DISCUSSION PAPER

Capital Regional District
Core Area Wastewater Management Program

Wastewater Flow Management Strategy
Discussion Paper – Existing and Future Populations, ICI Equivalents, and I&I
033-DP-1

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1 Introduction

A key task is to develop preliminary design flows for the proposed treatment plant locations and required conveyance facilities. Historically, this work has been undertaken by the CRD for conveyance facilities only, and was focused on one particular collection system at a time.

In order to provide a concise reference point from which to consolidate all of this information, this document compiles key source data from the previous efforts and updates it when possible. This source data is then used in analysis work that is presented in successive Discussion Papers.

The core data that is compiled and updated when possible includes:

- Existing and future population estimates for each municipality;
- Existing and future population equivalent estimates, to account for industrial, commercial, and institutional loadings; and
- Inflow and Infiltration estimates, to account for excessive wet weather flows.

The source data is often taken from extensive reports which use somewhat involved methodology. Therefore, the goal of this Discussion Paper is to describe the basic concepts behind the source information, to provide the reader with a high-level understanding of how the data was created. A reference list is provided to permit the reader to refer to the specific reports should more detail be desired.

Discussion Paper 033-DP-2 is the first document to use this new data, and presents the calculation of updated design flows from the source information.

2 Information Sources

Previous studies have been done at separate times on 3 major separate collection systems within the CRD:

- Northeast Trunk/East Coast Interceptor (NET/ECI)
- Northwest Trunk – Northern Section (NWT-N)
- Northwest Trunk – Western Section (NWT-W)

Table 1 shows the major information sources and reports which have been compiled for use in this document. This document provides a brief description of the data sources, but for more detail the reader is encouraged to consult the appropriate sections of the documents listed in Table 1.

Table 1
Document History

Ref	Document	Author/Date	Used in this Document for
1	Population Projections – CRD Sewer Project	CRD Environmental Services – DRAFT Oct 14, 2008	Municipal Population Projections, including updated values for Langford
2	Northeast Trunk/East Coast Interceptor Upgrade Capacity Deficiency Study	Kerr Wood Leidal (May 2003)	ICI Equivalents, Tributary Area Estimates and I&I for ECI/NET
3	Northwest Trunk Sanitary Sewer System Summary Report on Design Flows and Hydraulic Analysis	Kerr Wood Leidal (November 1999)	ICI Equivalents, Tributary Area Estimates and I&I for NWT-N
4	Northwest Trunk – Western Section – Design Flows and Capacity Deficiencies	Kerr Wood Leidal (October 2004)	ICI Equivalents, Tributary Area Estimates and I&I for NWT-W
5	Esquimalt Trunk and Western Communities Trunk Sewer Cost Sharing – Colwood (53,600) and Langford High Growth Scenario	Kerr Wood Leidal (December 1994)	Supplied information into Document # 3 and 4
6	Inventory of Flow Monitoring Stations along the Northwest and Esquimalt Trunks	Kerr Wood Leidal (February 1995)	Supplied information into Document # 3 and 4
7	I&I Rates and Sewer Infrastructure Age: Is There a Strong Correlation?	Kerr Wood Leidal/CRD (June 2005)	Infrastructure Decay Concepts
8	Vulnerability of Vancouver Sewerage Area Infrastructure to Climate change	Kerr Wood Leidal/Associated Engineering (March 2008)	Climate Change Concepts
9	056-DP1-Contributary Population and Wastewater Flows	KWL/AE/CH2M (Oct 7, 2008)	Detailed Population, Equivalents, and Tributary Areas for Langford

3 Populations by Municipality

The CRD Planning Department recently provided updated estimates for the Core Area populations by Municipality at various development horizons (Document Reference #1). Table 2 provides a copy of this information.

