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City of Colwood

Sewer Master Plan

Final
May 2013
KWL Project No. 2417.003

Prepared for:

City of Colwood

Colwood

Prepared by:

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Executive Summary

This Colwood Sewer Master Plan evaluates the existing sanitary sewer system, outlines a plan for servicing the City of Colwood (City) in its entirety, provides an overview of sanitary sewer alternatives, and discusses potential impacts of a future western communities' wastewater treatment plant. In general, this Sewer Master Plan will provide a summary of the existing system and guidance for making decisions regarding the future system.

The City of Colwood's existing sewer infrastructure system includes 32,000 m of gravity sewer mains, 7,350 m of sewer forcemains, and 8 sanitary sewer lift stations. The system currently services a residential population of approximately 5,420. Additionally, the City's system services commercial properties, Royal Roads University, DND lands, two golf courses, grade schools, and the Juan de Fuca Recreation Centre.

The sanitary sewer system was analyzed for the existing and future development scenario. The capacity analysis of the existing system indicates that for the existing populations, all of the City's sanitary sewers have adequate capacity with the exception of a short section. The depth of surcharge in this section of trunk sewer is minimal and upgrades are not necessary.

Future land-use was developed in order to populate the future modelling scenario. As sanitary sewer infrastructure can have a life span of 50 to 100 years or longer, the future land-use projections were made considering time frames in this range. The analysis of the future scenario indicates that there are some capacity limitations with the existing system. The future scenario 100-year return period peak wet weather flow for the City of Colwood is 685 L/s, or roughly double the City's allocation in the CRD's NWT of 347 L/s.

The Capital Regional District has stated that a wastewater treatment plant will be required in the future to service the western communities. Depending on this location, this wastewater treatment plant could eliminate the need for upgrades to Colwood's and the CRD's existing wastewater infrastructure to accommodate the future scenario flows.

As part of this project, a sewage heat recovery demand and supply analysis was completed. The analysis shows that Colwood Corners should have the highest priority for sewer heat recovery of all the potential opportunities in the City. A potentially promising opportunity identified through previous studies is the siting of a wastewater treatment plant in Royal Bay, which would allow the Royal Bay development to access treated effluent as a heat source.

The proposed sewer master plan is illustrated on Figure 7-1 (keyplan plus 8 drawing sheets). This sewer master plan is the proposed servicing strategy for servicing the entire City for the future land-use scenario. The plan includes sizing of future infrastructure as well as identifying required upgrades. These sizes and upgrades are based on the modelling analysis and results.

Section 1

Introduction

1. Introduction

1.1 Purpose and Intent

This Colwood Sewer Master Plan is intended for the following purposes:

- It provides an evaluation of the existing (2012) Colwood sanitary sewer system. This includes sanitary flows, inflow and infiltration rates and an assessment of the capacities of the existing system.
- It outlines a plan for servicing the City of Colwood in its entirety for future development density. This work includes preliminary layout and sizing of sanitary sewer infrastructure, including gravity mains, forcemains and lift stations.
- It provides an overview of sanitary sewer alternatives. These include potential connections to an adjacent municipality sewer system, sewer routes through private properties where a right-of-way would be required and low-pressure-sewer systems instead of a gravity system.
- It outlines some potential impacts of a future western communities' wastewater treatment plant and discuss the potential for a district energy system.

In general, this Sewer Master Plan will provide a summary of the existing system and guidance for making decisions regarding the future system. The Terms of Reference for this assignment were set by the City of Colwood and are included in Appendix A.

1.2 Acronyms and Definitions Used

ADWF = Average Dry Weather Flow

BSF = Base Sanitary Flow

CAWT = Core Area Wastewater Treatment

City = City of Colwood

CRD = Capital Regional District

DES = District Energy System

DND = Department of National Defence

GWI = Groundwater Infiltration

I&I = Inflow and Infiltration

ICI = Industrial, Commercial and Institutional

IMA = Inter Municipal Agreement

LPS = Low Pressure Sewer

LWMP = Liquid Waste Management Plan

NWT = Northwest Trunk (CRD sewer servicing the Western Communities)

PE = Population Equivalent

PF = Peaking Factor

PVC = Polyvinyl Chloride

PWWF = Peak Wet Weather Flow (Peak BSF plus I&I)

RDII = Rainfall Dependant Inflow and Infiltration

WSES = West Shore Environmental Services

WWTP = Wastewater Treatment Plant

1.3 Pump Station Names and Locations

For reference throughout the report, the pump station names and locations (street addresses) are summarized in the following Table 1-1.

Table 1-1: Pump Station Names and Location

Pump Station Name	Location
Belmont	340 Belmont Road
Metchosin	3548 Metchosin Road
Ocean	3301 Ocean Boulevard
Pelican	3684 Metchosin Road
Hatley	293 Perimeter Place
Portsmouth	205 Portsmouth Drive
Sewell	873 Cuaulta Crescent
Wilfert	1750 Wilfert Road

1.4 System Overview

The City of Colwood existing sewer infrastructure and the properties currently connected to the sewer system are illustrated on the attached Figure 1-1. The Colwood system includes the following components:

- 32,000 m of gravity sewer mains ranging from 150 mm to 600 mm in diameter;
- 7,350 m of sewer forcemains; and
- 8 sanitary sewer lift stations.

The system currently services a residential population of approximately 5,420. Additionally, the City's system (or the CRD system through the City) services commercial properties (primarily along Sooke Road), Royal Roads University, DND lands, two golf courses, grade schools, and the Juan de Fuca Recreation Centre.

1.5 CRD Capacity Allocation

The City's sewer system connects to the CRD sanitary sewer system at locations between the Aldeane Avenue and Sooke Road intersection, and the Colwood / View Royal municipal boundary. The flows from Colwood are calculated by the CRD by measuring the flows at the Colwood / View Royal boundary (Parsons Mag Meter) and subtracting the flows from Langford (Meaford Weir).

The maximum allocated capacity in the CRD trunks for the western communities is defined in the CRD Bylaw No. 2312[1]. **The City of Colwood's peak sewage flow allocation in the CRD system is 347**

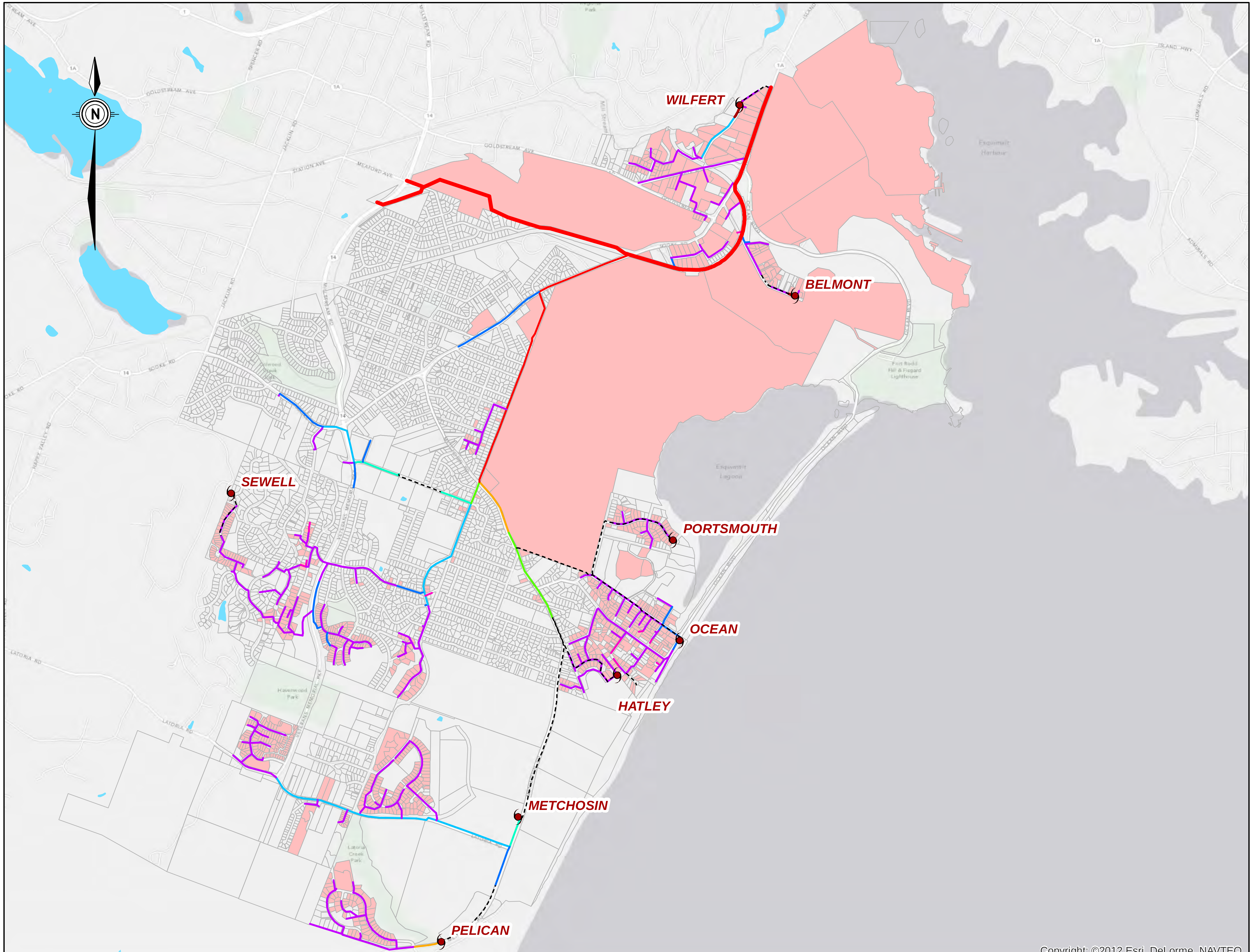
[1] Capital Regional District (CRD) Bylaw No. 2312, (As amended by Bylaws No. 3028, 3319), Consolidated version authorized in accordance with Bylaw No. 3014, CRD Consolidation Authorization bylaw No. 1, 2002, Liquid Waste Management Core Area Western Communities

L/s. In the event that peak flows from Colwood exceed 95% of the allocated capacity, this triggers required negotiations with the CRD and with the other participating areas for, “reallocation of capacity and the reapportionment of the annual debt cost of participating area facilities for providing increased capacity.”

