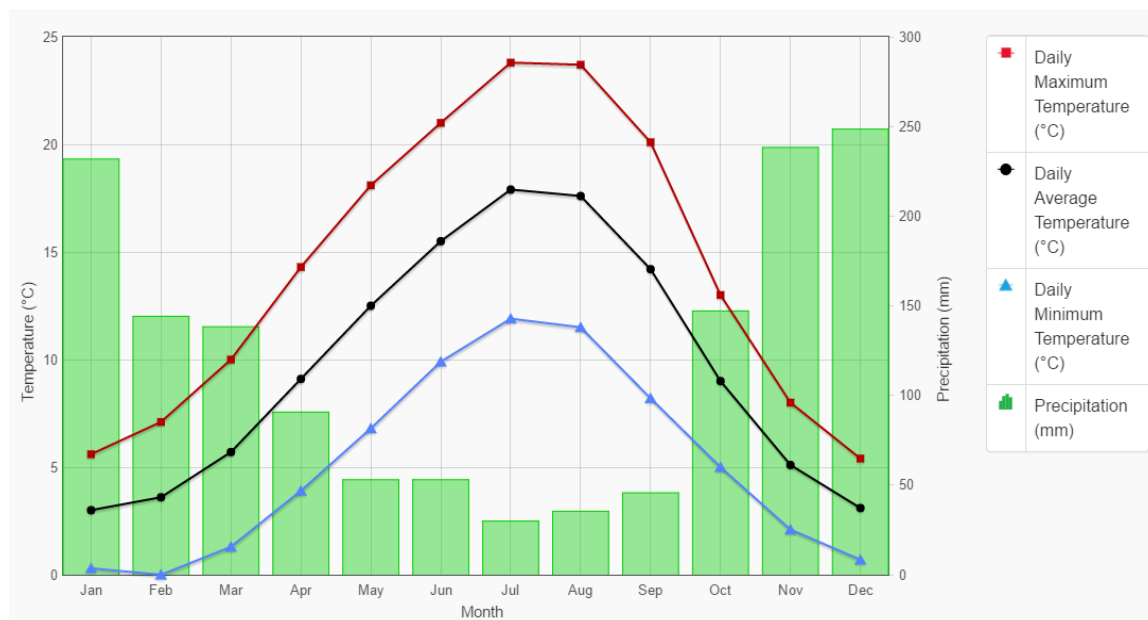
The map suggests the Cayet study area should receive an approximate average annual rainfall that is consistent with the region around Courtenay/Comox. Nearby weather recording stations at Comox Airport and Courtenay Meadowbrook, report mean annual precipitation values of 1097mm and 1401mm respectively. Therefore, since the location of the study area lies near the border between the 1201 to 1600mm and the 1601 to 2000mm zones and, due to the nearby Canadian Climate Normal Data, the Cayet lands would be expected to receive approximately 1200mm of



rainfall on average each year. Seasonal variations at available Island weather stations were compared and found to be consistent with **Figure 3.1** throughout the region.

The nearest Environment Canada (EC) Weather Station is at the BC Hydro Plant on the Puntledge River, but EC does not report Climate Normals for this station. **Figure 3.2** shows the long-term average monthly rainfall and temperature for the next closest weather station – Courtenay Meadowbrook. The graph provides a key observation of the seasonal distribution of rainfall: The summers are relatively dry, and most of the rainfall occurs between October and March each year. The average annual rainfall for this gauge is reported to be 1401 mm. The highest recorded daily rainfall is 107.2 mm, recorded March 17, 1997, which is statistically consistent with other rainfall gauges in the area, including the Comox Airport weather station. The Canadian Climate Normals data is only updated every 10 years, so data for the most recent years is not readily available. The intent of the graph is to illustrate the pattern and relative magnitude of precipitation patterns in the area, and is not meant for analyses.

