

# **THE CITY OF MERRITT, BC SANITARY SEWER UTILITY MASTER PLAN**

## **SUMMARY REPORT**

**Prepared for:**

City of Merritt  
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PO Box 189

**Prepared by:**

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**First Issue Date:** September 20<sup>th</sup>, 2012

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Re: Project 2011-026-MER

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## **Executive Summary**

The City of Merritt, BC retained GeoAdvice Engineering Inc. to develop the City of Merritt's Sanitary Sewer Master Plan (SSMP). Merritt is a community located in the Nicola Valley of the South-Central Interior of British Columbia with an area of about 25 km<sup>2</sup> and a population of approximately 7,285 people. This report summarizes the results of the capacity study that was undertaken to provide a Sanitary Sewer Master Plan (SSMP) for the City of Merritt. The study was divided into four sections that contributed to the development of the City of Merritt SSMP. The four sections are summarized below.

### **Technical Memorandum #1 – Proposed Flow Monitoring Locations**

This component of the study outlined the locations for temporary flow monitoring.

### **Technical Memorandum #2 – Development and Calibration of the City of Merritt Sanitary Sewer Collection System Model**

A comprehensive “all pipe” hydraulic network model of the City of Merritt's sanitary sewer collection system was constructed and calibrated in InfoSWMM (Innovyze).

### **Technical Memorandum #3 – System Analysis of the City of Merritt Sanitary Sewer Collection System**

This component of the study assessed the system capacity to service both existing and future conditions.

### **Technical Memorandum #4 – The City of Merritt Sanitary Sewer Collection System Financial Model**

This component of the study determined that the current utility rates provide sufficient funds for operating, maintaining, repairing, rehabilitating, and upgrading the City's sewerage system.

### **Modeling Best Practices, Standards, Conventions, and Flags for the City of Merritt Sanitary Sewer Models**

This document was compiled to establish new modeling standards to observe when building, analyzing, or updating the City's InfoSWMM (Innovyze) models.



## 1.0 Summary of Technical Memoranda

### 1.1 Technical Memorandum #1 – Proposed Flow Monitoring Locations

Technical Memorandum #1 described the proposed locations for temporary flow monitoring as summarized below.

**Table 1.1: Flow Monitoring Site Information**

Site	Pipe Length (m)	Pipe Diameter (mm)	Location (Nearest Address)
A	37.70	300	1902 2 <sup>nd</sup> Ave
B	128.60	300	2152 Coldwater Ave
C	71.86	250	1301 Government Ave
D	121.42	200	1802 Granite Ave (back alley)

### 1.2 Technical Memorandum #2 – Development and Calibration of the City of Merritt Sanitary Sewer Collection System Model

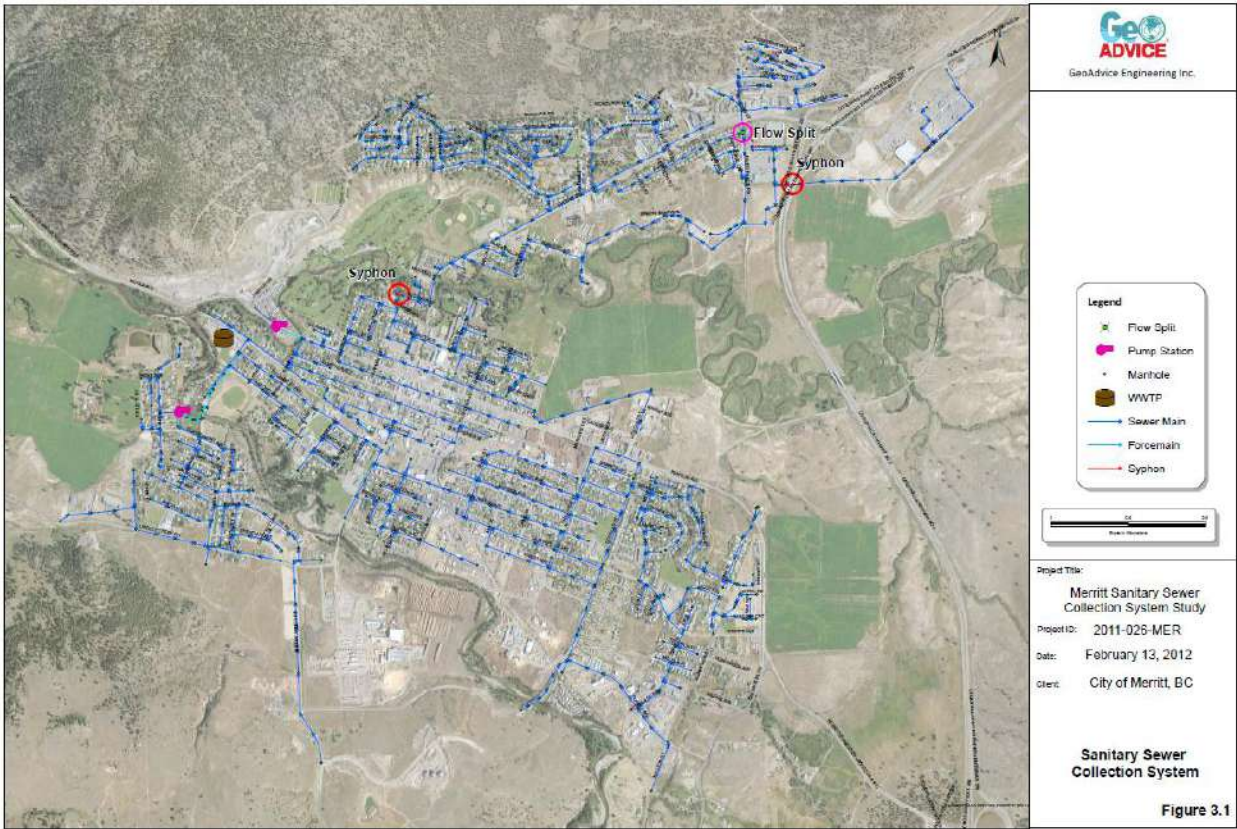
Technical Memorandum #2 described the methodology and assumptions used to build and calibrate the City of Merritt sanitary sewer collection system model. The model was built in compliance with the City of Merritt *Modeling Standards, Modeling Best Practices, Standards, Conventions, and Flags for the City of Merritt – Sanitary Sewer Models* (2011). The table below summarizes the main components of the City's sewer collection system. An overview of the system is presented on the following page.

**Table 1.2: Sewer Collection System Summary**

Component	Total
Gravity Mains	799
Manholes	622
Cleanouts	50
Siphons	2
Lift Stations	2
Total Pipe Length	60.2 km



Figure 1.1: Sanitary Sewer Collection System





The existing flows are summarized in the table below.

**Table 1.3: Summary of Existing Flows**

Subcatchment	Residential Load (L/s)	Non-Residential Load (L/s)	Total BSF (L/s)*	GW (L/s)*	ADWF (L/s)*
A	3.47	1.25	4.72	1.11	5.83
B	6.94	0.76	7.71	3.42	11.12
C	1.09	0.20	1.30	1.30	2.60
D	0.14	0.24	0.38	0.21	0.58
E	5.08	1.36	6.44	4.20	10.64
<b>Total</b>	<b>16.73</b>	<b>3.81</b>	<b>20.54</b>	<b>10.24</b>	<b>30.77</b>

\*BSF = Base Sanitary Flow

GW = Ground Water Infiltration

ADWF = Average Dry Weather Flow



## Technical Memorandum #3 – System Analysis of the City of Merritt Sanitary Sewer Collection System

Technical Memorandum #3 described the methodology and assumptions used to assess the sanitary sewer system's capacity using the hydraulic model of the City's system. Two (2) population growth scenarios were considered.

**Table 1.4: Population Growth Projections**

Year	Total Population	
	1.1% Growth/Year	3.5% Growth/Year
2010	7,285	7,285
2015	7,695	8,653
2020	8,127	10,276
2030	9,067	14,497

Deficient gravity mains were upsized using the criteria listed in **Table 1.5**.

**Table 1.5: Design Criteria (New Gravity Mains)**

Criteria	Parameter Value
Maximum d/D ratio	d/D < 0.50
Hydraulic Grade Line	HGL < Ground elevation
Minimum Velocity	v > 0.75 m/s
Material	PVC
Roughness Coefficient	Manning n = 0.013
Minimum Diameter	200 mm

The two pump stations have sufficient capacity to meet both existing and future loads and no upgrades are recommended.



In consultation with the City, 14 scenarios were developed as summarized in the table below.

**Table 1.6: Modeling Scenarios**

Scenario	Population Growth Rate (%)	Future Residential Unit Rate (L/cap/day)	Future Load Allocation	Gateway 286 Tie-in to Existing system
1-A	1.1	200	Proportional Growth	Bann St. and Thorpe Rd.
1-B	1.1	200	Proportional Growth	Excluded
2-A	1.1	200	OCP Development Areas	Bann St. and Thorpe Rd.
2-B	1.1	200	OCP Development Areas	Excluded
2-C	1.1	200	OCP Development Areas	Douglas Street
3-A	1.1	365	Proportional Growth	Bann St. and Thorpe Rd.
4-A	1.1	365	OCP Development Areas	Bann St. and Thorpe Rd.
5-A	3.5	200	Proportional Growth	Bann St. and Thorpe Rd.
5-B	3.5	200	Proportional Growth	Excluded
6-A	3.5	200	OCP Development Areas	Bann St. and Thorpe Rd.
6-B	3.5	200	OCP Development Areas	Excluded
6-C	3.5	200	OCP Development Areas	Douglas Street
7-A	3.5	365	Proportional Growth	Bann St. and Thorpe Rd.
8-A	3.5	365	OCP Development Areas	Bann St. and Thorpe Rd.