The City of Langford’s peak sewage flow allocation in the CRD system (upstream of Colwood) is 370 L/s.

Establishment Bylaw No. 1, 1995, A bylaw to Convert the Authority for Liquid Waste Management to a Service for the Core Area and Western Communities.

City of Colwood
Sewer Master Plan



Legend

- Sanitary Pump Station
- CRD Northwest Trunk
- Forcemains

DIAMETER

- 150
- 200
- 250
- 300
- 375
- 450
- 500
- 525
- 600
- 750
- Existing Serviced Lots

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Project No.	Date
2417-003	May 2013

Existing Sanitary Infrastructure

Figure 1-1

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Section 2

Land-Use

2. Land-Use

When combined with the design criteria, the land-use is the basis for generating and distributing the flows to the wastewater system. This section outlines the existing and future land-uses.

2.1 Existing Land-Use

The existing population densities for parcels currently connected to the sanitary sewer system are illustrated on Figure 2-1. Each of the land-uses are described below.

2.1.1 Residential Land-Use

The residential land-use represents single family detached dwellings as well as multi-family attached dwellings (duplex, townhouse, condominiums). The existing (2011) total residential population of 16,093 was obtained from Statistics Canada. This population was distributed to the active residential parcels based on census block data and confirmed using the existing zoning and visual assay of developed lots in orthophotos.

2.1.2 Industrial, Commercial and Institutional (ICI) Land-Use

The sanitary sewer flows from the ICI areas are modelled by assigning a population equivalent on a per hectare basis. For the City the ICI land-uses contribute only a minor portion of the flow. The ICI land-uses are described below.

Industrial

The Industrial land-use density used for modelling purposes was developed based on published information and standard values used by KWL on similar modelling assignments. The value used for the existing scenario is 25 PE per ha, which would represent standard light industrial (manufacturing/ warehouse) type uses that generate relatively low amounts of wastewater.

Commercial

The Commercial land-uses are primarily located along Sooke Road and can generally be described as restaurants and retail with some office. The value used for the existing scenario is 60 PE per ha, which is based on published information and standard values used by KWL on similar modelling assignments.

Institutional

The existing major Institutional properties (excluding Royal Roads which is described separately below) and their student populations are provided in the following table.

Table 2-1: School Populations

School	Grades	Student Population
Dunsmuir Middle	7 to 9	616
Ecolé John Stubbs Memorial[1]	K to 9	725
Colwood Elementary[1]	K to 6	183
Wishart Elementary	K to 6	315
Sangster Elementary	K to 6	167
David Cameron	K to 6	313
Note: 1 – currently connected to the municipal sewer system		

For Colwood Elementary the student population was converted to a population equivalent based on previous work by KWL. This previous work has found that 1 student equates to approximately 0.1 PE. For Ecolé John Stubbs Memorial, the flow rate was assigned based on flow measurement data.

For the minor institutional properties such as learning centres, pre-schools and daycares, the value used for the existing scenario is 50 PE per ha.

2.1.3 Major Properties

Olympic View

The Olympic View property is currently an 18 hole golf course, club house, restaurant and banquet room. This property is located in the City of Colwood, City of Langford and District of Metchosin. Currently this property does not have a connection to any municipal sanitary sewer systems and wastewater is treated and disposed of on-site.

Royal Bay

For the purposes of this study, Royal Bay is defined as the undeveloped portion of the former Lehigh Gravel Pit. This property is not currently connected to the sanitary sewer system.

Royal Roads University

Royal Roads University has a long-term lease from the federal government for the use of the grounds and facilities.

University facilities staff stated that students spend the majority of their time off campus. As a result the number of enrolled students is significantly higher than the number of students on campus at any one time. The statistics received from the University are for the average number of students on campus in one day: The existing student and staff populations are summarized as follows:

- 330 average daily students on campus; and
- 360 staff members.

Based on a review of the flow monitoring data obtained from the CRD, Royal Roads has a population equivalent of approximately 140.

There are 14 DND family houses located between the University and Sooke Road. These houses contribute to the Colwood system separately from the University. For these 14 properties a population of 24 has been assigned based on the census population distribution exercise.

DND Belmont

The total number of residential housing units for DND Belmont is 473. The total number of residents within this area is estimated to be 1,281, based on the 2011 Census data.

Royal Colwood Golf Course

The Royal Colwood Golf Course is an 18-hole golf course, club house, restaurant and banquet room. This property is located in the City of Colwood, however the connection to the CRD trunk sewer is upstream of the Meaford (Langford) Flow Monitoring Weir. Based on these facilities, and previous work completed by KWL, a population equivalent of 60 has been assigned for this property.

Colwood Corners

Currently the Colwood Corners area includes residential and commercial land-uses. The existing residential population has been assigned based on the census data and commercial population equivalents are calculated based on 60 PE per ha. It is estimated that the Colwood Corners properties will undergo significant redevelopment and densification. The future land-uses and densification of this area is discussed in the Future Land-Use section below.

DND Colwood

The DND Colwood property has a wide variety of uses. Through discussions with DND staff we understand these include facilities such as the Fleet Diving Unit, the Canadian Pacific Activity Centre, firefighter training facilities, warehouses, and educational buildings. DND staff indicated that they expect there are currently less than 200 people on-site on a daily basis.

Based on a review of the flow monitoring data obtained from the CRD, DND Colwood has a population equivalent of 437.

Additionally, while receiving fuel at a DND Colwood jetty, some of the naval vessels will pump ballast water into the sanitary sewer system. It is understood that this pumping into the sanitary sewer system is coordinated with the City's public works to ensure the system is not overwhelmed. We have therefore not included this ballast water pumping in the sanitary sewer model as it is assumed to occur very infrequently and during off peak periods.

Juan de Fuca Recreation Centre

The Juan de Fuca Recreation Centre includes the following wastewater generating facilities:

- 2,300 seat Bear Mountain Arena;
- 950 seat Juan de Fuca Arena;
- Library;
- Administrative building;
- 25 m swimming pool;
- 9 hole golf course with adjacent club house/field house;
- 3,500 ft^2 weight room;
- 8 sheet curling rink and lounge area, and;
- Various meeting rooms.

Based on a review of the flow monitoring data obtained from the CRD, the Juan de Fuca Recreation Centre has a population equivalent of 132.

2.2 Future Land-Use

Future land-use was developed in order to populate the future modelling scenario. The results from the future modelling scenario are the basis for sizing future infrastructure as well as indicating possible capacity limitations in the existing infrastructure (the City's and the CRD's).

In developing the future land-use scenario a series of meetings were held with the City's Engineering and Planning departments and projections of future land-uses and densities were assigned. As sanitary sewer infrastructure can have a life span of 50 to 100 years or longer, the land-use projections were made considering time frames in this range. It should be noted that the future land-uses are a long term estimate only and do not represent a commitment or acceptance of these land-uses in the future.

The future land-use plan developed through working with the City's Engineering and Planning departments is shown on Figure 2-2. The individual land-uses are described below.

The future land-use densities, as used in the future modelling scenario, are illustrated on Figure 2-3.

2.2.1 Residential Land-Use

The residential land-use represents single family detached dwellings as well as multi-family attached dwellings (duplex, townhouse, condominiums). The residential population, calculated based on the future land-use plan, results in a population of 46,697. This represents a 190% growth above the existing (2011) residential population of 16,093.

The various residential land-uses are described below.

Existing Residential

The existing residential areas are estimated to undergo little or an insignificant change from the current populations. In populating these areas for the future scenario, the existing populations were used.

Existing Residential plus Infill

The existing residential plus infill areas are estimated to grow by 5%, 10% or 20%, as shown on Figure 2-2. The future populations for these areas were derived by taking the existing populations and increasing them by the percentages as indicated.

Residential Development Properties

The residential development properties indicated are expected to be developed as either single family units, multi-family units or a combination of single family and multi-family. For development densities less than 15 units per hectare (single family developments) we used population densities of 2.7 people per unit (same as the existing density for single-family residential). For development densities of 15 to 24 units per hectare (low to moderately dense multi-family developments) we have used population densities of 2.5 people per unit. For development densities greater than 24 units per hectare (high density multi-family developments) we have used population densities of 2.2 people per unit.

These population densities (people per unit) were derived through analysis of the 2011 Census data and comparing with the existing number of units for single family and multi-family land-uses.

2.2.2 Industrial, Commercial and Institutional Land-use

The sanitary sewer flows from the ICI areas are modelled by assigning a population equivalent on a per hectare basis. For the City the total future ICI contributes only a minor portion of the flow as the PE is only 7,614, or only 14% of the total PE when including residential. The ICI land-uses are described below.

Industrial

The Industrial land-use density used for modelling purposes was set to match the existing density of 25 PE per ha, which would represent standard light industrial (manufacturing/warehouse) type uses.

Commercial

It is anticipated that existing commercial areas will generally undergo development and densification and the PE density is expected to increase. The value used for the future scenario is 90 PE per ha, or 50% higher than the PE density in the existing scenario.

Institutional

For the institutional properties (excluding Royal Roads which is described separately below) a density of 50 PE per hectare (excluding playground areas) has been used. A potential new school in the Royal Bay Drive / Promenade Crescent area is included in the future scenario. This equates to a future total institutional PE of 2,077.