Table 2:
CRD Total (not Sewered) Population Estimates (Growth Scenario 3)

	2006 Population	Avg. Annual Growth Rate (2006-2015)	2015 Population	Avg. Annual Growth Rate (2015-2045)	2045 Population	Avg. Annual Growth Rate (2045-2065)	2065 Population
Oak Bay	18,059	0.1%	18,222	0.1%	18,777	0.1%	19,175
Victoria	78,659	1.0%	86,028	0.5%	99,913	0.1%	102,032
Esquimalt	17,407	0.5%	18,206	0.5%	21,145	0.1%	21,593
Saanich	110,737	0.5%	115,821	0.5%	134,515	0.1%	137,368
View Royal	8,375	2.0%	10,009	1.5%	15,645	1.0%	19,280
Colwood	15,470	2.0%	18,488	1.5%	28,698	1.5%	39,506
Langford	22,229	5.1%	32,462	2.9%	60,851	1.5%	81,958
Total	**270,936**		**299,236**		**379,544**		**420,912**

It is important to note that these populations reflect estimates of total population, not sewered population. In most municipalities it is reasonable to assume that they are essentially the same, except for Langford and Colwood which currently have large unsewered areas (these are assumed to be fully serviced by 2030). Table 4 of this document details the sewered population estimates.

These newer residential population projections are assumed to supersede those previously calculated in Documents 2-5. They are not significantly different than previous estimates, with the exceptions of Colwood and Langford which are discussed further in this document.

4 Industrial, Commercial, and Institutional (ICI) Equivalents

In order to estimate the contributions from ICI sources, the approach that has been used previously is to assign “population equivalents” to area that is classified as industrial, commercial, or institutional.

Unlike the work done in Document #1, there has not been a “unified” approach to estimating ICI equivalents for the entire Core Area. Rather, consolidated values calculated from the previous reports have been used for each sanitary catchment.

Although outside the scope of this study, conducting a new ICI study for the entire unified Core Area would involve the following:

- Consolidate all of the GIS spatial catchments from the 3 main collection systems, or create them where non-existent.
- Using a GIS overlay with the current land use, calculate the amount of industrial, commercial, and institutional area within each catchment.
- Apply ICI parameters to calculate total equivalents for each catchment (see Table 3).
- Modify for special cases as required, including Downtown Victoria, major hospitals and institutions (using either water or sanitary flow records).
- Project current ICI values to future development horizons, using growth rates similar to residential or employment estimates.

Table 3
Typical ICI Parameters

Land Use	Population Equivalent per Hectare
Industrial	25
Commercial	90
Institutional	50

The above procedure is in fact what was done for the NET/ECI (Document #2) and NWT-W (Document #4), although they were done at different times.

The ICI analysis for the NWT-N is the oldest (Document #3) and did not use a GIS based approach. In that document, a manual process was done with the following sources collectively used to develop ICI equivalent estimates:

- Saanich SANSYS computer model;
- Cost sharing study for the NWT-W (Document #5) and flow monitoring data (Document #6); and,
- Manual counts of contributing lots multiplied by varying densities.

5 Combination of Residential and ICI Estimates

Table 4 provides both the sewered residential and ICI estimates that have been compiled from the documents in Table 1. An intermediate time horizon of 2030 has also been added for reader convenience. Figures 1 to 3 present the results graphically.

The residential estimates closely approximate the CRD estimates provided in Document #1, with two exceptions:

- It is assumed that the entire Langford and Colwood populations will not be sewered until 2030; therefore, the sewered residential values shown in Figure 1 and Table 4 for 2005 and 2015 are less than the total predicted values.

- The growth projections for Colwood from Document #1 are less aggressive than those that were originally calculated in the cost sharing agreement for the NWT-W (Document #5, originally called the Esquimalt Trunk). As part of the cost-sharing agreement however, Colwood has paid-up capacity in the NWT-W to 53,600 equivalents, estimated for 2045. We have therefore maintained the original values in order to provide conservative estimates of the potential flows that could be produced by Colwood.

For Langford, there have been two recent studies (a sewer master plan conducted by Focus Corporation projecting an ultimate build out total population equivalent for Langford of 127,300, and the new Langford OCP projecting a 2028 population of 47,244). These produce growth rates which are significantly larger than those originally envisioned in the cost-sharing agreement, and have been presented in the most recent CRD planning document (Document #1) and Discussion Paper (Document #9). It should be noted that the CRD Planning department does not provide wholesale agreement with these numbers, but merely lists them as one possible scenario. We have elected to move forward using the newly updated numbers as the most conservative (i.e. highest growth) scenario.