**Table 1.7** presents the estimate upgraded pipe cost for each scenario.

**Table 1.7: Sanitary Sewer Upgrade Cost**

Scenario	Length of Upgrade (m)	Estimated Cost (2012 \$)
1-A	3,081	\$ 2,297,000
1-B	1,012	\$ 683,000
2-A	3,081	\$ 2,276,000
2-B	1,012	\$ 683,000
2-C	1,944	\$ 1,219,000
3-A	3,251	\$ 2,471,000
4-A	3,251	\$ 2,475,000
5-A	3,946	\$ 2,989,000
5-B	1,523	\$ 1,072,000
6-A	5,176	\$ 3,938,000
6-B	2,442	\$ 1,837,000
6-C	3,488	\$ 2,595,000
7-A	4,263	\$ 3,286,000
8-A	5,493	\$ 4,284,000

Sensitivity analyses were completed based on:

- Per capita demand rate
- Population growth rate
- Load allocation methodology
- 286 gateway development servicing



### 1.3 Technical Memorandum #4 – The City of Merritt Sanitary Sewer Collection System Financial Modeling and Analysis

Technical Memorandum #4 described the methodology and assumptions used to develop a financial model for determining whether the existing utility rates are capable of providing sufficient funds for operation, maintenance, repair, rehabilitation and upgrading the City's sewerage system. The financial model is divided into four modules:

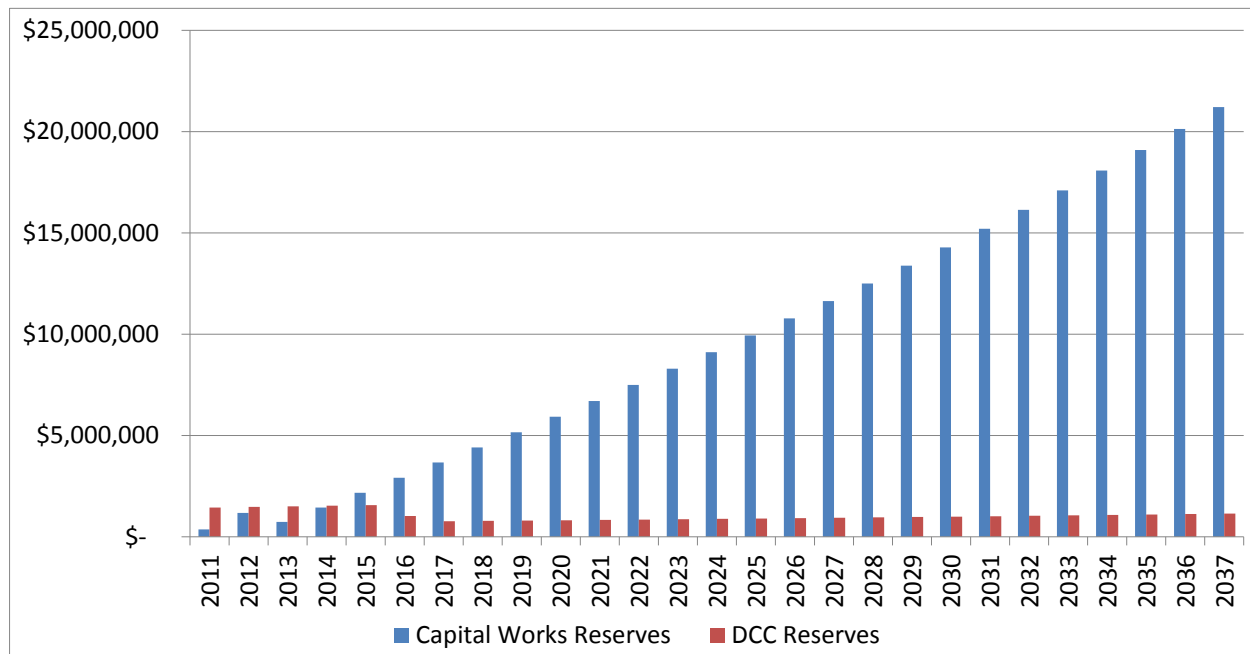
- **Revenue Module** – Identifies the various sources of revenue.
- **Operation & Maintenance Module** – Identifies the expenditures associated with operating and maintaining the City's sewerage system.
- **Capital Works Module** – Identifies the timing and cost of the various DCC, Non-DCC and asset repair/renewal projects.
- **Cash Flow Module** – Incorporating the above three modules, the cash flow module determines the year-end balance of the various funds and reserves to assess the City's financial stability and the capability to operate, maintain, repair, rehabilitate and upgrade the sewerage system.

The financial model extends out to a 100 year horizon to assess long term viability, however, only the first 20 years should be closely reviewed.

The financial model estimates for capital works and DCC reserves over the next 25 years are shown in **Figure 1.2**.



**Figure 1.2: Capital Works and DCC Reserves**



Given the assumptions made and at the current utility rates, the sewer system will be adequately funded over the next 25 years with capital works reserves and DCC reserves of approximately \$ 21,000,000 and \$ 1,000,000 respectively in 2037.

It is recommended that the City reviews and updates the financial model every 5 years.

## PROPOSED FLOW MONITORING LOCATIONS

# TECHNICAL MEMORANDUM 1

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**October 5, 2011**

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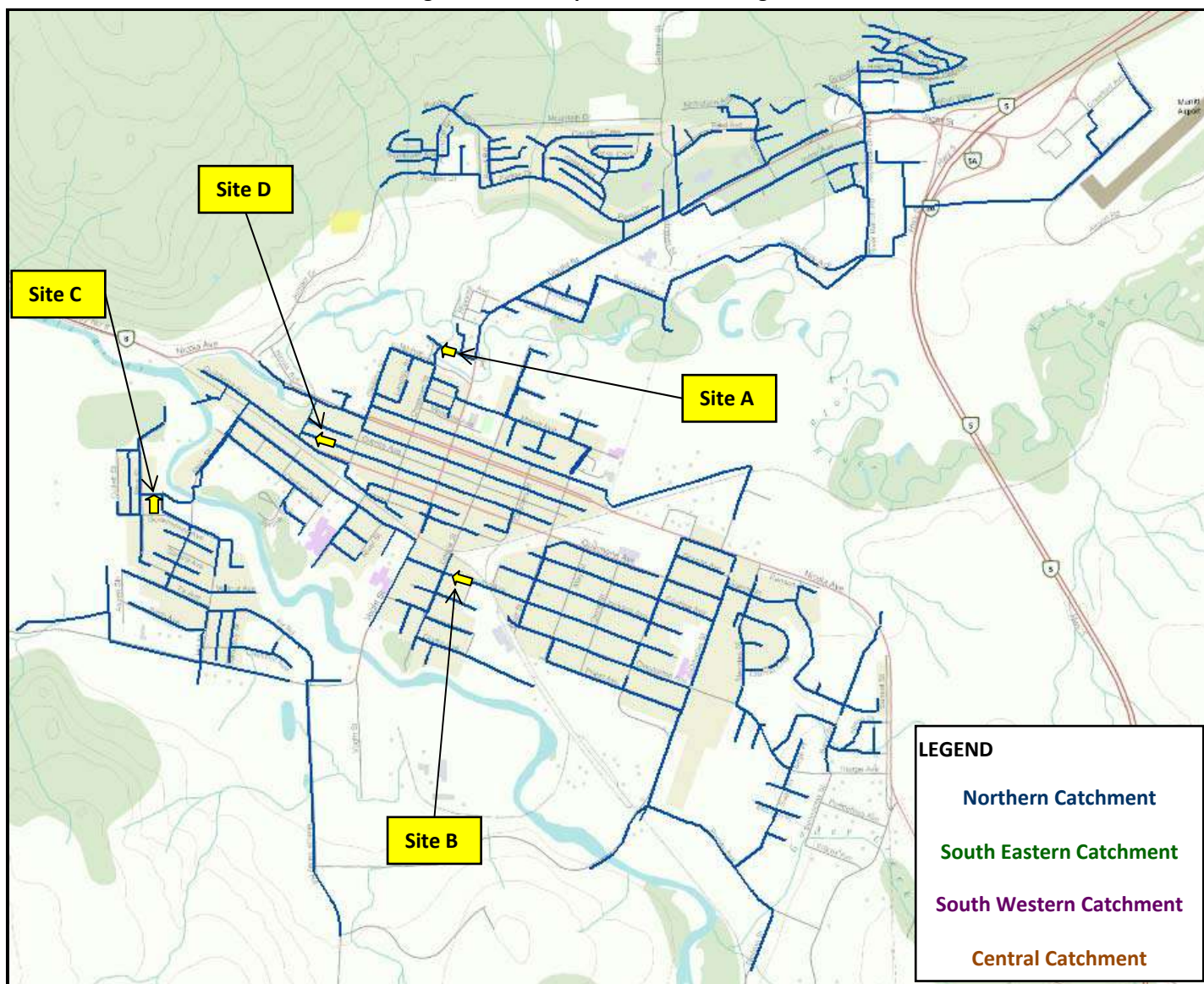
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## FLOW MONITORING LOCATIONS

**Figure 1** illustrates the proposed monitoring site locations and the corresponding area of interest. **Table 1** gives an overview of these locations. The proposed monitoring site locations may change depending on site inspection prior to installation.