2.2.3 Major Properties

Olympic View

The Colwood portion of the Olympic View property has been estimated to have land-uses for the future scenario as follows:

- 201 single family dwelling units;
- 140 low density multi-family units;
- 115 urban centre multi-family dwelling units;
- 120 suite hotel; and
- 1,250 m^2 of retail commercial with a model loading rate of 90 PE per ha.

We received a copy of a Memorandum of Understanding[2] which discusses the Langford portion of the Olympic View Golf Course connecting to the Colwood sanitary sewer system. We also received a plan prepared by Bullock Baur and Associates illustrating future sanitary sewer routes for the Olympic View site. This plan shows the Langford portion of Olympic View contributing to the Colwood sewer system. As a result we have assumed that the Langford portion of Olympic View will also contribute to the Colwood system. The resulting total (Colwood and Langford) future land-uses used in the model are as follows:

- 325 single family dwelling units (2.7 people per unit);

[2] Memorandum of Understanding, Services for Olympic View Development, July 21, 1997, between City of Colwood and District of Langford, and Happy Valley Timber Ltd., and Olympic View Golf Course Ltd.

- 347 low density multi-family units (2.5 people per unit);
- 245 high density multi-family dwelling units (2.2 people per unit);
- 135 hotel suites with a model loading rate of 1.5 PE per suite; and
- 3,500 m^2 of retail commercial or a gross area of 0.7 ha with a model loading rate of 90 PE per ha.

The Bullock Baur plan shows a portion of the Olympic View site serviced by the sanitary sewer on Briarwood Lane, with the balance contributing to the sewer on Latoria Road. We have estimated that to the Briarwood Lane there will be 148 single family units and approximately one third of the low density multi-family units (115 units).

We also received a copy of the technical memorandum, Latoria Valley Downstream Sewer capacity Review[3]. This memorandum states that a population equivalent of 650 could flow by gravity into Langford and that Westshore Environmental (the operators of the Langford sewer system) felt that they could accept the gravity flow from Olympic View. However, for our analysis we have assumed all of the Langford portion of Olympic View flows to the Colwood system.

Royal Bay

The Royal Bay property has been estimated to have land-uses as follows for the future scenario:

- 1,800 single family dwelling units (2.7 people per unit); and
- 1,400 multi-family dwelling units (2.2 people per unit, assuming high density).

These values are in addition to those areas already developed (i.e. Promenade Crescent and Pelican Drive areas). The Royal Bay development is planned for a mix of land-uses including residential, commercial and institutional. It was stated during our future land-use planning meetings that the 3,200 residential units would adequately account for the other land-uses within the Royal Bay development also.

Royal Roads University

Royal Roads University has estimated that their future average daily student on campus and staff populations will be as follows:

- 1,400 average daily students on campus; and
- 500 staff members.

Using the same population equivalent to staff and student ratio as the existing scenario, the total future population equivalent used for Royal Roads is 392.

We have assumed that there will not be any expansion of the 14 DND family houses located between the University and Sooke Road.

DND Belmont

Through our discussions with DND staff, we understand that the population of DND Belmont is not expected to grow more that 10% in the foreseeable future. We have assumed a 10% growth for a future residential population of approximately 1,400.

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[3] Technical Memorandum, Latoria Valley Downstream Sewer Capacity Review, March 12, 2007, Bullock Baur Associates Ltd.

Royal Colwood Golf Course

We are not aware of any significant changes to the Royal Colwood Golf Course and have therefore maintained the existing population equivalent for this property.

Colwood Corners

It is estimated that the Colwood Corners properties will undergo significant redevelopment and densification. The estimated densities are as follows:

- Office and retail commercial with a model loading rate of 90 PE per ha over 50% of the Colwood Corners area; and
- 4,890 multi-family dwelling units which represents a density of 100 units per hectare over the entire Colwood Corners area.

The resulting total future PE for Colwood Corners is 11,900.

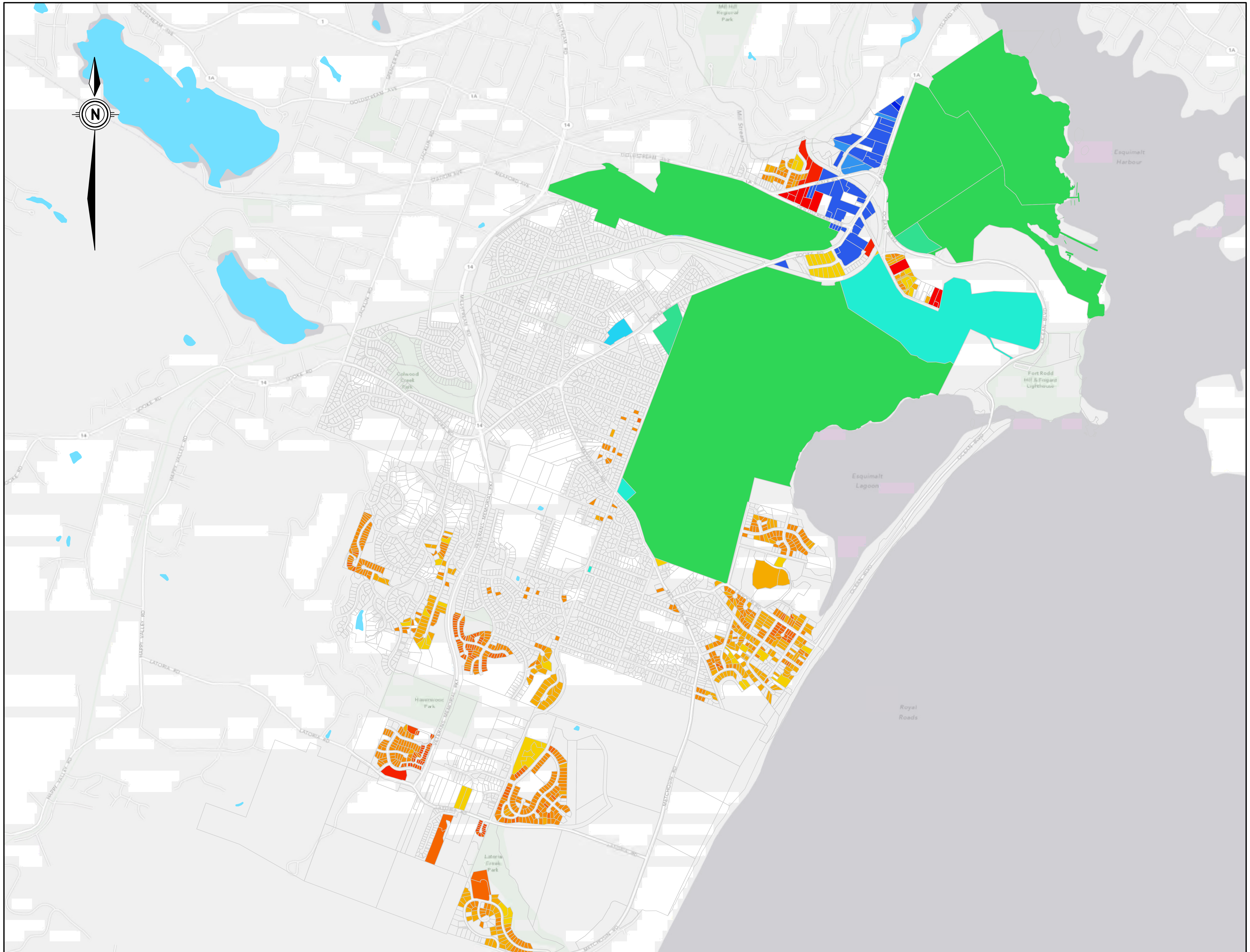
DND Colwood

DND staff were not able to discuss future plans for the DND Colwood site. It was hinted at that significant growth was not planned for this site. We have therefore assumed a 10% growth for a new population equivalent of 480.

Juan de Fuca Recreation Centre

Through discussions with Juan de Fuca Recreation staff we understand that a long term plan does not exist. They also mentioned that their future growth plans are increasingly more uncertain as a result of the City of Langford recently constructing their own recreation facilities.

However, after discussing with Colwood staff we decided it is prudent to assume that the Juan de Fuca Recreation Centre would grow at the same rate as the overall Western Communities. As summarized above, the residential population of Colwood in the future scenario represents a growth of 190%. KWL has previously estimated the future populations for the City of Langford. This analysis indicated a 2045 population of 60,852. This equates to a growth of 144%. Summing the current and future population for Colwood and Langford, the total growth is 160%. This same growth rate has been applied to the population equivalents for the Juan de Fuca Recreation Centre for a new total of 343 PE.