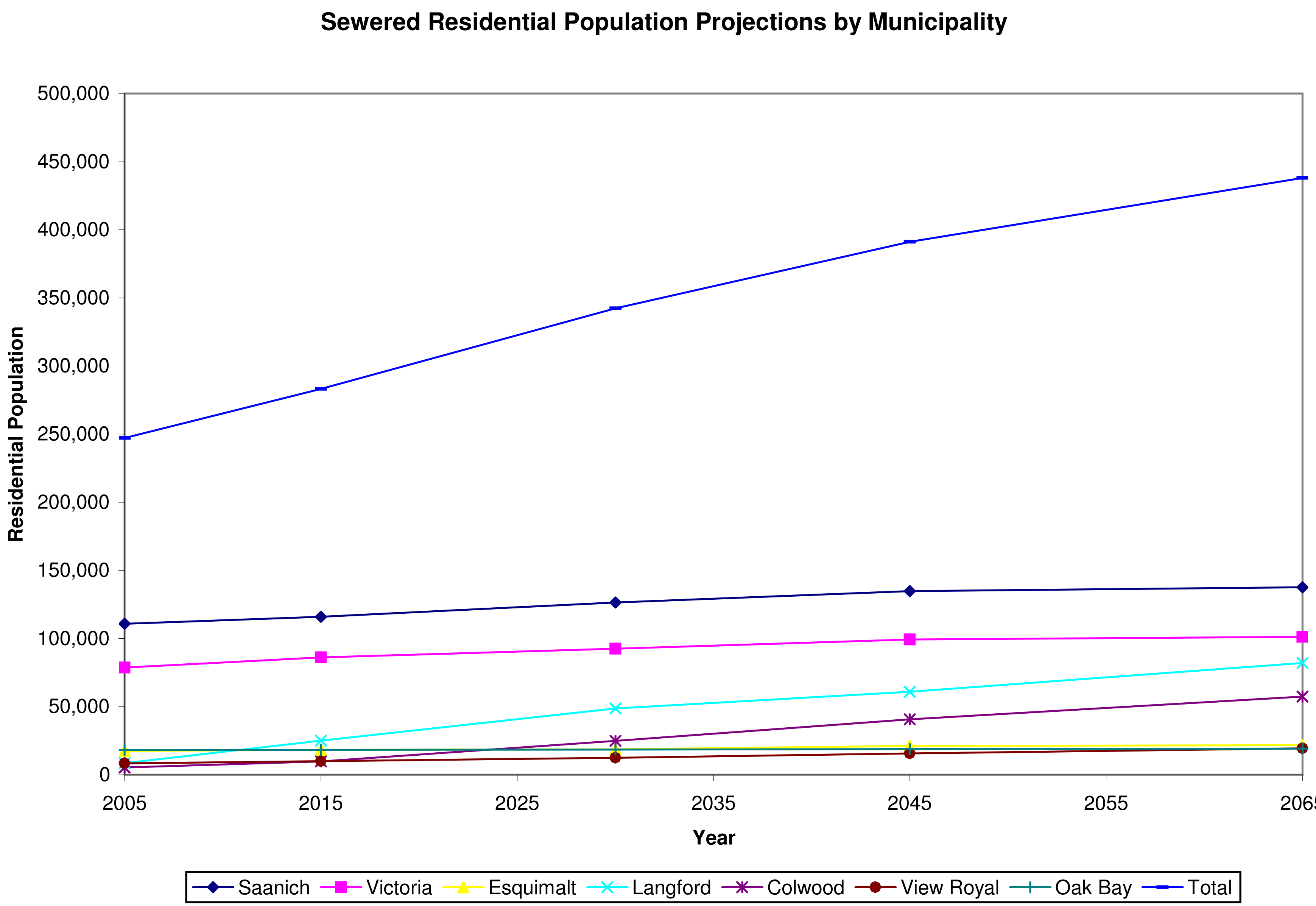
6 Tributary Area Estimates

Tributary areas are used in the design flow calculations for estimation of the I&I flow from each catchment, as most I&I rates are expressed as area-weighted values. Many of the Municipalities are assumed to have little to no spatial growth due to physical constraints or a desire to maintain the urban boundary. The exception is the Western Communities. Figure 4 shows what the CRD understands to be the current and ultimate sewerage areas.