**Figure 1: Area Map & Flow Monitoring Sites**





**Table 1: Flow Monitoring Site Information**

SITE	Pipe Length (m)	Pipe Diameter (mm)	Location (nearest address)
A	37.70	300	1902 2 <sup>nd</sup> Ave
B	128.60	300	2152 COLDWATER AVE
C	71.86	250	1301 GOVERNMENT AVE
D	121.42	200	1802 GRANITE AVE (back alley)

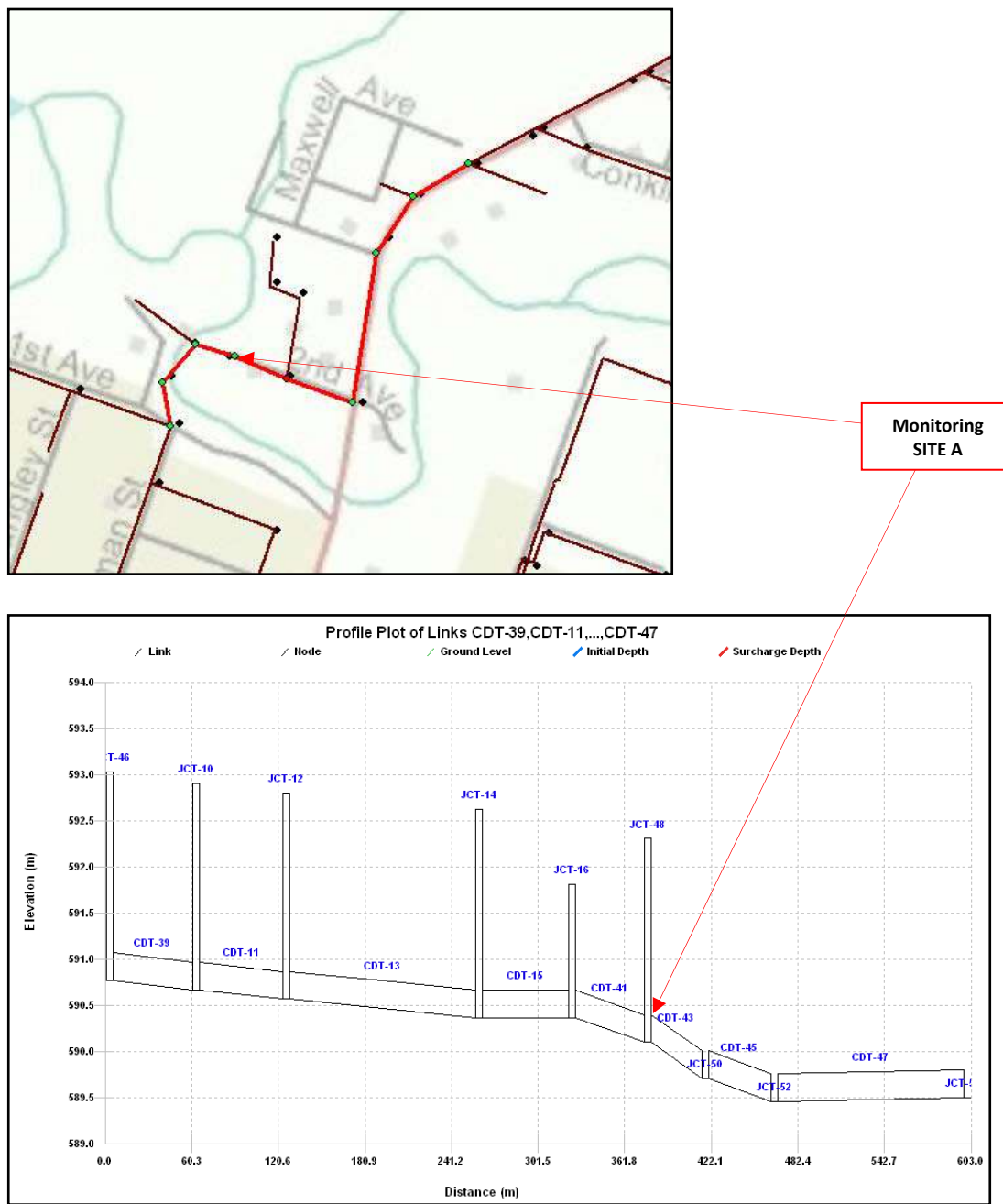




The following pages describe the individual sites in more detail and highlight any area of concern.

### Site A

This site serves to monitor flow from the entire Northern Catchment as illustrated in **Figure 1**. The area is at higher ground levels, there are fewer concerns about inflow and infiltration (I&I).





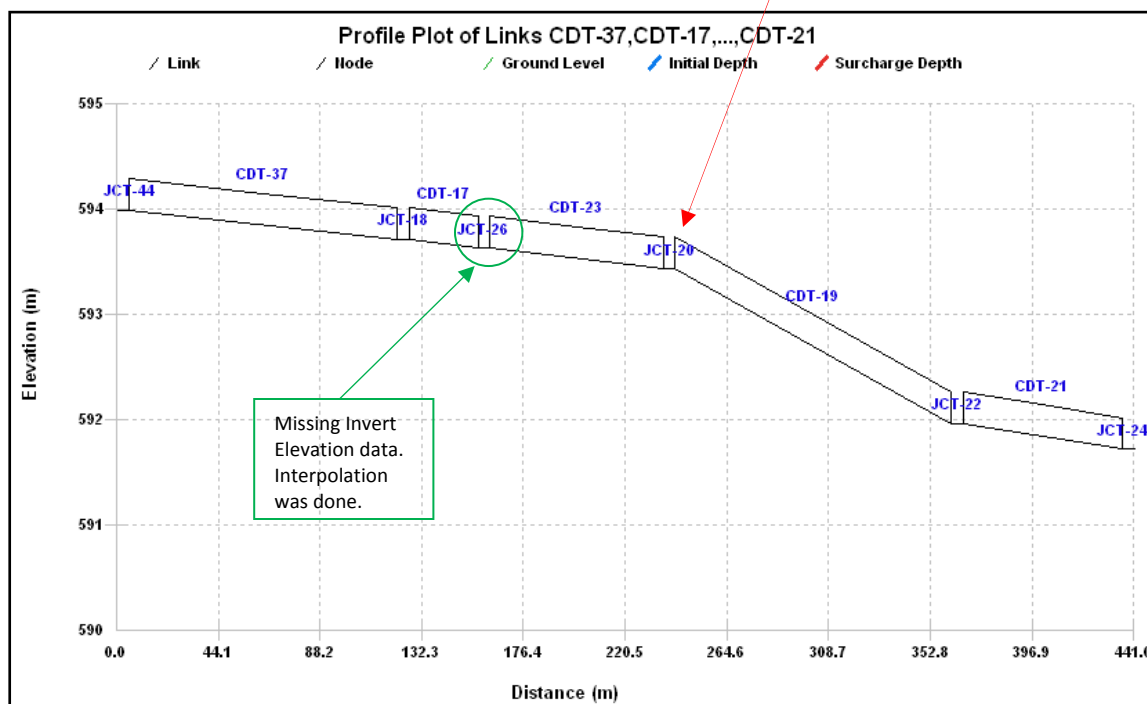


## Site B

This site serves to monitor flow from the entire South Eastern Catchment.