City of Colwood
Sanitary Sewer
Master Plan

Legend

2011 ICI/Mixed (PE/ha)

- 0
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 65
- 65 - 85

2011 Res (PE/ha)

- 0
- 0 - 15
- 15 - 30
- 30 - 50
- 50 - 75
- 75 - 100
- 100 - 150
- 150 - 200

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500 0 500 (m)
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Project No.	Date
2417-003	June 2012

Existing Population Density Connected to Sewer System

Figure 2-1

LEGEND

- PARK/GREENSPACE
- INSTITUTIONAL
- EXISTING RESIDENTIAL
- INFILL RESIDENTIAL
- COMMERCIAL / INDUSTRIAL
- MAJOR PROPERTIES (SEE REPORT FOR DESCRIPTIONS)

RESIDENTIAL DEVELOPMENTS

- DENSITY LESS THAN 15 UNITS PER HECTARE
- DENSITY OF 15 TO 24 UNITS PER HECTARE
- DENSITY OF 25 TO 50 UNITS PER HECTARE
- DENSITY GREATER THAN 50 UNITS PER HECTARE

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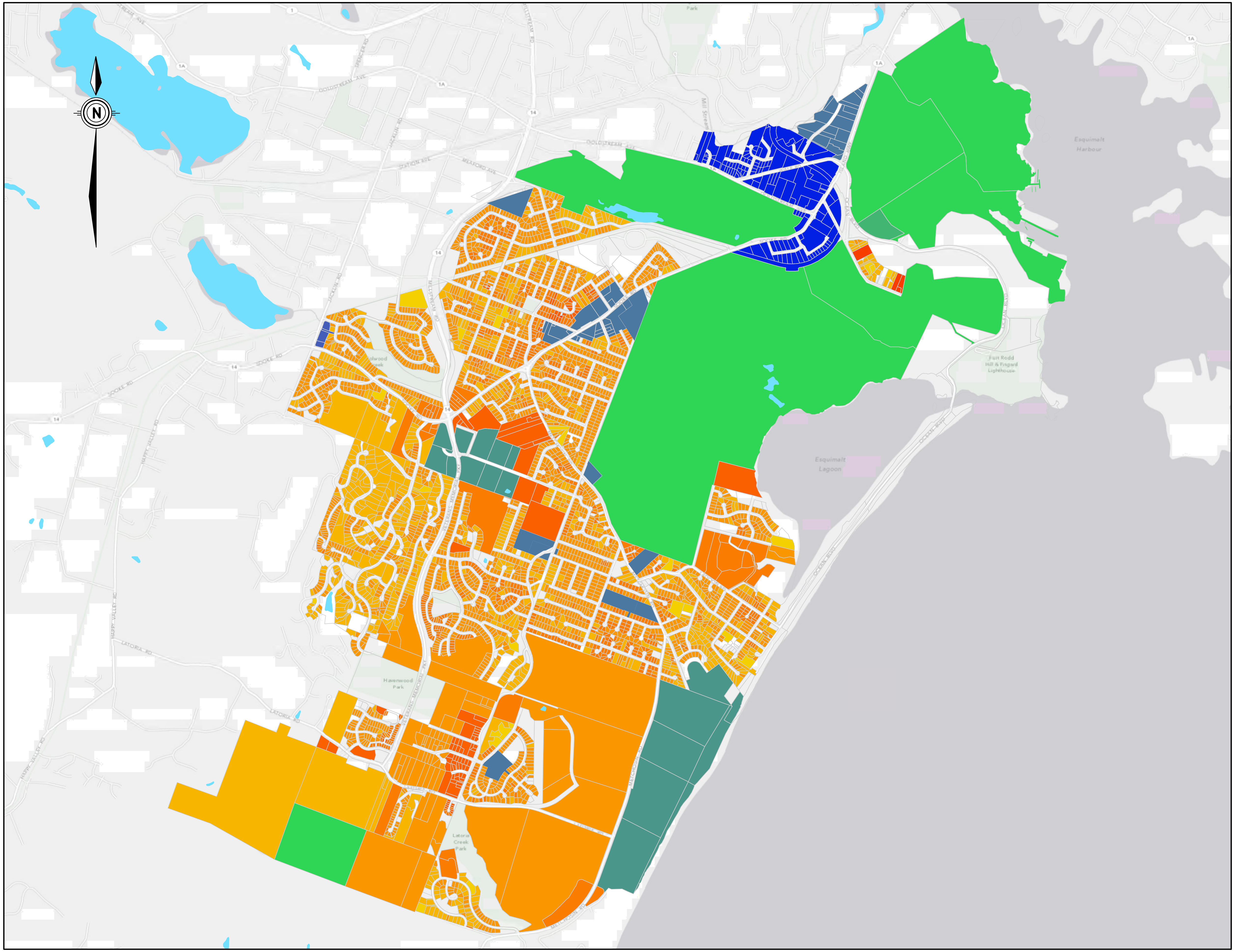
CITY OF COLWOOD
SEWER MASTER PLAN
FUTURE LAND USE PLAN

KWL Project No.	2417.003	Scale	NTS
Sheet	1	Rev. No.	0
Client: CITY OF COLWOOD		Figure Number	2-2



City of Colwood
Sanitary Sewer
Master Plan

Legend

Future ICI/Mixed (PE/ha)

- 0
- 0 - 10
- 10 - 30
- 30 - 60
- 60 - 95
- 95 - 175
- 175 - 250
- 250 - 330

Future Res (PE/ha)

- 0
- 0 - 10
- 10 - 30
- 30 - 50
- 50 - 90
- 90 - 150
- 150 - 300
- 300 - 500

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500 0 500 (m)
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Project No.	Date
2417-003	June 2012

Future Population Density

Figure 2-3

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Section 3

Infrastructure Model

3. Infrastructure Model

3.1 Software Platform

The City selected InfoSewer modeling software produced by Innovyze as the platform for the model. This software is an extension of ArcGIS, and includes the most up-to-date GIS capabilities. It is capable of performing steady-state calculations and extended-period simulations (EPS).

The EPS uses diurnal patterns to peak base loads, and InfoSewer allows for up to ten different diurnal peaking patterns at any given loading point. Base sanitary loads are peaked with diurnally-varying patterns, while the design I&I rate is applied with a unit hydrograph. This ensures a peak-on-peak approach to estimating design flows. Section 4 describes the diurnal patterns used in this study.

Model Database

The InfoSewer platform uses open-format dBase (DBF) and personal geodatabase feature classes for modelling data storage. The advantage of this arrangement is that interoperability between the infrastructure geodatabase for model build and the model is nearly seamless. In addition, the user is able to simultaneously take advantage of the GIS tools offered with ArcGIS and the modelling tools provided with InfoSewer.

The sewer infrastructure data (e.g. pipe size, manhole inverts, etc.) for this study was provided in AutoCAD format (or as-constructed drawings in PDF) instead of a standard ESRI format. In order to transfer the system data to the model easily, a system GIS database was created by extracting the required infrastructure attributes from the CAD drawing through a series of data manipulation processes, together with manual input based on the as-constructed drawings.

The created sewer infrastructure GIS database also provides the City with a robust management tool and a start point for future updates.

For modelling purposes, the following parameters were entered within the model environment:

- COEFF (Num) – pipe roughness – 0.013 (Manning's 'n') for gravity main; 120 (Hazen-Williams C) for forcemain;
- TYPE (Num) – element type – specifies gravity/force main for pipes and loading manhole, chamber, or wet well for nodes; and
- DIAMETER (Num) – nodes only – generally set to 1.05 m for manholes.

3.2 GIS Data Quality Assurance/Control

There were a few missing data records for pipes and manholes based on the drawings received from the City. In order to ensure the accuracy of the model the GIS data was thoroughly examined and a number of elements were updated with assumptions that are normally accepted in general practice. The modifications made to those elements are described in "DESCRIPT" of the model data field.

3.3 Sewer Network Topology

The sanitary networks in InfoSewer for the study area are developed from manhole and pipe building blocks that were created from the available AutoCAD drawing.

Network topology requirements for InfoSewer follow simple link-node rules, which means that each link must begin and end at a node point. Some modifications were made to the GIS data in preparation for model development, such as insertion of additional nodes to split pipes, and addition of KWL notes indicating what changes were made. A record of changes accompanies the model so that the City can review the source data.

Logical Network

A logical network defines connectivity in a table by specifying start and end nodes, with unique ID's for each link feature. This is the system that the InfoSewer model uses to determine flow sequence. It is absolutely necessary to have this system defined correctly in order for the model to operate with reliable results.

Logical sequences were examined using the software until the graphic directions of all pipes matched their defined connectivity in CAD.

3.4 Attribute Data

There are several key physical attributes that are required for hydraulic analysis. For pipes this includes invert elevations, diameter and length. For manholes the required data are rim elevation and diameter.

Manhole diameters and rim elevations were not provided in the source CAD drawing. The manhole diameters were assumed to be 1.05 m dia. for all manholes. Manhole elevations were assigned based on interpolated ground elevations from available 1-m contours provided by the City.

Missing invert elevations for pipes were updated based on the connected manhole invert elevations. Where a pipe has a known invert elevation for one end only, a slope of 0.5% was assumed to calculate the invert elevation of the other end.

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Section 4

Model Population and Loading

4. Model Population and Loading

4.1 Lot-to-Node Association

KWL's methodology for loading sewer models uses each legal lot in the City's GIS cadastral dataset as an individual catchment. This ensures that nearly every pipe in the system receives some level of sanitary loading.

As only a portion of the City lands are currently serviced by the sanitary sewer system, only the parcels shown as being connected to the sewer system were included for domestic flow calculation in the model existing scenario based on the provided AutoCAD drawing.

Within the InfoSewer model, loads are introduced at loading manholes. This was accomplished in two steps. First each lot was spatially joined to the closest pipe, and then the closest of the nodes attached to that pipe was assigned to the lot. These connections were mapped in GIS and subject to a visual examination based on the service connections shown in the AutoCAD drawing. Connections that were deemed incorrect were reassigned manually in GIS.

The model future scenario has lots connected to the City's sewer system. The future serviced lots will be either connected to the potential connecting points in the existing system or to the future network that is proposed as part of this study, based on topography, existing system alignment, and land expansion.

4.2 Residential Population

Census distribution is based on Statistics Canada's Dissemination Area Boundary Files, which portray the boundaries for the 2011 Census data. A dissemination area is a small area composed of one or more neighbouring blocks and is the smallest standard geographic area for which all census data are distributed. Each dissemination area has residential population and dwelling unit estimates associated with it.

The residential population in the existing serviced lots is 5,426 based on the 2011 census data. To develop the residential population loading for the sewer model, KWL performed a distribution of the 2011 Census data within the City's GIS cadastral dataset. As the BC Assessment Authority (BCAA) actual use codes were not available for this assignment, the City's existing zoning was used instead to allocate population to active residential lots.