Based on Documents #2-4, Table 5 presents the projected sewered tributary areas for each Municipality.

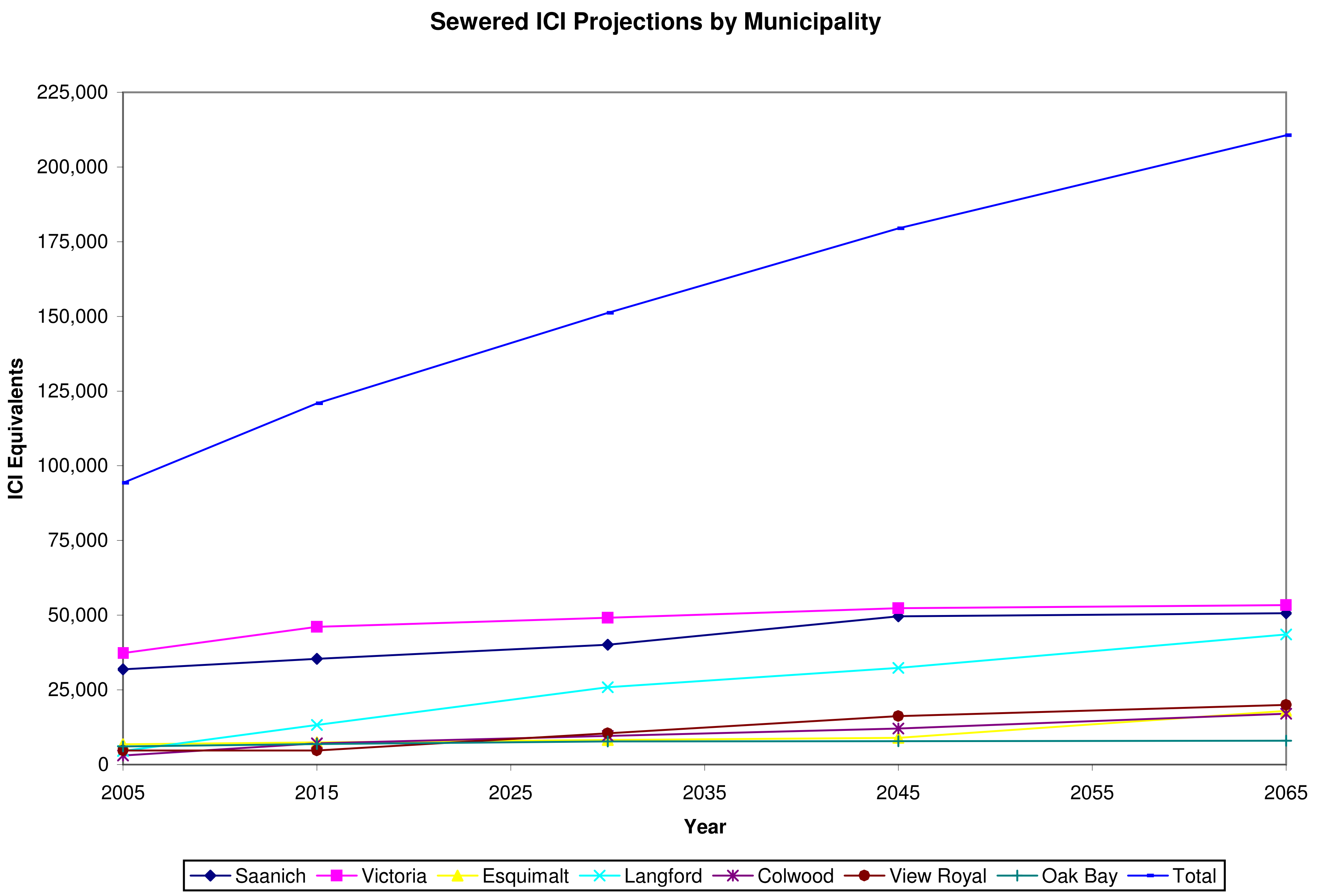
Table 4 - Sewered Residential and ICI Estimates by Municipality