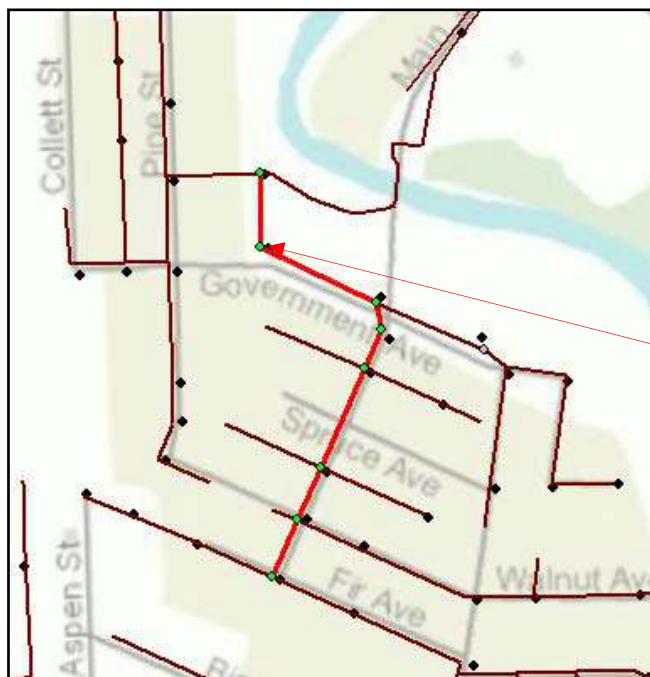
Monitoring  
SITE B



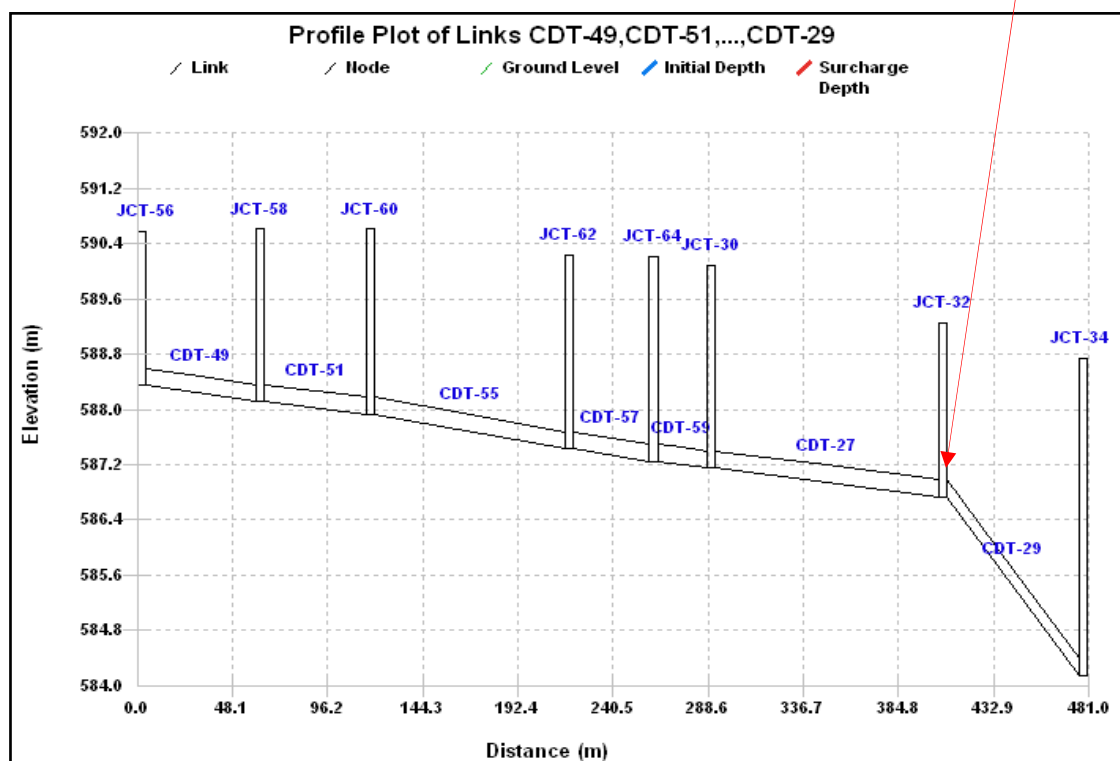


## Site C

The primary purpose of this site serves to verify the I&I of the South Western Catchment where the ground water table is high.



Monitoring  
SITE C



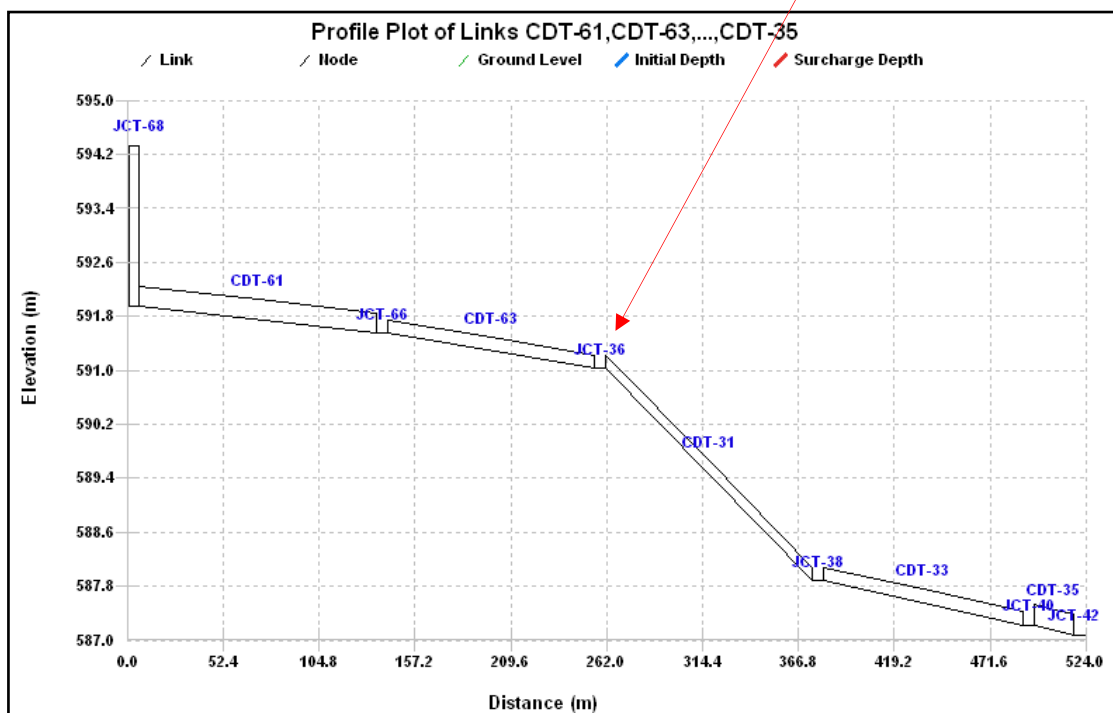


## Site D

The primary purpose of this site serves to verify the I&I of the Central Catchment where the ground water table is high.



Monitoring  
SITE D



# MODEL BUILD AND CALIBRATION OF THE CITY OF MERRITT SANITARY SEWER COLLECTION SYSTEM

## TECHNICAL MEMORANDUM 2

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**First Issue Date:** February 13, 2012

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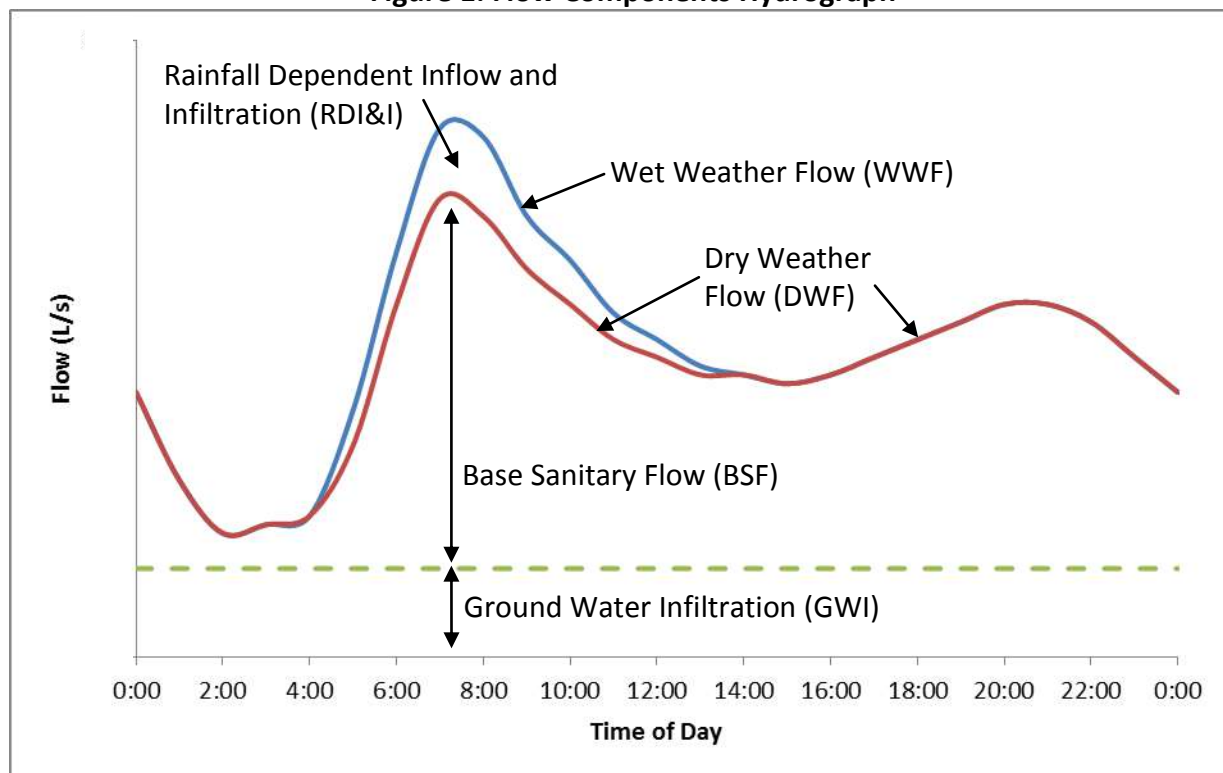


## Definitions

Daily flow conveyed in a sanitary sewer collection system can be divided into five (5) components as shown in **Figure 1**:

- Ground Water Infiltration (GWI)
- Base Sanitary Flow (BSF)
- Dry Weather Flow (DWF)
- Rainfall Dependent Inflow and Infiltration (RDI&I)
- Wet Weather Flow (WWF)

**Figure 1: Flow Components Hydrograph**



Metro Vancouver has provided definitions for those flow components. These definitions can be found in the *Inflow and Infiltration Reduction Program I/I Analysis Results: 1993 – 1994 Flow Monitoring Sites Volume I, January 1995* and are also listed below. These definitions are applied in this report.