Using the existing zoning information, the number of single family (SF), and multi-family (MF) lots within each dissemination area can be found. For each area a SF lot is assigned one dwelling unit, and the remaining dwelling units are assigned to MF lots based on relative area. The distribution of the 2011 Census population results in an average occupancy ratio of 2.7 pop/unit for single-family type of residential lot, compared to the City-wide 2.5 pop/dwelling based on the 2011 Census.

4.3 Base Sanitary Flow Rate

Base sanitary loads are flows generated from domestic and ICI sources, and are population-based. For the existing scenario, the per-capita loading rate was calculated based on the measured dry weather flows (less GWI) from residential areas. GWI was estimated to be 85% of the minimum night time flow in each sub-catchment. Table 4-1 displays the calculated per capita loading rate for each residential pump station sub-catchment.

Table 4-1: Calculation of Per Capita Loading Rate

Catchment	Serviced Population	ADWF (L/s)	GWI (L/s)	BSF (L/s)	Per Capita Rate (L/cap/day)
Pelican	311	0.46	0.04	0.42	117
Metchosin (less Pelican)	1,030	1.96	0.24	1.72	144
Sewell	58	0.1	0	0.1	149
Ocean	534	1.19	0.2	0.99	160
Hatley	99	0.21	0.02	0.19	166
Portsmouth	175	0.45	0.05	0.4	197

As can be seen from the above table, the calculated per capita loading rate is generally in the range between 140 and 200 L/cap/day (except for Pelican), comparing to a typical loading rate of 225 L/cap/day for the core area of the Capital Region found in other studies[4]. Based on the model calibration exercise (see Section 6), the calibrated per capita loading rate is 200 L/cap/day. The number is then adopted as a typical domestic sewage loading rate for Colwood and applied in the existing scenario model for all residential people and ICI population equivalents.

It is understood that the CRD is implementing a wastewater management strategy that involves future water conservation efforts. Potential reduction in the per-capita rate could occur based on some design assumptions regarding current and future usage. However, we have used only a slightly reduced 195 L/cap/day as a future design number thus providing some level of flexibility and allowance for future land-use changes.

4.4 ICI Equivalent Population

The typical industrial, commercial and institutional (ICI) equivalent population (PE) densities developed from the CRD flow meters are described in Section 2.

Royal Roads University and Other DND Lands

It has been reported by the University that there are more students on campus during summer time than in winter time. This is also evident by looking at the pump station SCADA data, which shows that multiple pumps ran often during the summer period (mainly from June to September) while only single pump ran during the off-summer period. Although more domestic flows are expected in the summer, the winter period flows were used in the model as significant I&I normally occurs in winter. The derived equivalent populations for the Royal Roads University and other DND lands are summarized in Table 4-2:

[4] Capital Regional District Core Area Wastewater Management Program, Wastewater Flow Management Strategy Discussion Paper – Design Flow Tables 033-DP-2, Sep 10, 2008, KWL

Table 4-2: Summary of Flow and Population Equivalents for DND and Juan de Fuca Lands

Name	ADWF (L/s)	Estimated Area (ha)	GWI[1] (L/s)	BSF (L/s)	PE (cap)	Note
Royal Roads University	0.95	12.3	0.63	0.33	140	Based on Mar-May, 2011 pump flow data
Juan de Fuca Recreation Centre	0.69	7.6	0.39	0.3	132	Based on May-Aug, 2011 pump flow data
DND Colwood	1.6	12.9	0.66	0.91	393	Based on F. Jetty Apr-Sep, 2004 pump flow data
DND Belmont[2]	5.48	47.9	2.44	3.04	1,354	Based on DND Belmont PS 2008 data; PEs include residents in 473 houses and PE from Ecole John Stubbs Memorial Elementary School

Notes:

[1]GWI rate of 4,400 L/ha/day is derived from DND Belmont PS flow data, and is applied to all the other lands in the above table.

2 The populations are the sum of the distributed census population in DND Belmont and school student equivalent people. This number compares to 1,313 PEs if 200 L/cap/day is used to calculate the total PEs.

4.5 Total Serviced Populations

Based on the distribution of 2011 Census data and estimation of ICI equivalent populations based on the available flow data or general density criteria, the existing total serviced populations are displayed in the table below.

Table 4-3: Total Serviced Populations

Existing Serviced Residential Populations	5,426
Existing Serviced ICI Equivalent Populations	2,177
Existing Total Serviced Populations	7,603

4.6 Diurnal Patterns for Extended Period Simulation

A diurnal pattern specifies the shape of the base sanitary flow as a function of time of day. Several diurnal patterns have been used in the model, as explained in the following table.

Table 4-4: Diurnal Patterns

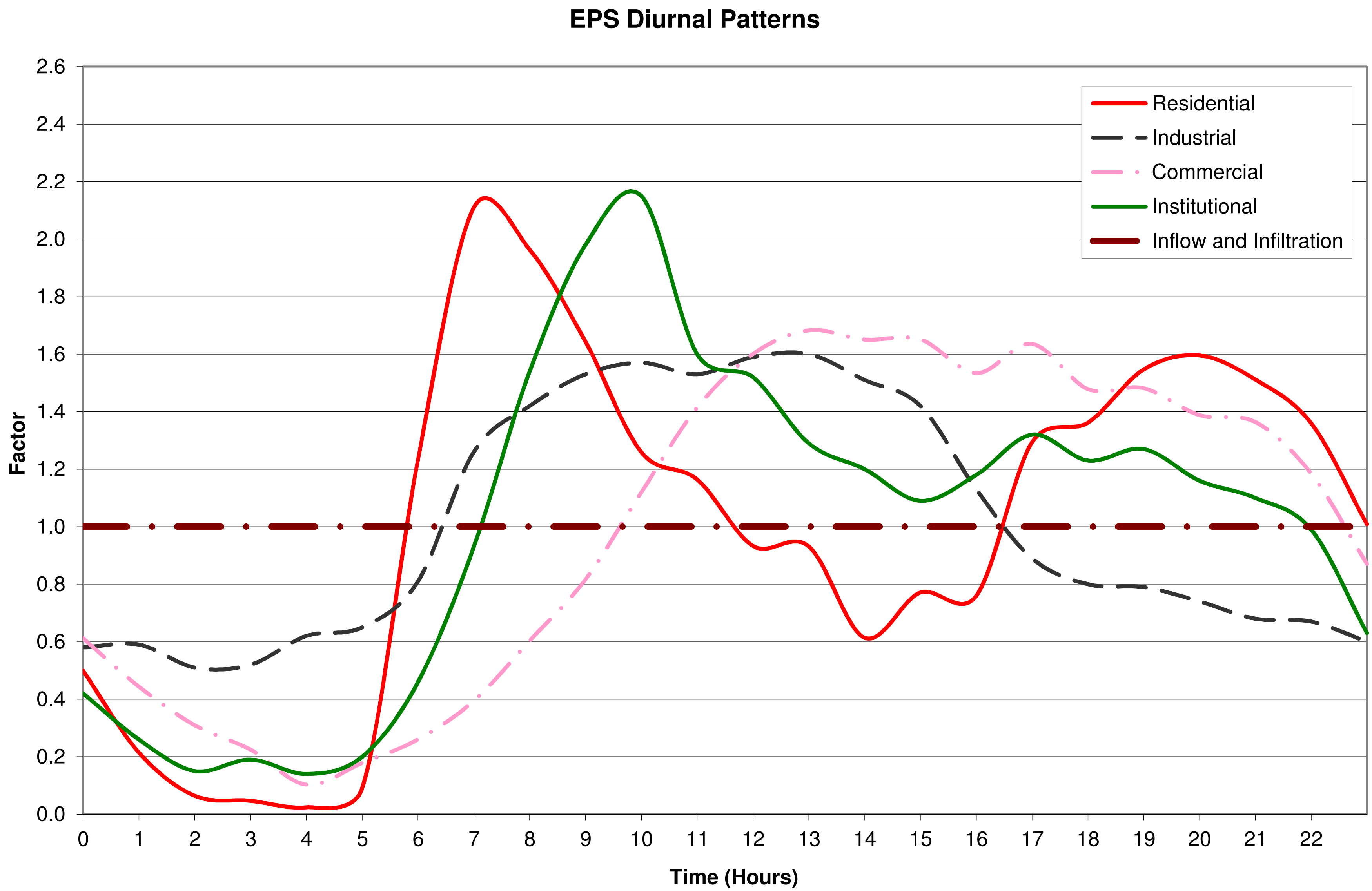
Pattern ID	Denotation	Source	Description
1	Residential Weekday	Metchosin Flow Signals	Weekday residential pattern derived from the Metchosin PS flow data.
2	Industrial	KWL Pattern	Industrial pattern from KWL database
3	Commercial	KWL Pattern	Typical commercial pattern from KWL database
4	Institutional	KWL Pattern	Institutional signal from KWL database
5	Base II		Constant, used for I&I

Residential lots use the pattern ID “1”, which was derived from the Metchosin Pump Station catchment flow signals. This is typical for residential-dominated areas. The ICI use patterns are based on KWL’s past experience in the flow monitoring of similar type of land-uses.

The pattern “5” applied for I&I is a constant distribution (i.e. peaking factor = 1). This ensures a ‘peak on peak’ application of I&I with the base sanitary flow.

All these patterns are applied to the existing and OCP scenarios for system EPS runs.

All of the patterns are shown in Figure 4-1.



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Section 5

Inflow and Infiltration

5. Inflow and Infiltration

This section describes I&I components, and presents how the area-based I&I rates are developed. I&I characterization through a hydrological modeling exercise and discussion of the results is also presented.

I&I represents the ground and stormwater that invariably shows up in sanitary sewer systems. Studies have shown that older systems typically have greater amounts of I&I compared with newer systems. Additionally, studies have shown that the rate of I&I will increase with time if efforts are not made to reduce or prevent I&I.