**Figure 3.2: Temperature and Precipitation Graph for 1981 to 2010**  
**Canadian Climate Normals**  
**Courtenay Meadowbrook Weather Station**





Some notable rainfall statistics for the Comox Airport weather station, which are statistically applicable to the study area include:

- o The ½ Mean Annual Rainfall (MAR) is calculated to be 24mm in 24 hours.
- o The MAR is calculated to be 48mm in 24 hours.
- o Largest single day of rainfall was 113mm, which occurred on December 22, 1957

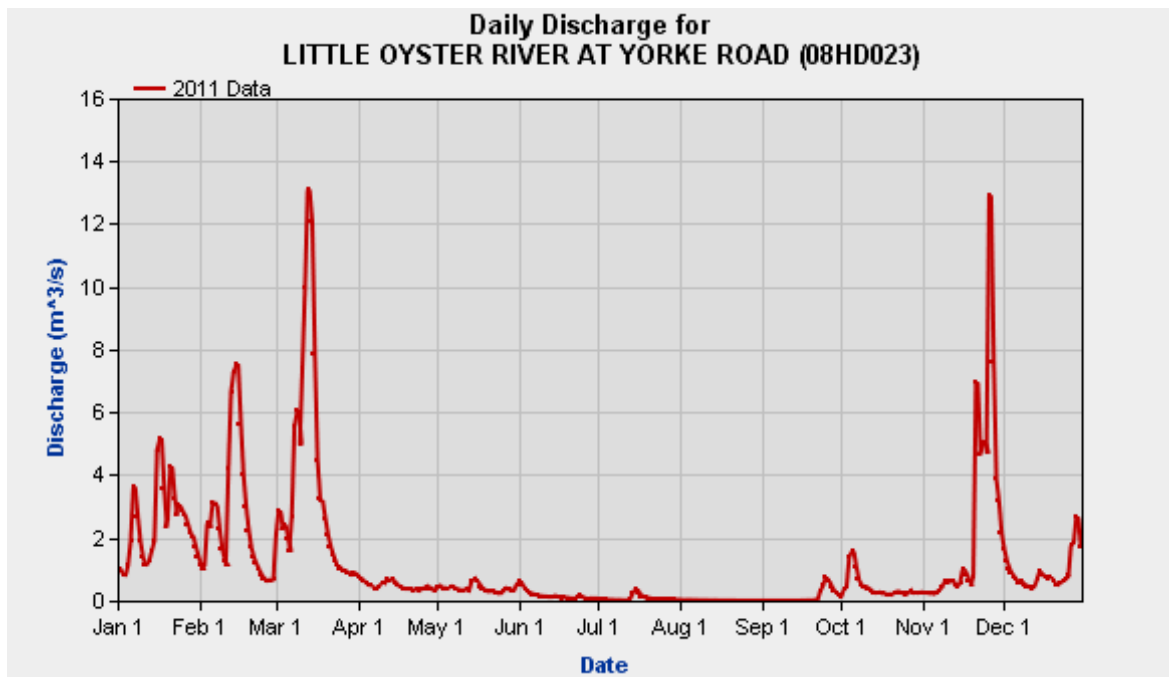
### 3.2. Regional Runoff Characteristics

Rainfall runoff is directly correlated to the amount of rainfall experienced in an area, but it is also a function of topography, soil characteristics and vegetated cover. Typically, runoff on the east coast of mid-Vancouver Island follows the same pattern as rainfall with most areas displaying a rather homogeneous response to rainfall. That is, there is usually a direct correlation to the amount of runoff to rainfall, and more importantly the amount of runoff tends to be fairly uniform on a unit area basis. Put another way, drainage areas that have similar hydrologic characteristics tend to produce the same amount of runoff on a per hectare basis regardless of their size.

To illustrate the runoff characteristics for the proposed Cayet development, the daily flow record for the Little Oyster River at York Road (Water Survey of Canada Gauge 08HD023) for 2011 is shown on **Figure 3.3**. The figure shows a typical year of flow with most runoff occurring from November through to the end of March. It can also be shown that for this 38 square kilometer drainage basin, on average, the volume of runoff is about 70% of the total volume of rainfall.



**Figure 3.3: Daily Discharges for Little Oyster River at York Road**



The use of the above hydrometric gauge, with other similar gauges in the region, to define the response of the local watershed runoff to rainfall infers the estimated hydrologic response for the watersheds with the Cayet lands.