	2005			2015			2030			2045			2065		
	Residential	ICI	Total PE	Residential	ICI	Total PE	Residential	ICI	Total PE	Residential	ICI	Total PE	Residential	ICI	Total PE
Saanich	110,730	31,860	142,590	115,944	35,368	151,312	126,393	40,120	166,513	134,773	49,651	184,424	137,614	50,693	188,307
Victoria	78,658	37,341	115,999	86,057	46,115	132,172	92,566	49,168	141,735	99,239	52,350	151,589	101,216	53,397	154,612
Esquimalt	17,412	6,773	24,185	18,206	7,411	25,617	18,667	8,199	26,866	21,153	8,987	30,140	21,581	17,991	39,572
Langford	8,547	4,542	13,089	24,988	13,279	38,267	48,672	25,865	74,537	60,852	32,337	93,189	81,958	43,554	125,512
Colwood	5,389	3,010	8,400	9,779	7,137	16,916	24,942	9,606	34,548	40,623	12,075	52,697	57,278	17,019	74,297
View Royal	8,372	4,693	13,065	10,009	4,693	14,702	12,512	10,460	22,972	15,640	16,226	31,867	19,276	19,991	39,267
Oak Bay	18,075	6,033	24,108	18,237	6,899	25,135	18,514	7,790	26,304	18,816	7,854	26,670	19,183	8,003	27,187