5.1 Flow and Rainfall Data

5.1.1 The City's Pump Stations

The City's pump station influent flow data, which was converted from the pump stations' SCADA records, was provided for I&I analysis and model loading development. The flow data period is from November, 2010 to November 2011 for each sewer pump station except the Belmont PS for which only Jun, 2011 to January, 2012 is available. The provided data is considered consistent with the existing development conditions and the 2011 Census population.

The flow data was reviewed and analysed to determine catchment flow characteristics. The provided flow data was in 1-hour time step for most of the pump stations except for the Belmont PS, where 5-minute flow data was provided. Though using the hourly flow data will lose some level of accuracy when developing peak 1-hour rainfall dependent I&I, it is still considered acceptable in development of I&I using the I&I envelope method.

5.1.2 Major Property Pump Station

Flow data was provided by the CRD for some of the major property pump stations including Juan de Fuca, Royal Roads University, DND Belmont, and F Jetty (DND Colwood) pump stations. The data was converted from the pump's start / stop records and pumping rate based on draw-down tests conducted in earlier years (2004 – 2006). Only the DND Belmont PS was provided with pump station influent flow data (1-hour time step), while the rest were provided with pumped flow only (5-minute time step). Therefore I&I analysis was carried out for DND Belmont only.

5.1.3 Rainfall Data

The University of Victoria School-Based Weather Station Network operates a rain gauge at Wishart School for research purposes. The rainfall data collected at this rain gauge was used to analyse how the sewer system responds to storm events.

For DND Belmont I&I analysis, rainfall data collected at the nearby Langford Municipal Hall rain gauge was used instead, as the Wishart rain data period does not overlap the flow data period.

Rainfall Intensity-Duration-Frequency data (IDF) was previously derived from the Langford Municipal Hall rain gauge based on historical rainfall data. The return period rainfall amounts (mm) are summarized in Table 5-1 below.

Table 5-1: Langford Municipal Hall Rainfall Statistics (mm)

Return Period	1 hour Total	2 hour Total	6 hour Total	12 hour Total	24 hour Total
2 year	10.2	15.8	29.4	46.8	64.8
5 year	12.5	19.4	39	60	91.2
10 year	14.8	21.8	46.8	68.4	110.4
25 year	17.0	25.4	55.2	81.6	129.6
50 year	17.7	27.6	57.6	88.8	141.6

5.2 Development of I&I Rates

5.2.1 Basic Definitions

For the purposes of this analysis, I&I is categorized in the following standard definitions, adopted from the Metro Vancouver's I&I Task Force report, "I&I Detection: The First Step" (August 1993).

Groundwater Infiltration (GWI)
Groundwater Infiltration (GWI) is typically regarded as infiltration not directly influenced by a particular rainfall event, but more long-term, seasonal rainfall patterns. As noted in the GVRD report: "GWI results from the movement of groundwater in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table".

Stormwater Inflow (SWI)
The Stormwater Inflow (SWI) is generated by rainwater entering the sanitary collection system through "direct connection" such as roof leaders and catch basins and surface runoff entering through manhole lids.

Rainfall Induced Infiltration (RII)
Rainfall induced infiltration (RII) is the entry of extraneous water into the sewer system indirectly through the ground. Typically, the soil must be completely saturated in order for RII to fully occur. RII enters the system once the water level in the service connection and mainline trenches reaches the level of defects in the system. The effects of this type of infiltration do not show up immediately at a downstream flow monitor, but rather over a number of days. In many cases the effects of the infiltration are still measurable days after a storm event.

Rainfall-Dependent Inflow and Infiltration (RDI&I)
RDI&I is the sum of the SWI and RII (i.e. it does not distinguish between the two mechanisms, but shows in the data as the extra flow that occurs during a storm event).

Total I&I
By adding the GWI to the RDI&I, the total I&I is determined.

5.2.2 Return Period and Duration

As expected, I&I rates increase as the precipitation intensity increases. The CRD's LWMP[5] states the following:

> *In accordance with the policy for overflow to receiving environments, the Capital Regional District policy is to design new or replacement trunk sewer for the flows generated by a storm with a return period of 100 years in areas where there is a potential for a wastewater spill to an area of high sensitivity. This policy was applied to the design of new trunk sewer extending into Colwood and Langford and was adopted for planned upgrades to the northwest trunk (NWT) sewer.*
>
> *In the NWT, every overflow point upstream of the Macaulay pump station, with the exception of the Sea Terrace storm drain in West Bay, discharges to a highly sensitive location.*

Therefore, to be consistent with the CRD's LWMP, the design criteria (proposed infrastructure) will be for the 100-year return period I&I event.

The CRD's LWMP goes on to say the following regarding triggers for upgrades of existing portions of the NWT:

> *No section of the trunk meets the proposed design standard, but it was judged impractical to upgrade sewers that are in good condition based solely on that criterion. The concept of a trigger return period was conceived to determine when section of the trunk should be replaced. A trigger return period was determined for each a section of the NWT based on the consequences of a spill, i.e. spills to some locations further upstream in the system were determined to have more serious consequences than spills to other downstream locations. Applying this philosophy, a section of pipe will be upgraded when predicted flows will trigger a spill more frequently than the trigger return period for that section.*

The CRD's LWMP then provides an application of this philosophy including a table of overflow locations and trigger return periods. This table includes Gorge Waterway – 10 year return period, Cecelia Creek – 25 year return period, and Colquitz Creek – 100 year return period. The table does not provide information for any of the watercourses in Colwood.

Overflow from the existing Colwood sewer system would most likely discharge to either Colwood Creek or Bee Creek, both of which discharge to Esquimalt Lagoon. In reviewing information available from the CRD regarding fish presence[6] both Colwood Creek and Colquitz Creek have points of known fish presence, while both Bee Creek and Cecelia Creek do not. This indicates that the existing infrastructure within the Colwood Creek watershed should be able to convey (without overflow) the 100-year return period event and within the Bee Creek watershed the infrastructure should be able to convey the 25-year return period event. To simplify the analysis we have selected the 100-year event for all of the City (this is conservative in the Bee Creek watershed).

Therefore, to be consistent with the CRD's LWMP, the existing infrastructure evaluation criteria will be for the 100-year return period I&I event (same as the design criteria for proposed infrastructure).

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[5] Core Area Liquid Waste Management Plan, July 12, 2000, Capital Regional District, Environmental Services Department

[6] CRD Regional Community Atlas, Natural Areas Atlas > Fish Presence (layer), http://viewer.crdatlas.ca/public#/Home (February 15, 2012)

5.2.3 I&I Analysis Procedure

In order to develop the I&I rates, the following process is followed:

- determine an estimate of the GWI for each catchment during the winter;
- use the RDI&I envelope method in order to make estimates of the RDI&I rates for each site; and
- combine the RDI&I and GWI for each site into total I&I rates.

This report uses a graphical method based on a summary of rainfall and sewer flow events taken from the flow monitoring period. By plotting these results, the relationship between rainfall and RDI&I can be developed. It is then possible to develop 'return-period' design values for RDI&I, based on the rainfall analysis. KWL refers to this specific methodology as the RDI&I Envelope. The RDI&I envelopes for the pump station catchments are presented in Appendix B.

5.3 Calculation of Total I&I Rates

Inflow & infiltration (I&I) loads are modelled as area-based loads representing the additional loading on the sanitary sewer system during wet weather. The I&I rate is calculated by dividing the total I&I flow by the gross area of the contributing catchment. Figure 5-1 illustrates the delineated sub-catchments for calculating I&I rates. Table 5-2 below summarizes I&I for each of the pump station sub-catchments.

Table 5-2: Sub-Catchment I&I Rates

Item	Catchment Name								
	Pelican	Metchosin (less Pelican)	Ocean Blvd	Ports-mouth	Wilfert	DND Belmont	Bel-mont	Hatley	Se-well
5-yr 24-hr RDII (L/s)	1.9	2.4	1.7	0.7	2.3	28.0	-	-	-
5-yr Peak 1-hr RDII (L/s)	2.9	4.5	2.6	1.4	4.2	59.4	-	-	-
25-yr Peak 1-hr RDII (L/s)	3.8	6.0	3.5	1.9	6.0	84.3	-	-	-
GWI (L/s)	0.04	0.2	0.2	0.1	0.4	2.4	0.07	0.02	-
5-yr 24-hr I&I (L/s)	2.0	2.6	1.9	0.8	2.7	30.5	-	-	-
5-yr Peak 1-hr I&I (L/s)	2.9	4.7	2.8	1.4	4.6	61.8	-	-	-
25-yr Peak 1-hr I&I (L/s)	3.9	6.3	3.7	2.0	6.3	86.8	-	-	-
Catchment Area (ha)	15.5	32.6	36.7	8.6	21.4	47.9	5.7	5.5	1.7
GWI Rate (L/ha/day)	200	600	500	500	1,400	4,400	1,000	300	-
5-yr 24-hr I&I Rate (L/ha/day)	11,000	6,900	4,500	7,900	10,700	55,300	-	-	-
5-yr Peak 1-hr I&I Rate (L/ha/day)	16,200	12,400	6,700	14,400	18,500	112,200	-	-	-
25-yr Peak 1-hr I&I Rate (L/ha/day)	21,400	16,600	8,600	19,800	25,500	157,500	-	-	-
100-yr Peak 1-hr I&I Rate (L/ha/day)	24,900	19,400	9,900	23,100	30,000	187,700			
Notes: - Development of I&I rates for Belmont, Hatley, and Sewell PS catchments is not successful in this assignment - All DND lands use I&I rates from DND Belmont									

The weighted average (weighted based on catchment area) of the I&I rates for the Pelican, Metchosin, Ocean Boulevard, Portsmouth and Wilfert Pump Stations is 19,400 L/ha/day for the 100-year peak 1-hr I&I rate. This compares well with past analysis work KWL has completed for the CRD which calculated the 100-year I&I rate at the Aldeane meter to be 23,000 L/ha/day. Based on these values, the 100-year I&I rate used for existing system modelling is 20,000 L/ha/day. This includes 800 L/ha/day of GWI.