Ground Water Infiltration (GWI) – Ground water infiltration results from the movement of ground water in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table.

Base Sanitary Flow (BSF) – All wastewater from residential, commercial, institutional, and industrial sources that the sanitary sewer system is intended to carry.

Dry Weather Flow (DWF) – The portion of the total flow that is composed of BSF and GWI.  
 $DWF = GWI + BSF$ .

Average Dry Weather Flow (ADWF) – The daily average value of the diurnally varying Dry Weather Flow, averaged over a 24-hour period.

Rainfall Dependent I&I (RDI&I) – Rainfall dependent inflow and infiltration equals rainfall-induced infiltration plus all sources of inflow.

Wet Weather Flow (WWF) – All flow contributions carried by the sanitary sewer system during wet weather.  $WWF = GWI + BSF + RDI\&I$ .

Peak Wet Weather Flow (PWWF) – All flow contributions carried by the sanitary sewer system during peak wet weather.

Peak Wet Weather Flow 5-year I&I ( $PWWF_5$ ) – All flow contributions carried by the sanitary sewer system during a 5-year return storm event.

Peak Wet Weather Flow 25-year I&I ( $PWWF_{25}$ ) – All flow contributions carried by the sanitary sewer system during a 25-year return storm event.





## 1 Introduction

The City of Merritt, BC retained GeoAdvice Engineering to develop the City of Merritt's Sanitary Sewer Master Plan (SSMP). A critical component of the SSMP is the assessment of the City's sanitary sewer system's capacity to service both existing and future sanitary loads. In order to complete the sanitary system assessment, GeoAdvice first constructed a comprehensive "all pipe" hydraulic network model of the City's sanitary sewer collection system. This report describes the methodology and assumptions used to build and calibrate the hydraulic model.

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Mr. Shawn Boven
- Mr. Darrell Finnigan
- Ms. Danielle Cass
- Mr. Kevin Vilac
- Mr. Sean O'Flaherty

## 2 Scope

The scope of this report covers the following items:

- Development of the sanitary sewer hydraulic model
- Collection and analysis of sanitary flow monitoring data
- Definition of per capita sanitary flow rates
- Review of sanitary inflow and infiltration rates
- Calibration of the sanitary model to observed field data



### 3 Development of the Hydraulic Sanitary Sewer Model using InfoSWMM

Development of the sanitary sewer model was divided into multiple tasks to ensure the model is representative of the “real” sewer collection system. In sequential order and as discussed in detail below, these tasks include:

- Task 1: Data collection and review
- Task 2: GIS data conversion
- Task 3: Data gaps and system connectivity review
- Task 4: Primary system components import
- Task 5: Load calculation and spatial allocation
- Task 6: Ground water infiltration (GWI)
- Task 7: EPS model setup

The model was built in compliance with the City of Merritt modeling standards, *Modeling Best Practices, Standards, Conventions, and Flags for the City of Merritt – Sanitary Sewer Models* (2011). Any assumptions deviating from the standards are highlighted in this report.

**Table 3.1** summarizes the main components of the City’s sewer collection system. A model of the City’s sewer collection system was constructed using the InfoSWMM modeling and management software application. **Figure 3.1** provides an overview of the sewer collection system model.

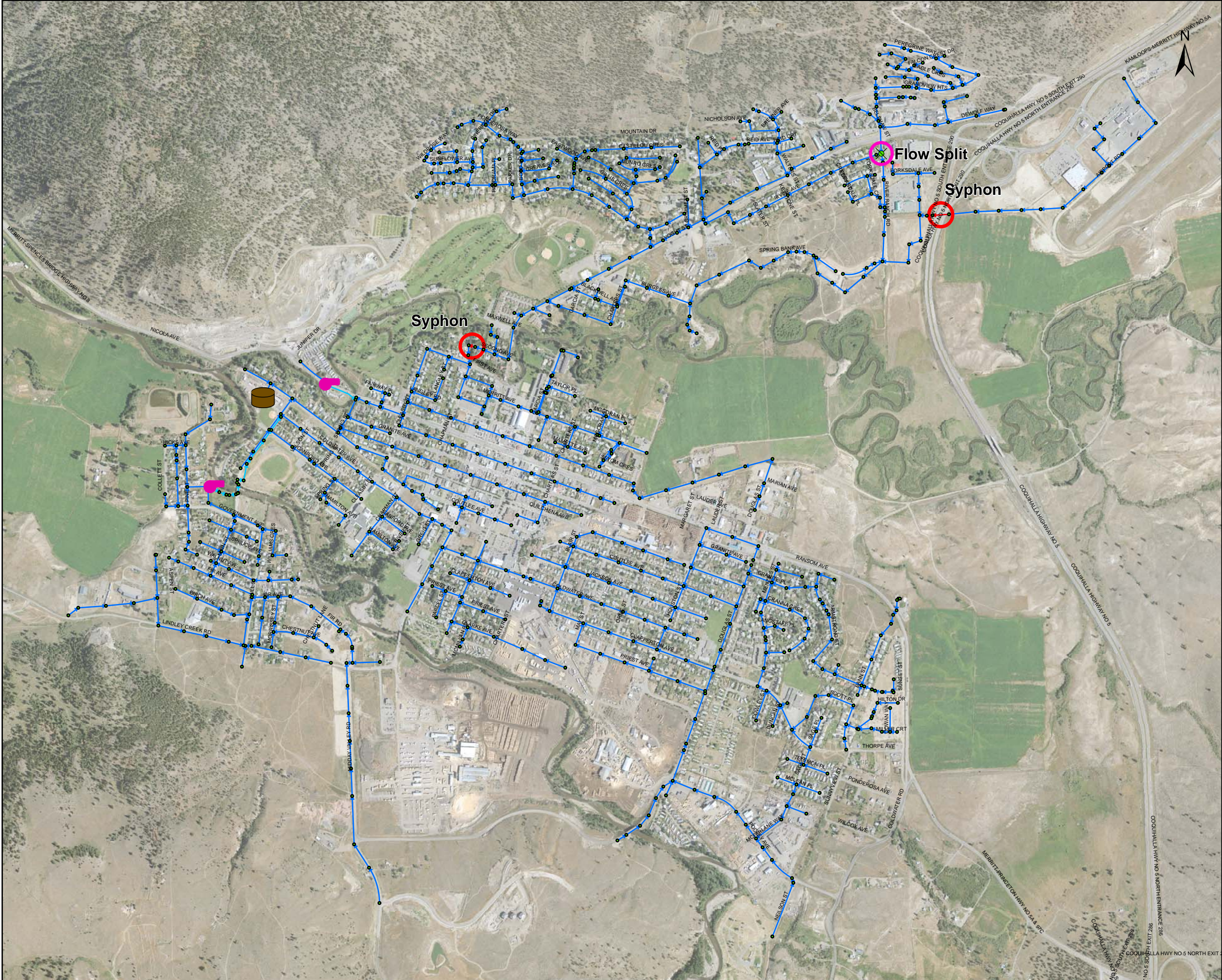
**Table 3.1: Sewer Collection System Summary**

Component	Total
Gravity Mains	799
Manholes	622
Cleanouts	50
Siphons	2
Lift Stations	2
Total Pipe Length	60.2 km
Total Catchment Area	603 ha



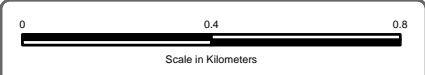


GeoAdvice Engineering Inc.



**Legend**

- Flow Split
- Pump Station
- Manhole
- WWTP
- Sewer Main
- Forcemain
- Syphon



Project Title:  
**Merritt Sanitary Sewer  
Collection System Study**

Project ID: 2011-026-MER

Date: February 13, 2012

Client: City of Merritt, BC

**Sanitary Sewer  
Collection System**

**Figure 3.1**





### **3.1 Data Collection and Review**

Prior to developing the model, a comprehensive data review was conducted. The following information was reviewed:

- City's GIS database;
- As-built drawings;
- Pump curves and operational controls;
- Land-use and zoning maps;
- City's 2010 water consumption data; and
- WaterCAD model.

### **3.2 GIS Data Conversion**

The model's network topology (i.e. the pipes and nodes) was primarily built using the City's GIS database. The model represents a one-to-one match with the City's GIS model, complete with matching identification numbers for each asset. Some additional elements were added to the model in order to satisfy the software requirements for system operation and continuity.