At this stage, the intent is to define the current, or pre-development, hydrologic features of the Cayet lands, which are spread among 5 local watersheds, each of which would have common hydrologic response given the homogeneity of the area in terms of rainfall, land use (undeveloped), land cover and surficial geology. On this basis, a regional approach to establishing the expected runoff, and in turn, the predevelopment hydrology is utilized.

The water balance approach states that the post-development hydrologic conditions should statistically mimic pre-development conditions, the establishment of pre-development runoff targets provide the basis for future designs. The study area is relatively small and has relatively

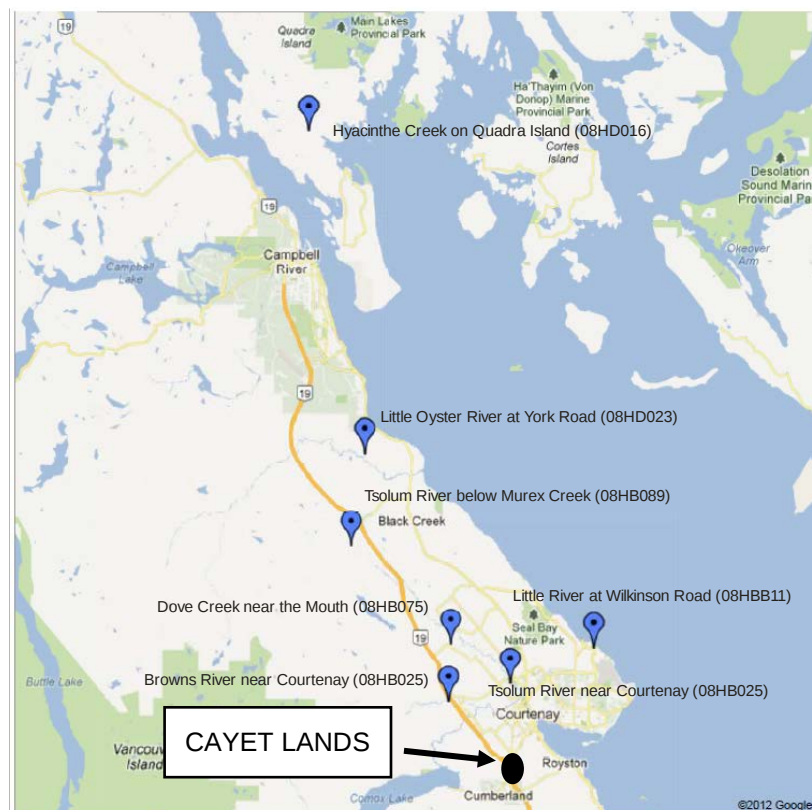


consistent soil permeability and it is assumed that the hydrologic response is fairly uniform over the entire Cayet lands. That is, the same pre-development targets are to be used for further analysis, regardless of lot or subcatchment size.

The intent of the regional analysis is to compare model results with similar watersheds within the same geographic area. Peak discharge rates and run-off volumes are typically used. The regional analysis method is most accurate when utilizing long term flow measurements. Thus, proxy streams for comparative analysis were selected, in part, based on the duration of reliable flow data available.

To select an appropriate proxy stream, a nearby gauge needs to be within a region of similar climate and geography, including land use and soil characteristics. Based on regional mean annual precipitation, the streams initially considered for use in a regional analysis are shown on **Figure 3.4.**

**Figure 3.4: Hydrometric Station Locations**





All stations were deemed suitable based on their geographic characteristics, as well as their relative state of catchment development and similar soil characteristics. Notably: Hyacinthe Creek and the Browns River were found suitable based on their relatively undeveloped catchments. Dove Creek and the Tsolum River were deemed suitable based on their lack of development. These watersheds were also favourable based on their long record of flow data and similar geographic and soil characteristics.

Given the limited data available for the area, the above stations were all utilized for the calibration of run-off volumes and peak flows.

Throughout the course of our previous work in the region<sup>1</sup>, MCSL have developed an assessment of pre-development runoff rates using a flood frequency analysis. This relationship will form the basis of the targets for pre-development flows in the Cayet area, and the metric against which post-development modelling should be compared to, up to the 1:100 year return periods.