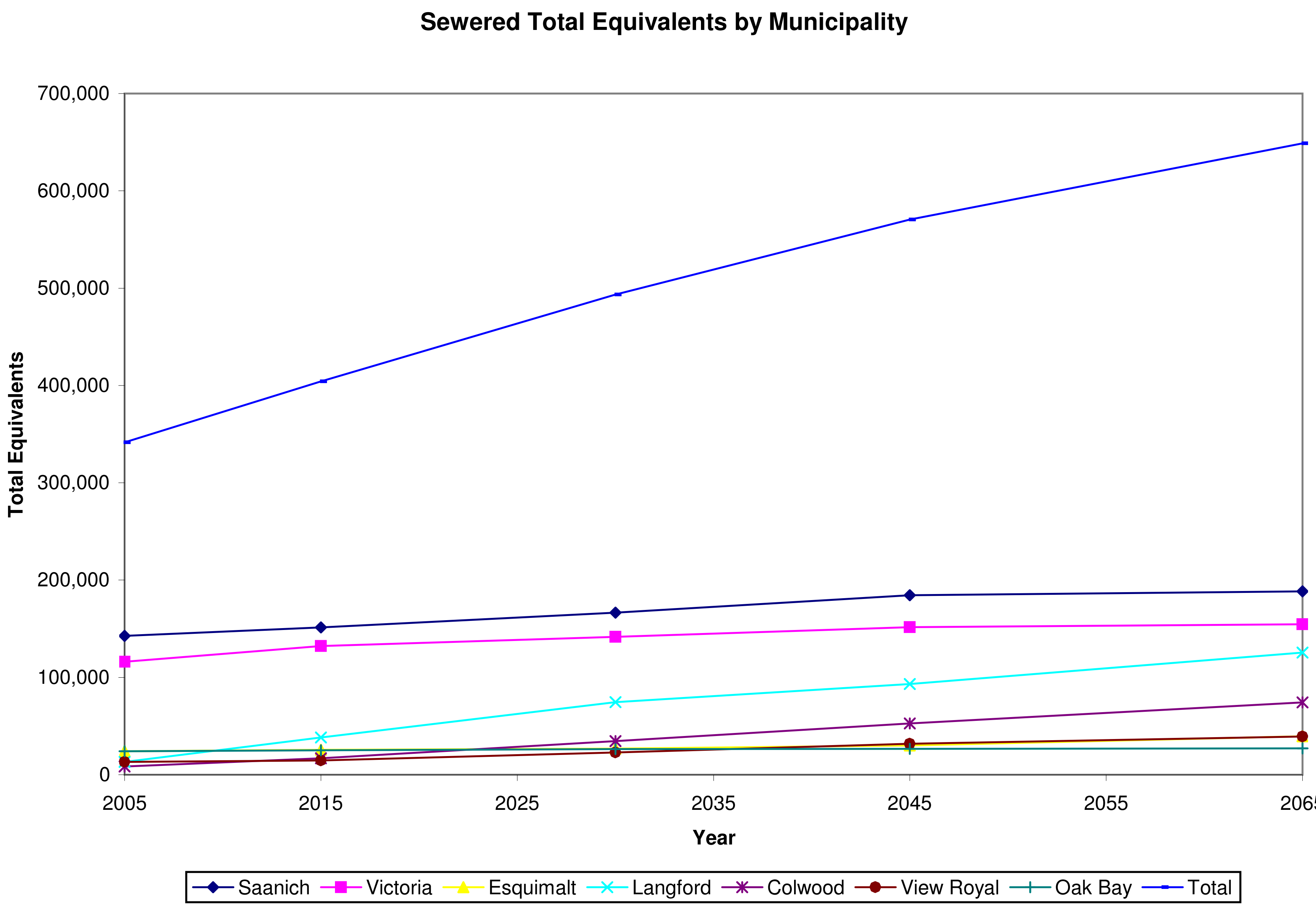
DesignSheets_Municipal_Summary.xls

Figure 1



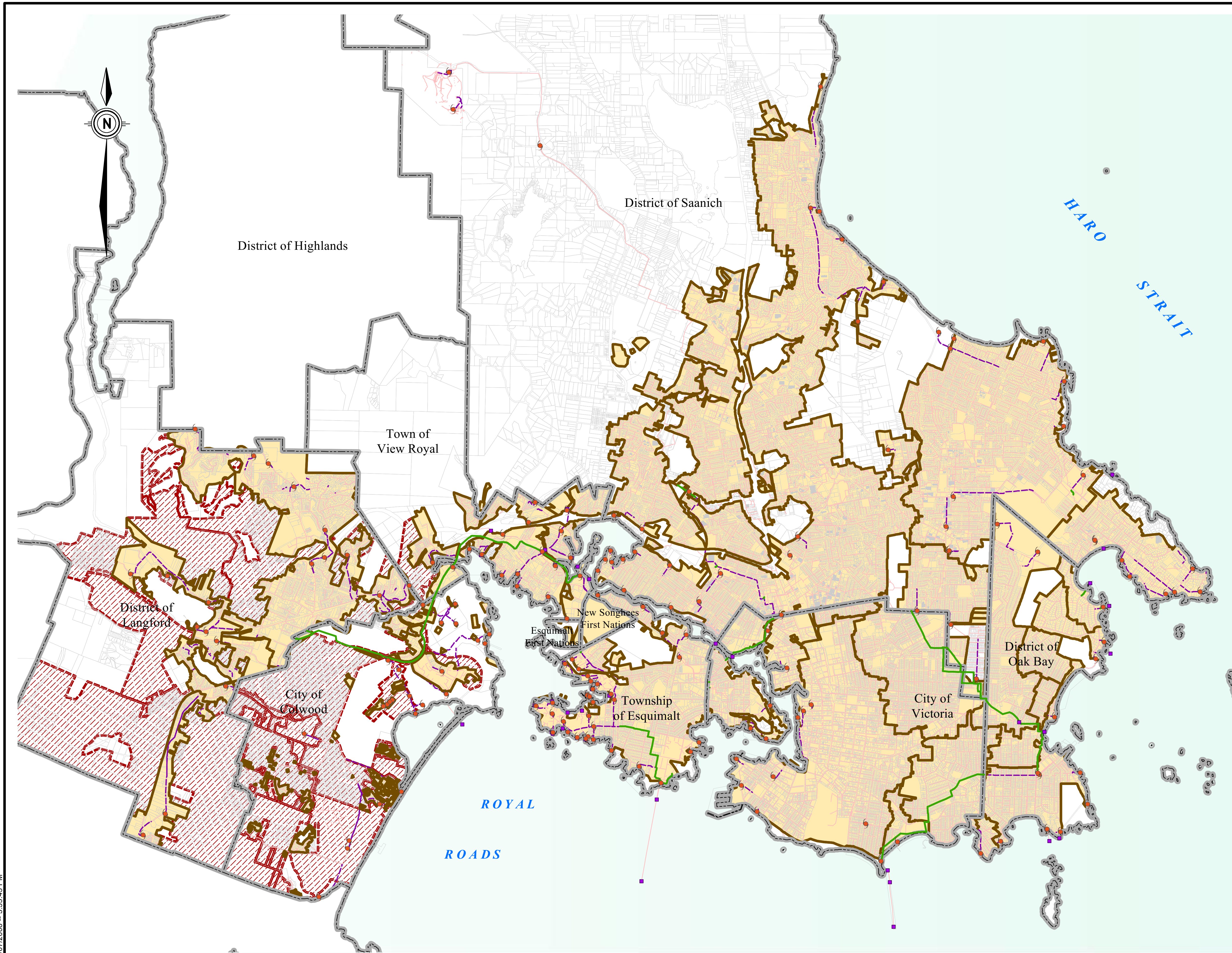
DesignSheets_Municipal_Summary.xls

Figure 2



DesignSheets_Municipal_Summary.xls

Figure 3



Capital Regional District

Legend

- Municipal Boundary
- Pump Station
- Discharge Point
- Trunk Sewer
- Forcemain
- Existing Sewered Area
- Ultimate Sewered Area

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

1,500 750 0 1,500
Scale in Metres

Project No.	Date
764-011	July 2008

Sanitary Catchment Boundary

Figure 4

Map Document: (O:\0700-0799\764-011\430-Gis\MXD-Wk\764011Fig_SeweredAreas.mxd)
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Table 5
Estimated Sewered Tributary Areas (ha)

	2005	2015	2030	2045	2065	Comment
Oak Bay	896	896	896	896	896	No spatial growth
Victoria	2,066	2,066	2,066	2,066	2,066	No spatial growth
Esquimalt	486	486	486	486	486	No spatial growth
Saanich	4,709	4,709	4,709	4,709	4,709	Urban boundary contained
View Royal	444	457	522	586	586	Minor growth on the perimeter
Colwood	190	305	553	800	1,034	Major growth
Langford	367	1,025	1,852	2,160	2,670	Major growth

Figure 4 shows the newest information for estimated current and ultimate spatial growth of the sewered Core Area for illustrative purposes. As a general comment, the tributary areas shown in Table 5 are not exact matches to those areas shown on Figure 1, as many of the tributary areas for each catchment come from reports that were produced years prior to the creation of Figure 1. These differences are summarized in Table 6.

Table 6