Gravity mains attributes, such as length, diameter, and inverts and manhole attributes such as inverts and rim elevations were also extracted from the City's GIS database.

The model was constructed using nominal pipe diameters. Pipe material and age were used to assign roughness coefficients for gravity and pressure mains as per Table 3.1 of the City's modeling standard.

The coordinate system used for building the model was NAD 1983 UTM Zone 10 N.

### **3.3 Data Gap and System Connectivity Review**

Following the creation of the network model, a data gap and system connectivity review was completed. These reviews help to minimize simulation errors and increase the accuracy of the model results. To complete this task, an iterative approach was used in which GeoAdvice worked cooperatively with the City to resolve data gap and connectivity issues.

Where possible, missing invert and diameter information were populated using record drawings and/or by interpolating from connecting elements. Missing rim elevations were then interpolated using the City's the elevation contour shapefile.

A complete list of data gaps was submitted to the City for review. Where available the City updated the missing information via survey and/or a review of as-built information, any remaining data gaps were interpolated using upstream and downstream elements.



A list of assumptions for the manholes and pipes are shown in **Table 3.2**. These assumptions are consistent with the City's modeling standards.

**Table 3.2: Manhole and Pipe Data Assumptions**

Component	Assumptions
Manhole	Diameter = 1.05 m Rim Elevation = interpolated using topographic information Headloss coefficient = 0
Pipe with Unknown Material/Age	Roughness <ul style="list-style-type: none"> <li>Gravity Main (Manning <math>n = 0.013</math>)</li> <li>Force Main (Hazen-Williams <math>C = 120</math>)</li> </ul>

### 3.4 Primary System Components

One of the most important tasks associated with model development is incorporating boundary conditions and all major system components (wet wells and pump stations). Detailed information on all of the City's components was input into the model, with the parameters and settings as presented in **Table 3.3** and **Table 3.4**.

**Table 3.3: Pump Data**

Pump Station (Pump Station ID)	Number of Pumps and HP	Design Flow (L/s)	Design Head (m)
<b>Colletteville</b>	2		
PMP-COLLETTEVILLE-1 (Lead)	10HP	26.5	13.6
PMP-COLLETTEVILLE-2 (Lag)	10HP	26.5	13.6
<b>Nicola Ave</b>	1		
PMP-NICOLA	2.4HP	16.3	4.7

The above operational settings were provided by the City of Merritt.

**Table 3.4: Wet Well Data**

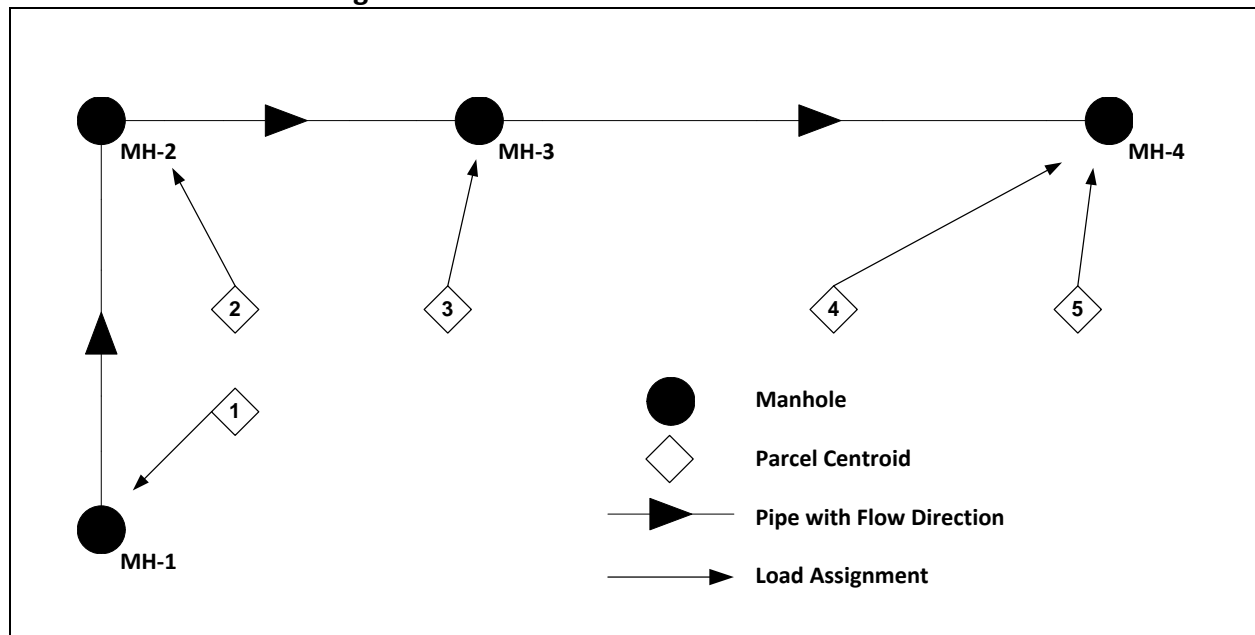
Wet Well (Wet Well ID)	Invert Elevation (m)	Off Level (m)	Lead Pump On level (m)	Lag Pump On Level (m)	Diameter (m)	Active Volume (m <sup>3</sup> )
<b>WW-COLLETTEVILLE</b>	582.26	0.01	0.64	0.96	2.44	2.95
<b>WW-NICOLA</b>	586.17	0.43	1.00	N/A	2.13	2.03

### 3.5 Load Spatial Allocation

The next step was the spatial allocation of existing loads. Cadastral parcel data were received from the City, and then the loads were calculated and assigned to the model as follows:

- First, non-loading nodes were excluded from the allocation process (e.g. nodes connected to pumps, wet wells and forcemains).
- Each parcel was allocated to the closest node as shown in **Figure 3.2**.
- Residential sewer loadings were estimated on per capita basis.
- Industrial, Commercial and Institutional (ICI) sewer loadings were estimated on per area basis.

Sanitary loading rates are further discussed in detail in **Section 4.2**.

**Figure 3.2: “Closest Node” Allocation Method**



### 3.6 EPS Model Setup

Extended Period Simulation (EPS) was then set up. Running an EPS will be required for evaluating the system over time as opposed to the instantaneous results obtained from a steady-state analysis. The Extended Period Simulation (EPS) model was developed with the following time parameters:

- Duration = 24 hours
- Start time = 00:00
- Hydraulic timestep = 1 hour
- Pattern timestep = 1 hour
- Report timestep = 1 hour



## 4 Field Measurements Analysis

The objective of the field data review was to estimate and validate the various sanitary loading rates. Field data was provided by two different sources: Veritec and the City. The Veritec data consisted on four (4) sanitary flow monitors, collecting continuous flow data from four (4) discreet locations within the system for two months. The Veritec data was used to:

- Establish the 24 hour diurnal flow patterns
- Validate Average Dry Weather Flows (ADWF)
- Estimate Peak Wet Weather Flows (PWWF)
- Estimate Groundwater Infiltration (GWI)
- Estimate Rainfall Dependent Inflow and Infiltration (RDI&I)
- Calibrate the model

The City's data consisted of flow and operational records for the various system facilities, as well as rainfall data from the City's weather station. The City data was used to:

- Establish ADWF
- Estimate RDI&I
- Calibrate the model

**Table 4.1** below summarizes the various data sources used to calibrate the model.

**Table 4.1: Summary of the Field Data used for Model Calibration**

Measurement Type	Source	Number of Monitoring Stations
Flow	Veritec	4
Water Treatment Plant Flow	City	1
Pump On/Off Hours	City	2
Weather Station	City	1
Census Data-Population	City	1





## 4.1 Sanitary Data Review

### 4.1.1 Veritec Flow Results

At GeoAdvice's recommendation, the City contracted Veritec to install four (4) flow-monitoring gauges to measure sanitary flows. The locations of the monitoring sites are shown in **Figure 4.1** and are summarized in **Table 4.2**. For further information on the flow monitoring locations, please refer to *GeoAdvice TM 1 - Flow Monitoring Locations*.

**Table 4.2: Flow Monitors used for Calibration**

Site	Collected By	Gravity Main ID	Address
1	Veritec	GM-4045	1902 2nd Ave
2	Veritec	GM-3703	2152 Coldwater Ave
3	Veritec	GM-3848	1301 Government Ave
4	Veritec	GM-3624	1802 Granite Ave (back alley)

Flow data from the four (4) sites was collected from October 26<sup>th</sup> to December 13<sup>th</sup>, 2011. **Figure 4.2** presents the observed flow records. A summary of the flow information is presented in **Table 4.3**: Summary of Flow Data below.

**Table 4.3: Summary of Flow Data**

Subcatchment (Site)	ADWF (L/s)	MNF (L/s)	Catchment Area (ha)	Equivalent Population	Unitized Rate* (L/Capita/Day)
A (1)	5.40	2.08	197.43	2,205	211.6
B (2)	10.98	5.94	159.25	3,599	263.6
C (3)	0.27	0.03	56.27	605	38.5
D (4)	3.36	1.97	8.95	176	1,649.3

\*Includes GWI

Based on our understanding of the system the observed flows from Site 1 and Site 2 are a representative measure of system performance. Data from Site 1 and Site 2 will be used to calibrate the model and validate system loads. However, the observed flows from Site 3 and Site 4 have too high a level of uncertainty to be of beneficial use, as such, information from Site 3 and Site 4 will not be used for further analysis.