As determined in the Area “D’ SWMP and NE Comox Neighbourhood SWMP, the following volumetric targets should be considered as the pre-development standard.

- The following rates form the peak discharge targets for the study area:
  - o 18.5 l/s/ha for the 1 in 100-year event
  - o 13.3 l/s/ha for the 1 in 10-year event
  - o 11.6 l/s/ha for the 1 in 5-year event
  - o 9.1 l/s/ha for the 1 in 2-year event

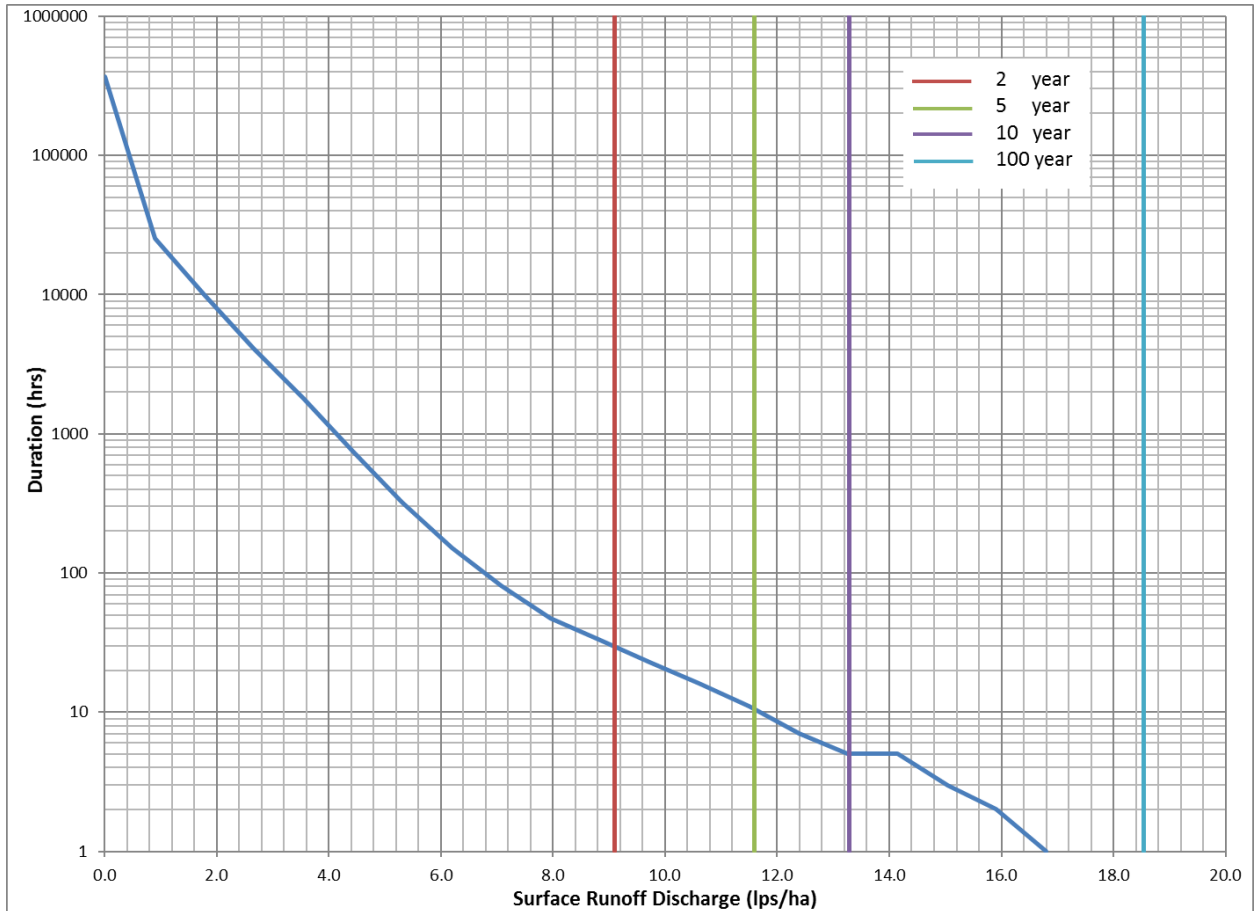
The above peak pre-development flow rates will need to be compared to site specific flow-duration relationships for the Cayet lands, which will be approximately equal to the relationship shown on **Figure 3.5** below.