Comparison of Total Core Area - Spatial GIS Catchments vs. Previous Report Values

Year	GIS Catchment Area (ha)	Report Totals (ha)	Difference (%)	Comment
2005	9,304	9,173	+1.4	Minimal Difference
2065	12,102	12,447	-2.8	Minimal Difference

7 Inflow & Infiltration (I&I)

I&I rates were previously calculated for nearly the entire Core Area as part of Documents #2, 3, 4, and 6. There are numerous return periods and catchments; too many values to present in a single table. However, these values are shown in the appropriate tables in document 033-DP2 – Design Flow Tables.

I&I are defined by the following equation:

$$I\&I = RDI\&I + GWI_{winter}$$

Where:
RDI&I is rainfall dependent inflow and infiltration (responds to individual storms)
GWI_{winter} is groundwater infiltration (base flow that is seasonal in nature)

When defining I&I rates, they are described in the following terms. As an example, let us consider the "5-Year, Peak 6-Hour I&I":

"5-Year" – refers to the return period of I&I flow. In the previous reports where these I&I values have been calculated, the assumption is made that the rainfall return period is equivalent to the I&I flow return period. This is a key assumption of the methodology that has been previously used, termed the "I&I Envelope" method. This is a reasonable assumption given that the I&I Envelope methodology compensates for storm events with unsaturated ground conditions.

"Peak" – refers to I&I flow being average over a short duration (usually 15 minutes), to make it appropriate for use in hydraulic facilities design.