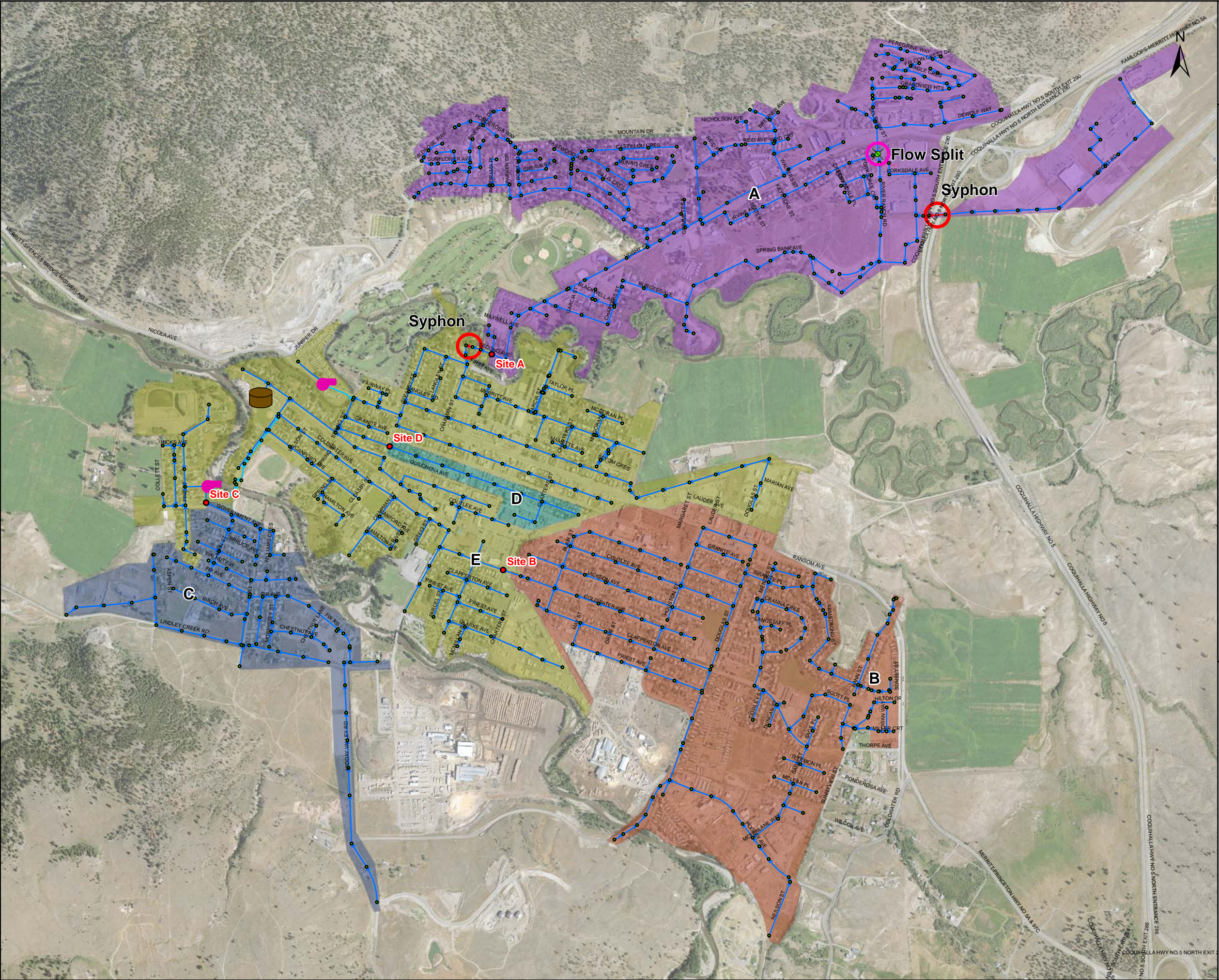
All field measurements come with a certain amount of uncertainty. This uncertainty may be due to:

- Instrument measurement error
- Usual events (a debris blockage, pump failure, etc.)
- Uncertainty in system configuration
- Daily and seasonal variations in sanitary demands
- Uncertainty in actual upstream population
- Others





GeoAdvice Engineering Inc.



Legend

- Flow Split
- WWTP
- Pump Station
- Manhole
- Flow Monitoring Site
- Sewer Main
- Forcemain
- Syphon

Catchment

- A
- B
- C
- D
- E



Project Title:  
Merritt Sanitary Sewer  
Collection System Study

Project ID: 2011-026-MER

Date: February 13, 2012

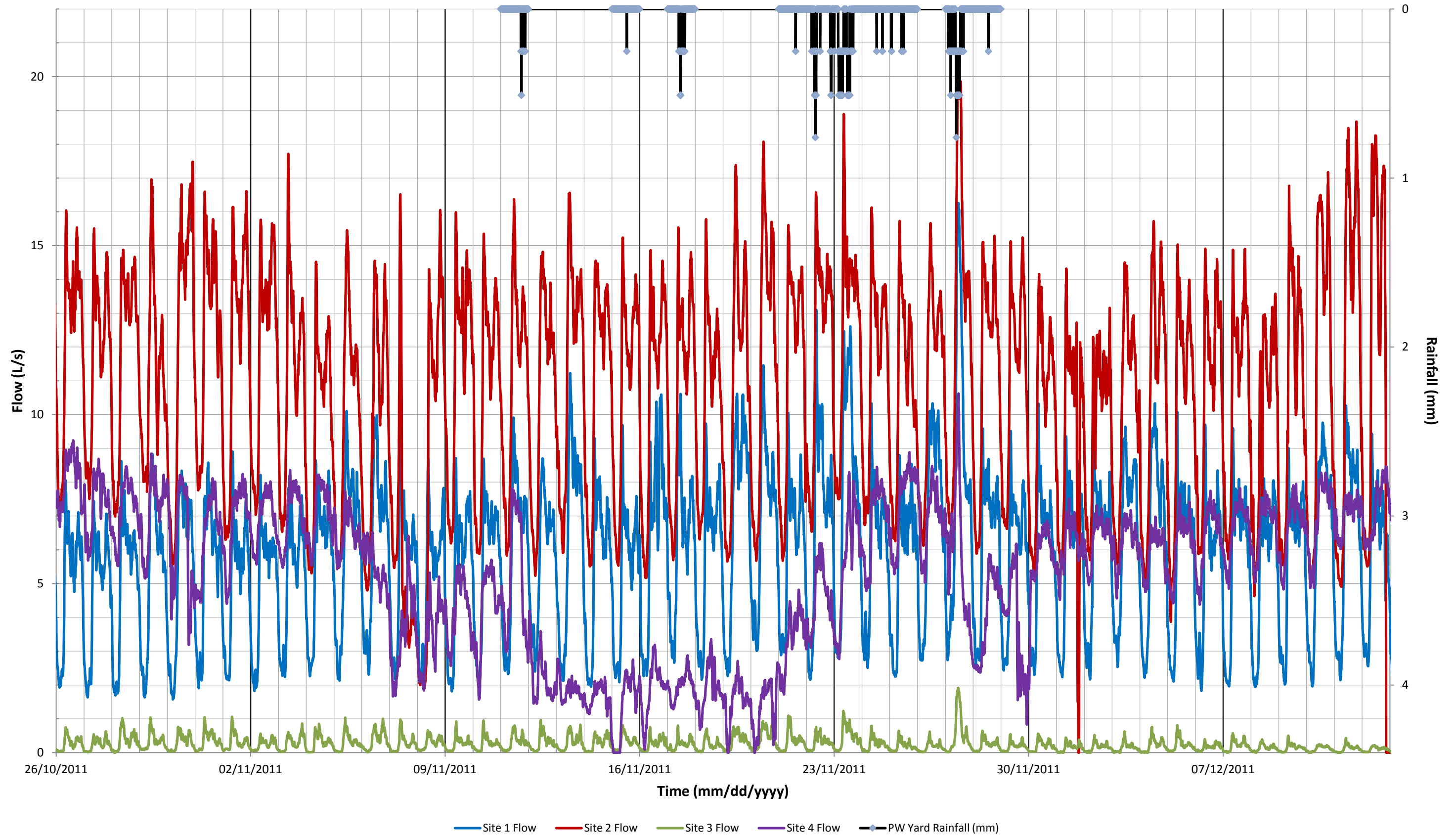
Client: City of Merritt, BC

Location of Flow  
Monitored Sites

Figure 4.1



Figure 4.2 - Flow Monitoring Results





#### 4.1.2 Wastewater Treatment Plan (WWTP) Flow Records

The City provided SCADA records for the wastewater treatment plant (WWTP), located at 1299 Quilchena Ave. A summary of the flow records are presented in **Table 4.4** below. Based on 2010 Flow records, the average flow to the WWTP is 2,653 L/d or 30.7 L/s.