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<sup>1</sup> Area ‘D’ Stormwater Management Plan and NE Comox Neighborhood SWMP



**Figure 3.5: Flow-Duration Relationship for the Cayet Lands**



The above figure illustrates that the vast majority of runoff volume is less than a 1:2-year event, which is consistent with rainfall observations for the north island, where 97% of all rainfall is less than the Mean Annual Rainfall amount of 48mm.

### 3.3. Lot Level Hydrologic Characteristics

The Cayet lands consist of a number of individual land parcels and the hydrologic characteristics of each lot (sub lot areas are grouped together, as applicable) are provided on **Table 3.1** below. Only those lots applicable to the current re-zoning application are included herewith. The table is



accompanied by a figure for each lot area (see Appendix A), which illustrates the lot area, proposed development scheme, and key hydrologic features.

**Table 3.1: Summary of Hydrologic Features on a Lot Basis**

| Lot #         | Lot Area Total (Ha) | Watershed                     | Surficial Geological Unit       | Current Land Use, Land Cover                                                                                                   |
|---------------|---------------------|-------------------------------|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Lot 3</b>  | 32.6                | Millard Creek/<br>Percy Creek | Dashwood-<br>Hawarth-<br>Ronald | Comprised of wetland areas and second growth forest, as well as recently cleared areas in the northeast corner of the property |
| <b>Lot 4</b>  | 10.9                | Roy Creek                     | Dashwood-<br>Hawarth-<br>Ronald | Forested                                                                                                                       |
| <b>Lot 6</b>  | 15.2                | Roy Creek                     | Dashwood-<br>Hawarth-<br>Ronald | Mixed Second growth with cleared areas                                                                                         |
| <b>Lot 7</b>  | 2.7                 | Roy Creek                     | Dashwood-<br>Hawarth-<br>Ronald | Forested                                                                                                                       |
| <b>Lot 8</b>  | 20.4                | Roy Creek                     | Dashwood-<br>Hawarth-<br>Ronald | Forested                                                                                                                       |
| <b>Lot 9</b>  | 138.6               | Maple Creek/<br>Trent River   | Kye-Cassidy                     | Mixed density forest on higher elevations with lower wetland and streamside areas                                              |
| <b>Lot 10</b> | 9.9                 | Maple Creek/<br>Trent River   | Dashwood-<br>Hawarth-<br>Ronald | Forested upland area                                                                                                           |
| <b>Lot 11</b> | 8.7                 | Maple Creek/<br>Trent River   | Dashwood-<br>Hawarth-<br>Ronald | Gravel extraction activity over the southerly 2/3 of the site. Balance of site is covered by second growth forest.             |

Based on regional runoff characteristics the proposed hydrological targets by lot are summarized in **Table 3.2**.



**Table 3.2: Proposed Hydrological Targets by Lot**

| Master Parcel No. | Ha    | Lot No. | Ha   | Event flow rates in litres per second. |        |         |          |
|-------------------|-------|---------|------|----------------------------------------|--------|---------|----------|
|                   |       |         |      | 2 Year                                 | 5 Year | 10 Year | 100 Year |
| 1                 | 39.6  | 4       | 10.9 | 99                                     | 126    | 145     | 202      |
|                   |       | 6       | 14.5 | 132                                    | 168    | 193     | 268      |
|                   |       | 10b     | 5.5  | 50                                     | 64     | 73      | 102      |
|                   |       | 11      | 8.7  | 79                                     | 101    | 116     | 161      |
| 2                 | 20.4  | 8a      | 9.0  | 82                                     | 105    | 120     | 167      |
|                   |       | 8b      | 11.4 | 104                                    | 132    | 152     | 211      |
| 3                 | 142.2 | 7       | 2.3  | 21                                     | 26     | 30      | 42       |
|                   |       | 9a      | 40.5 | 369                                    | 470    | 539     | 749      |
|                   |       | 9b      | 95.0 | 865                                    | 1,102  | 1,264   | 1,758    |
|                   |       | 10a     | 4.4  | 40                                     | 51     | 59      | 81       |
| 4                 | 32.6  | 3a      | 0.7  | 6                                      | 8      | 9       | 12       |
|                   |       | 3b      | 3.2  | 29                                     | 37     | 43      | 60       |
|                   |       | 3c      | 28.7 | 261                                    | 333    | 382     | 531      |