The I&I rate for newly serviced areas may initially be less than 20,000 L/ha/day, as is the case for the catchment to the Ocean Boulevard Pump Station. However, it has been shown that I&I increases as a system ages. We have assumed that through ongoing I&I reduction and general maintenance programs, the I&I rate of 20,000 L/ha/day will be maintained for the life of the sewer.

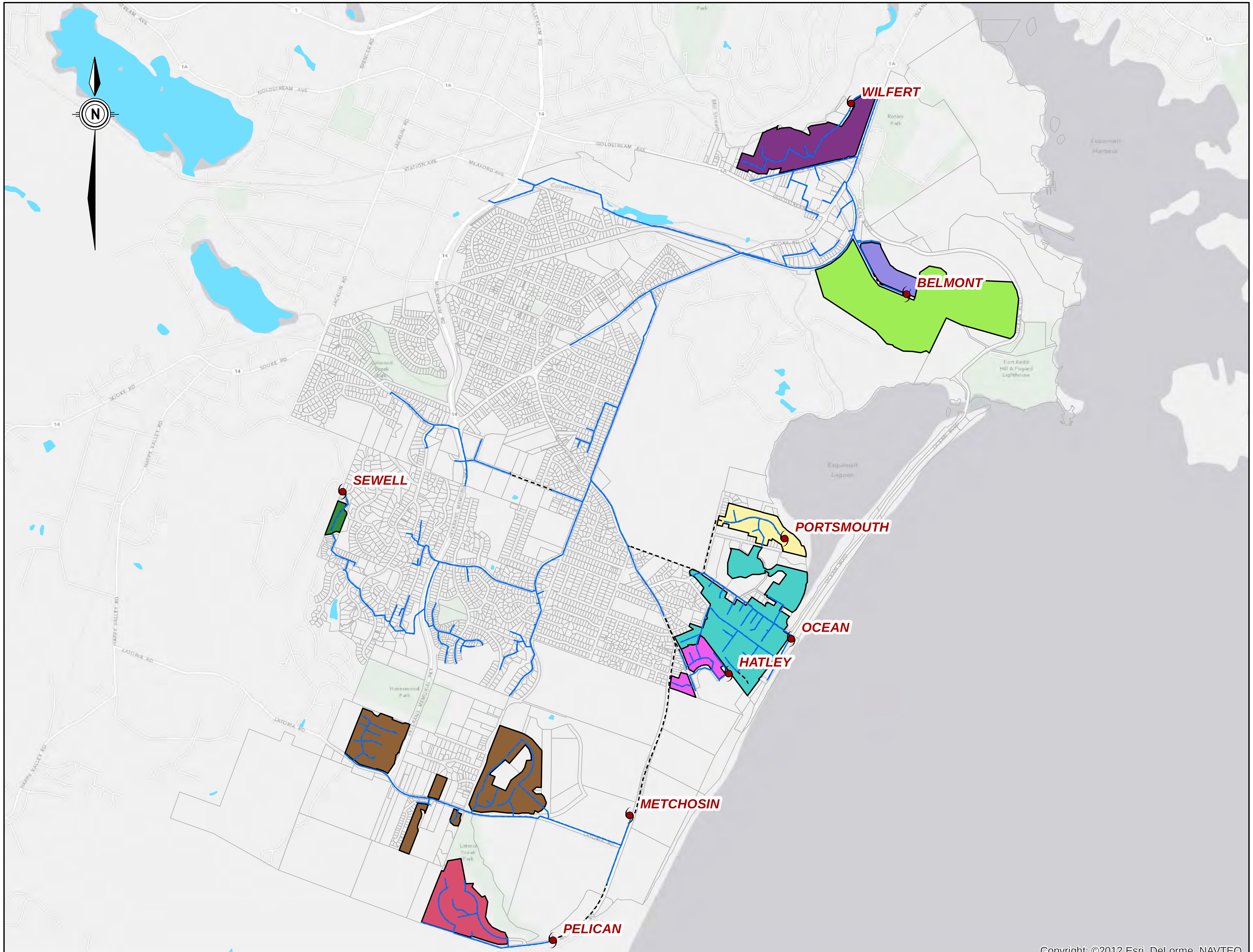
When applying I&I loads to the model, a net area factor (NAF) is used to adjust the contributing lot area. The net area factor is the ratio of total area of the catchment to the active lot area of the catchment. The net area factor is necessary to account for the difference between the gross flow monitoring area (including roads) used to calculate I&I rates, and the net area used in the model (the lot area) to apply I&I flows. For the existing developed lands outside the I&I catchment areas, a typical NAF of 1.25 is applied.

As indicated in Table 5-2 above, the I&I rate for DND Belmont is significantly higher than the I&I rate for the other Colwood catchments. Between 1998 and 2001 approximately 54 % of the sewers within DND Belmont were replaced with PVC pipes in an effort to reduce I&I. The extent of the rehabilitation and the resulting I&I rates are recorded in a 2007 CRD I&I Analysis Report[7]. This study also recommended that the remaining original sewers at DND Belmont be rehabilitated.

As the CRD proceeds with the core area wastewater treatment plant project, the costs for treating stormwater will increase resulting in a greater need to reduce I&I. Following discussions with the City Engineer, we understand that the City will support and encourage I&I reduction programs for the areas with high rates of I&I. Therefore, it is assumed that DND Belmont and other areas with potentially high I&I rates (DND Colwood and Royal Roads University) will undergo I&I reduction programs. As these properties are owned by a single land owner, the I&I program could include the full extent of the mains and service laterals. Therefore, we have assumed a 100-year I&I rate for the future modelling scenario of 20,000 L/ha/day for the DND and Royal Roads University catchments (assuming a fully rehabilitated sanitary sewer system). For the existing scenario, the 100-year I&I rate of 187,700 L/ha/day will be used for the DND and Royal Roads catchments.

[7] Inflow and Infiltration Analysis Results: 2005/2006 and 2006/2007 Flow Monitoring Sites in Colwood, Capital Regional District Environmental Services, November 2007.

City of Colwood
Sewer Master Plan



Legend

- Sanitary Pump Station
- Existing Gravity Mains
- Forcemains

Pump Station Catchment

- Belmont
- DND Belmont
- Metchosin
- Ocean
- Pelican
- Hatley
- Portsmouth
- Sewell
- Wilfert

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2417-003	May 2013

Existing Subcatchment Areas for I&I Calculations

Figure 5-1

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Section 6

Model Calibration and Validation

6. Model Calibration and Validation

6.1 Dry Weather Flow

6.1.1 The CRD's Flow Monitor

There are three flow monitors on the CRD trunk sewer, Meaford, Aldeane, and Parsons. Meaford measures total flows in the CRD trunk sewer that enters into Colwood from the upstream user (City of Langford). Parsons measures total outflows in the CRD trunk sewer before it enters into the downstream city (Town of View Royal). Aldeane measures total flows from the City's Sooke Rd sewer before it discharges into the CRD trunk sewer at Aldeane Ave. The total flow from Colwood is calculated as the difference between the Parsons and Meaford flows.

1-hour time step flow data from Oct, 2007 to Jan, 2011 is available for Meaford and Parsons. Data from Jun 2007 to Feb 2012 at 5-minute time step is available for Aldeane. As the measured flows at Aldeane are primarily from the existing residential developments with minimum ICI flow contribution, the Aldeane flow data is then used for the base sanitary flow calibration and the Parsons flow data is used for verification of the calibrated model.

It is noted that the measuring weir at Meaford was removed on Apr 28, 2010 and was put back on Jun 06, 2010, flow data for this period was re-built based on a data regression analysis for Meaford and Craigflower (a CRD meter in View Royal). After Jun 06, 2010, the flow signals also showed abnormities thus were also re-built based on a temporary FLO-DAR® meter. For the purpose of model verification, the dry weather flow data measured at Meaford in the summer of 2009 was used as input to simulate the starting flow in the CRD trunk sewer. The modeled dry weather outflow at Parsons will be compared with the Parsons' 2010 dry weather flow, taking into account the increased flow due to population growth from 2010 to 2011.

The selected time periods are:

- Aldeane Flume (CRD): August 01 – August 05, 2011, for model calibration; and
- Parsons (CRD): July 26 – 31, 2010, for model verification / validation.

6.2 Dry Weather Flow Calibration

The recommended tolerances for dry weather flow calibration are detailed in the following table.

Table 6-1: Recommended Dry Weather Flow Calibration Tolerances

Parameter	Recommended Accuracy
Volume of Flow (24-hour)	+/- 10%
Peak Flow (1-hour)	+/- 5%
Peak Timing	+/- 1 hour
Shape	Representative of observed flow or depth pattern

Using different per capita loading rate for BSF, the results from the model were compared against the flow monitoring data for the Aldeane Flume site, and compared according to the above parameters, as well as visually by overlaying the hydrograph results. The model calibration exercise resulted in a per capita loading rate of 195 L/cap/day, with which the modeled flow closely matches the observed flow in terms of 24-hour flow volume, peak hourly flow, and peak timing. Although 195 L/cap/day reaches the upper bound of the typical range of 140 – 200 L/cap/day calculated for each pump station sub-catchment, it is considered a reasonable value when comparing to the typical value of 225 L/cap/day in the capital region.

The calibration results are presented in Table 6-2, and the hydrographs are displayed at the end of this section.