"6-Hour" – refers to the rainfall duration which provides the best correlation between observed rainfall and observed I&I flow rate. Typically larger and/or newer catchments correlate best with longer rainfall durations (12- or 24-hours). Whereas smaller and/or older catchments have shorter durations (often 2, 4, or 6-hours). The selection of the best correlation for return period is done as part of the I&I Envelope methodology.

There are two I&I scenarios that have been considered by the CRD: Base-Case and I&I Strategy 3, each of which is described below.

7.1 I&I Base Case

Under the Base Case scenario, I&I are assumed to remain constant at the currently measured values for all existing catchments in the CRD. New catchments are assumed to have the following I&I rates based on flow monitoring done in Document #4:

Table 7
Assumed I&I Rates for New Development Areas

Return Period (Years)	RDI&I (L/ha/day)	GWI_{winter} (L/ha/day)	I&I (L/ha/day)
2	9,400	3,000	12,400
5	10,500	3,000	13,500
10	11,600	3,000	14,600
25	12,200	3,000	15,200
100	13,300	3,000	16,300

7.2 I&I Strategy 3

Research done by KWL (Document #7) using numerous catchments from the CRD, City of White Rock, and City of Surrey has indicated a correlation between the average age of a catchment and measured I&I. When design flows are calculated using this Strategy, the following assumptions are made:

- Catchments older than 50 years are assumed to have their currently measured I&I rates maintained through rehabilitation efforts that target a 1% replacement rate by each Municipality.
- The I&I rates in catchments with an average pipe age younger than 50 years increase with time due to infrastructure decay.
- At an average age of 50 years, a 1% replacement program is started in these catchments by each Municipality.
- Replaced and new areas start out with I&I rates as shown in Table 6, with I&I rates increasing in time from that point.

The current version of this document does not calculate values using I&I Strategy 3; however, those values could be calculated in a future revision if required.

7.3 Impact of Climate Change on I&I

In addition to infrastructure decay, there is also the issue of future climate change and how that may affect I&I rates. Consider the following two points:

- Information provided in Document Reference #8 suggests that by 2050, for the Vancouver Sewerage Area, 24-hour rainfall totals may increase by 18%. It is reasonable to suppose that precipitation changes of a comparable magnitude may occur in the CRD area.
- Many catchments in the CRD Core area will be under some form of rehabilitation by 2050 in order to counter infrastructure decay. We may expect as a result of this rehabilitation

that catchment response to rainfall events will be pushed from shorter duration periods to longer periods (such as 12 or 24 hours).

Based on the above points, one conclusion is that I&I rates could increase by roughly the same amount as rainfall. Extending the trend to 2065, this suggests an increase in I&I rates by 25% over those currently measured.

As with the affects of infrastructure decay, an increase in I&I rates could be calculated for the design flow tables but has not been done so as part of this current document. For infrastructure decay, it is hoped that efforts by the municipalities will not only maintain existing I&I rates but perhaps even lower them eventually. This could provide some room to accommodate increases in I&I due to climate change. The impacts of both infrastructure decay/rehabilitation and climate change on I&I are only predictions at this point, with a future time horizon spanning 50 years or so. Given that design flow timelines for the WWTPs only extend to the order of 20 years, it would be prudent to conduct ongoing monitoring of both I&I rates and climate change to permit for adjustments in design flows as required in the future.

8 Summary

The following summarizes the information used to move forward into the design flow calculations shown in 033-DP2 – Design Flow Tables:

- Updated residential population estimates are taken from work by the CRD Planning Department.
- These values generally agreed with estimates from previous studies, except for Colwood where the more conservative cost-sharing agreement values were maintained, and for Langford where the more conservative OCP and Sewer Master Plan values were used.
- Industrial, Commercial, and Institutional (ICI) estimates, along with tributary areas, were maintained from major previous reports on the CRD collection systems.
- I&I estimates come from flow monitoring studies that have been previously done as part of major reports on the CRD collection systems.
- Two I&I scenarios are available for use: a "Base Case" where values stay the same, and "I&I Strategy 3" which attempts to account for infrastructure decay and rehabilitation efforts. The current issue of this document only presents the values calculated for the "Base Case".