The above targets suggest that the developed sites should include stormwater management practices that will limit surface water discharges to the values stated on the table. These numbers should be re-visited when development is initiated to include the most recent rainfall data available and should also include allowances for anticipated climate change as legislated at the time.



## 4. CONCLUSIONS AND RECOMMENDATIONS

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The Trilogy Properties VI Corporation has commissioned this assessment of the existing hydrologic features within the proposed Cayet development area. From the information gathered, analysed and confirmed through field verification, the following summary conclusions and recommendations are made.

1. Infiltration potential of native soils in Cayet lands were reviewed in the context of the existing surficial geological mapping. The 2 distinct geological units found in the area were assessed as being capable of moderate to high infiltration rates. Though surface infiltration rates may be moderate to high, shallow till layers create pockets of seasonally wet areas or wetlands throughout the property, which need to be considered in the final designs of the development.
2. The rainfall statistics for the area should be based on the BC Hydro weather station at the Puntledge River Powerhouse, which are similar to the Environment Canada gauge – Courtenay Meadowbrook. Some notable rainfall statistics for the area include:
  - o The  $\frac{1}{2}$  Mean Annual Rainfall (MAR) is calculated to be 24mm in 24 hours.
  - o The MAR is calculated to be 48mm in 24 hours.
  - o Largest single day of rainfall was 113mm, which occurred on December 22, 1957.
3. A regional analysis of nearby hydrometric gauging stations was used to illustrate the runoff characteristics for the proposed Cayet development. Typically, stream flows for the year show most of the runoff occurring from November through to the end of March. It can also be shown that, on average, the volume of runoff is about 70% of the total volume of rainfall within the region.
4. The management of stormwater from a quantity perspective should be based on the Water Balance Model approach. From an assessment of the regional hydrology, the post-development target peak flows as presented in Table 3.2 should be used throughout the



study area. To achieve this, Low Impact Development concepts such as infiltration galleries, rain gardens and/or ponds could be incorporated into future plans, as each site will need to be assessed and designed once a development plan is made. Groundwater tables and subsurface soil types will dictate the best options, but to investigate these now is pre-mature, without more specific knowledge of the development plan.

5. In the future, qualified professionals must also be cognizant of any regulatory changes that may take place, either locally or in higher levels of government, that are not present at the time of writing this report.

## 5. CLOSURE

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We trust that the information herein provides sufficient information to assist in your assessment. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

McELHANNEY CONSULTING SERVICES LTD.

Prepared by:

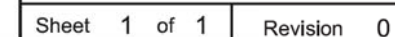
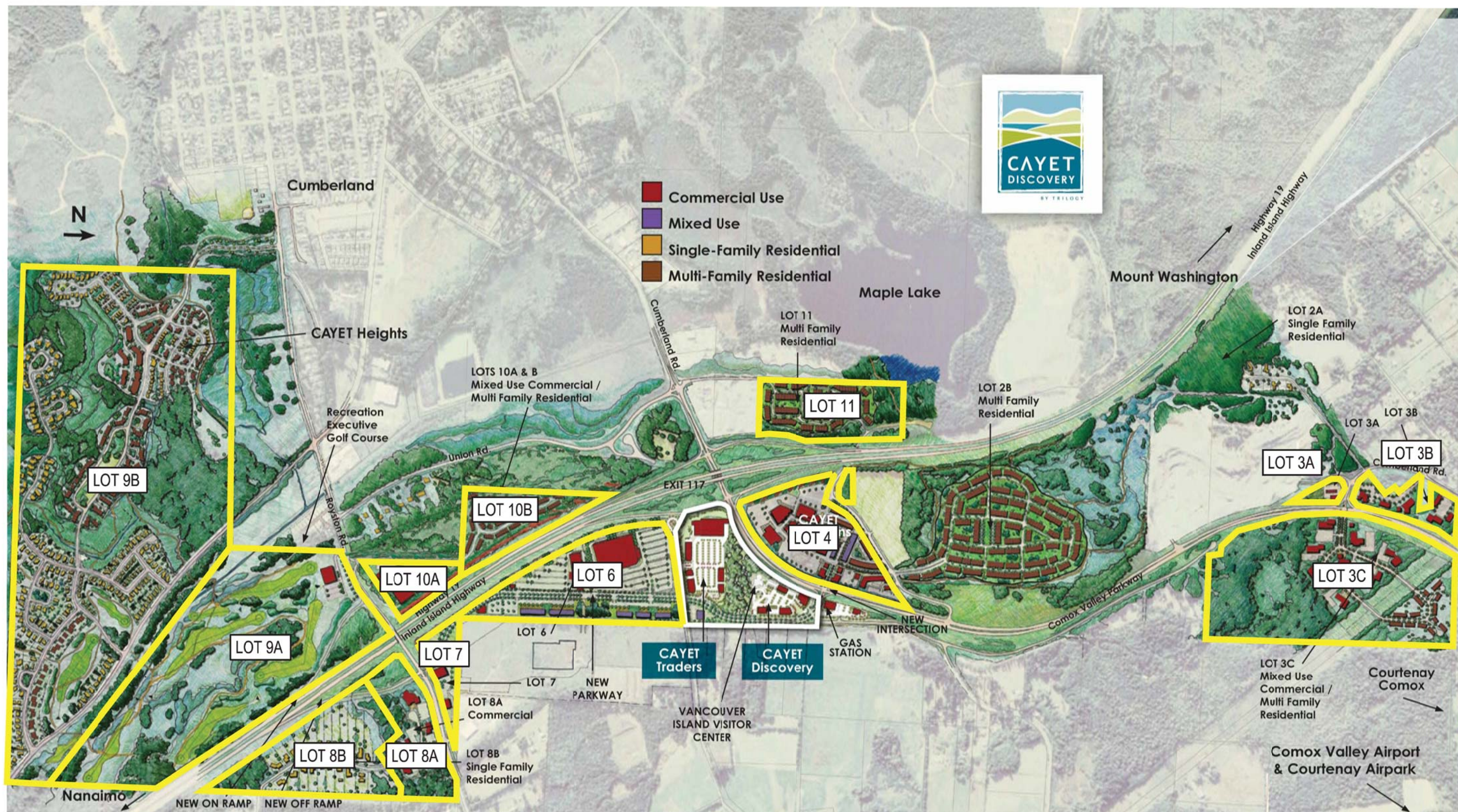
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## MAPS

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**LEGEND**

WATERSHED BOUNDARY

GROUNDWATER PROTECTION BOUNDARY



NOT TO SCALE



**McElhanney**

McElhanney Consulting Services Ltd.

1307 SHOPPERS ROW  
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PH (250) 287-7799

WATERSHED AND AQUIFER  
BOUNDARIES  
CAYET SWMP

Drawing No.

**MAP 2**

DATE : 2016/01/06

Sheet 1 of 1 Revision 0

MADRONE

environmental services ltd

FIGURE 4b:

Cayet 30m Buffers

Riparian, Mature and Old Forest

PROJECT:

Cayet Terrestrial Ecosystem Mapping

CLIENT:

McElhanney Consulting Services Ltd.

GEOGRAPHIC AREA:

Cumberland, BC

ASSESSMENT DATE:

Dec 22-23, 2016 & Sep 14-15, 2017

MAP SCALE:

1:12,000

MAPPING DATE:

December 19, 2017

DOSSIER NO:

16.0412

DRAWN BY:

Ian Wright

Study

Streams (Mapped by McElhanney and Madrone)

TRIM Streams and Waterbodies

Mature or Old Forest

Wetland Dominant or Codominant (incl. forested swamps)

Wetland Subdominant (incl. forested swamps)

Riparian, Old and Mature Forest Buffer

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