Table 6-2: Model Dry Weather Flow Calibration Results Summary

	Modelled	Measured	Difference	Difference (%)	Note
ADWF (L/s)	7.6	7.9	-0.3	-3.8%	
PDWF (L/s)	17.4	15.8	1.58	10.0%	
Peaking Factor of BSF	2.15	2.3			
Peak Timing	8:45 AM	9:55 - 10:25 AM	1.5 hour		for typical days

As can be seen in the above table that the modeled peak flow is about 10% higher than the observed peak flow, it is considered acceptable. This is because the model was run with 1-second hydraulic time step in order to better simulate pumps' operation, thus creating numerous flow spikes due to pumping. Also, the residential diurnal pattern was derived from the upstream Metchosin PS flow signals (1-hour time step flow) which have a peak time at 7 am, resulting in the modeled peak time earlier than the observed.

6.3 Model Verification and Validation

The model verification / validation process is an exercise performed to justify that a calibrated hydraulic model is capable of providing sufficient accuracy when used to predict the performance of the real-world system that it represents. The validation of the model also verifies all the assumptions made in the model loading development and model calibration phases. This is done by comparing the modeled total ADWF with the observed ADWF at the Parsons meter, as there are significant flow contributions to the CRD trunk sewer downstream of the Aldeane flume.

Comparison results of the modeled and observed ADWF at Parsons are summarized in Table 6-3, and the hydrographs are displayed in Figure 6-2.

Table 6-3: Model Dry Weather Flow Verification Results Summary

	Modelled	Measured	Difference	Difference (%)	Note
ADWF Flow (L/s)	79.2	80.2	-1	-1.2%	
PDWF (L/s)	109.2	114.3	-5.1	-4.5%	
Peak Timing	11:20 AM	11:00 AM	< 1 hour		for typical day

Table 6-3 demonstrates that the modeled ADWF also closely matches the observed ADWF at the Parsons meter, in terms of 24-hour total flow volume, peak flow and time to peak. Therefore the calibrated model is capable of performing hydraulic analysis with sufficient accuracy and forms the basis for future development scenarios.

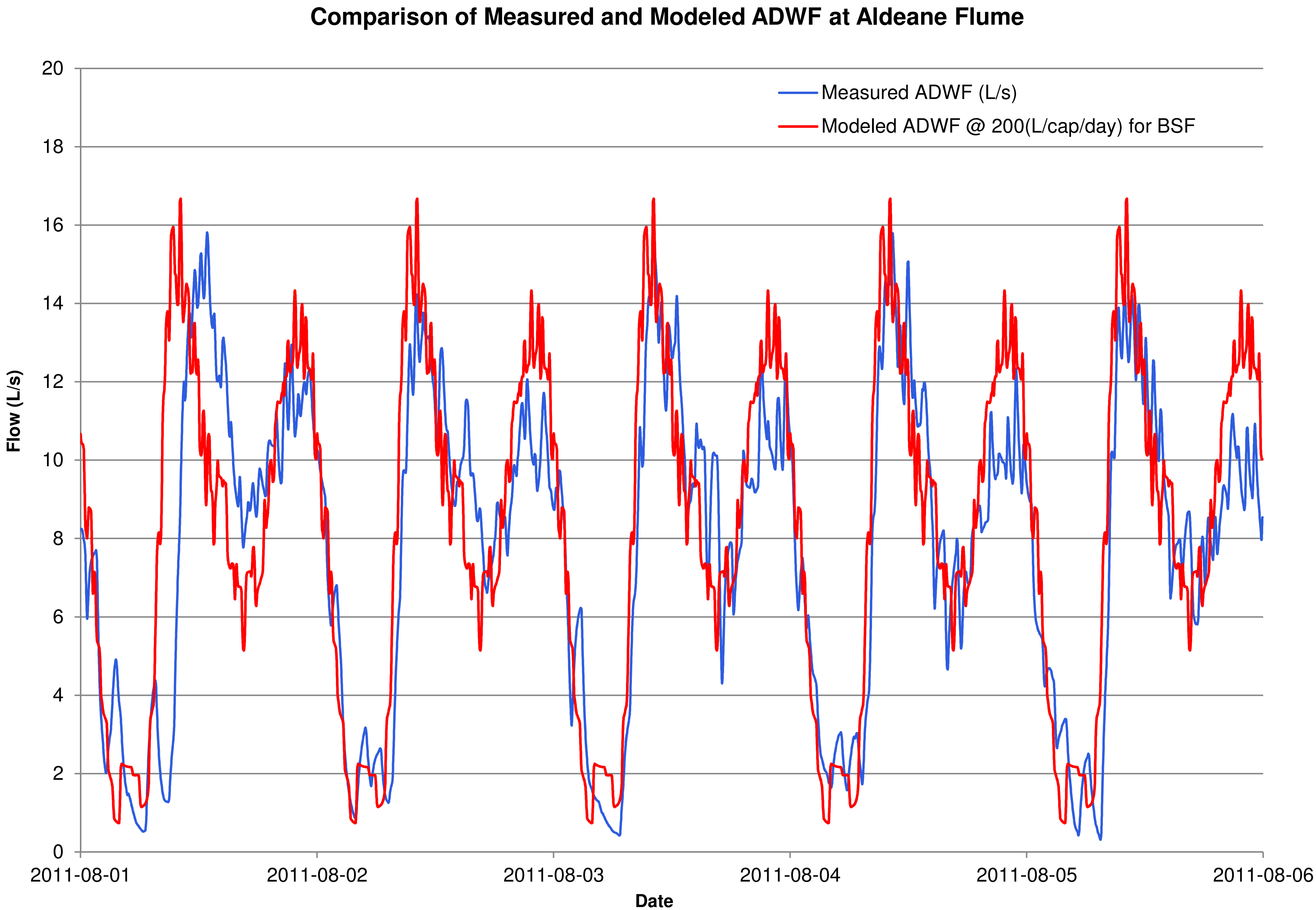

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Figure 6-1

Comparison of Measured and Modeled ADWF at Parsons Meter

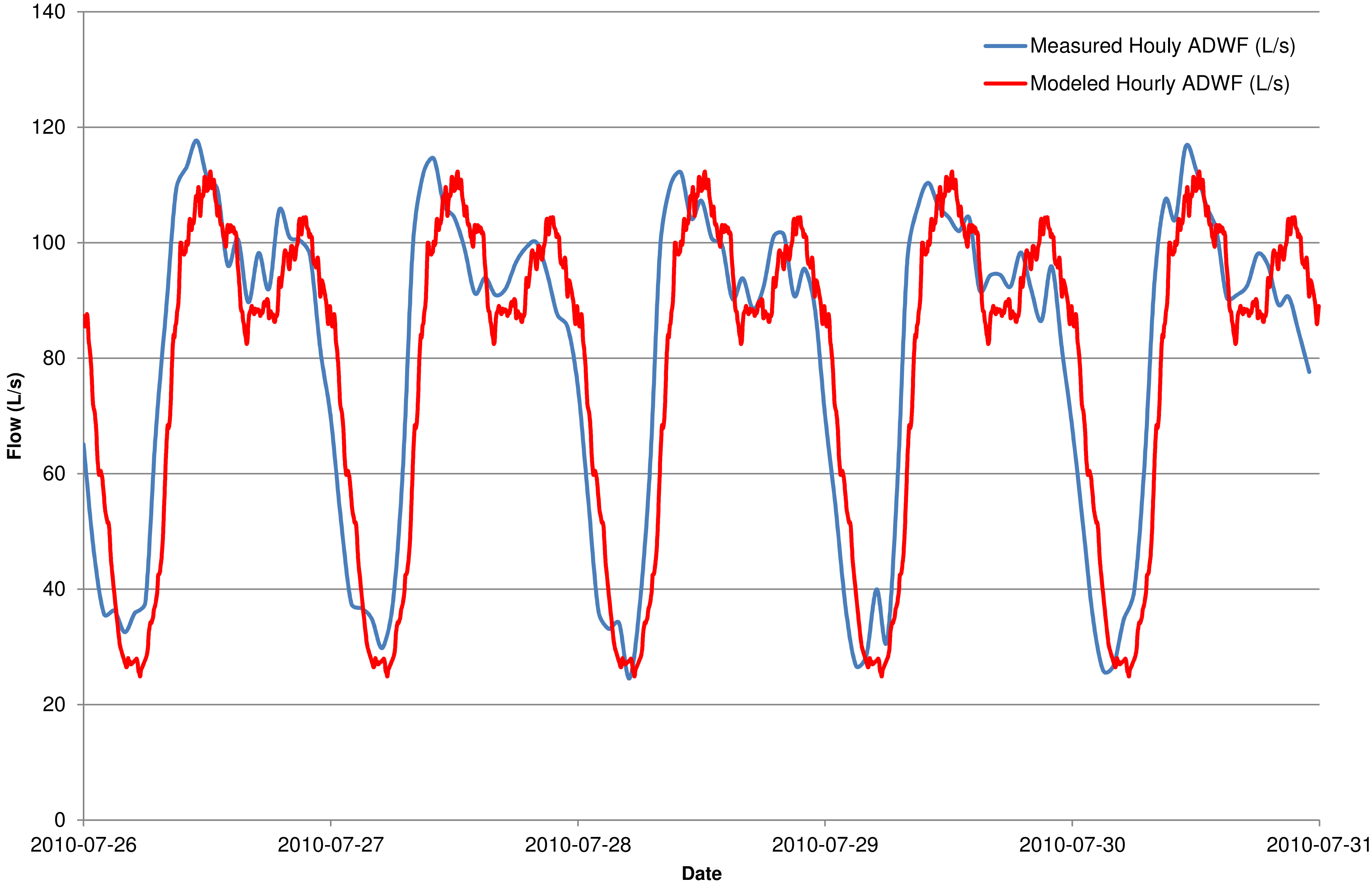

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Figure 6-2