**Table 4.4: 2010 WWTP flows**

Month	Total Volume (m3)	Flows (m3/day)
Jan	83,645	2,698
Feb	65,766	2,349
Mar	79,750	2,573
Apr	75,637	2,521
May	85,529	2,759
June	88,197	2,940
July	73,332	2,366
Aug	75,234	2,427
Sept	75,718	2,524
Oct	88,415	2,852
Nov	86,389	2,880
Dec	91,688	2,958
Average	80,775	2,654

**Inflows to the WWTP present two (2) high inflow and infiltration (I&I) periods. The first** high I&I period is the results of increase in groundwater infiltration caused by the freshet raising the local groundwater table. The second high I&I period corresponds to the winter when several residents leave their taps running, increasing the base flow, to prevent their pipes from freezing. During those high I&I periods, average flows to the WWTP increased up to 14% above average levels. The WWTP's recorded single day peak flow rate is 5,610 m<sup>3</sup>/day. The WWTP's current license limit is 4,610 m<sup>3</sup>/day.

#### 4.1.3 Pump Station Data

The City provided pump records for the Nicola and Collettville pump stations. **Table 4.5** below summarizes the pertinent pump data.

**Table 4.5: Average Pump Hours**

Pump Station (Pump Station ID)	Average Run Time (Hour/day)	Design Flow (L/s)	Average Total Flow (m <sup>3</sup> /day)
<b>Colletteville</b>			
PMP-COLLETTEVILLE-1 (Lead)	4.4	26.0	412
PMP-COLLETTEVILLE-2 (Lag)	0		
<b>Nicola Ave</b>			
PMP-NICOLA	1.1	16.3	64

The above figures are based on average pump hours for the period Nov 1-28, 2011. Flow rates are based on design flow rates as listed on manufacturer supplied pump performance curves.

#### 4.1.4 Rain Gauge Data

The City of Merritt maintains and operates one rain gauge station. The City has provided rainfall records for the period of November 11<sup>th</sup> to November 28<sup>th</sup> 2011. A summary of the rainfall records are presented in **Table 4.6** below.

**Table 4.6: Daily Precipitation**

Days in 2011	Total (mm)
11-Nov	2.26
12-Nov	0.0
13-Nov	0.0
14-Nov	0.0
15-Nov	0.25
16-Nov	0.0
17-Nov	5.79
18-Nov	0.0
19-Nov	0.0
20-Nov	0.0
21-Nov	0.25
22-Nov	8.35
23-Nov	21.96
24-Nov	0.50
25-Nov	0.75
27-Nov	15.87
28-Nov	0.25
<b>Total</b>	<b>56.23</b>



## 4.2 Dry Weather Flow (DWF) Analysis

The DWF analysis was used to establish the following items.

- Average Dry Weather Flow (ADWF)
- Minimum Nightly Flow (MNF)
- Base Sanitary Flow (BSF)
- Groundwater Infiltration (GWI)

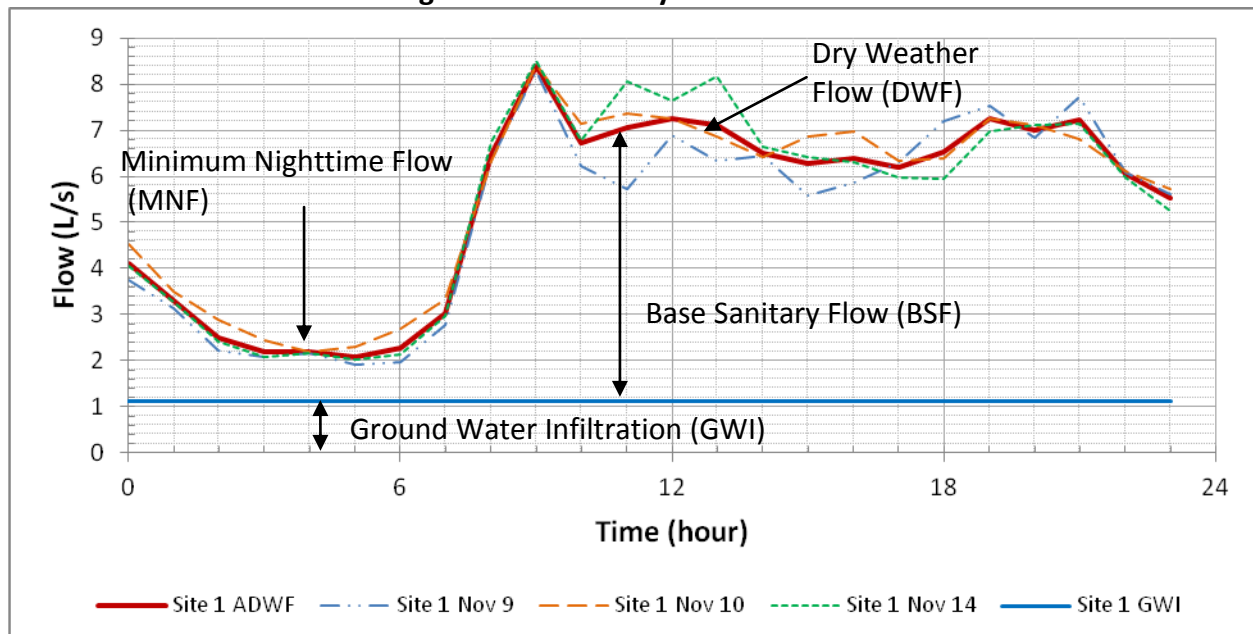
The DWF analysis consisted on an iterative process where a sensitivity analysis of per capita sanitary loading rates and contributing GWI ratios are compared to observed field data. The results of the DWF are presented in the following sections.

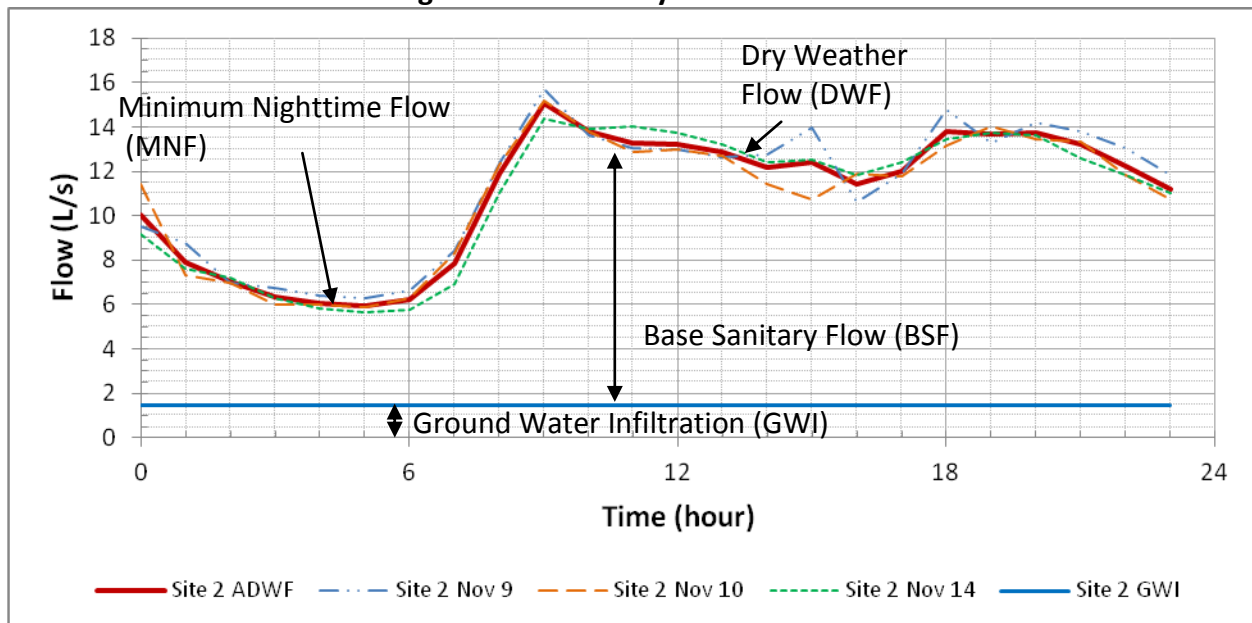
### 4.2.1 Average Dry Weather Flow Analysis

A review of Veritec's flow data alongside with the City's rain gauge data was used to select a typical dry weather flow period. Field data from three dry days (November 9, 10, and 14 2011) were averaged to represent the typical DWF.

**Figure 4.3** and **Figure 4.4** illustrate the DWF results for Site 1 and Site 2. The BSF and GWI will be further discussed in the next section.

**Figure 4.3: Site 1 Dry Weather Flow**



**Figure 4.4: Site 2 Dry Weather Flow**

#### 4.2.2 Ground Water Infiltration (GWI)

The results of the DWF analysis indicated that the total GWI contribution can be measured as follows.

- 60% of the minimum nightly flow (MNF) from residential areas during a period free from Rainfall Dependent Inflow and Infiltration (RDI&I) influence.
- 35% of the minimum nightly flow (MNF) from ICI areas during a period free from RDI&I influence.

The ratios of 60% and 35% were derived by matching the observed field data to WWTP flow records, and available landuse data. The GWI rates for each sub catchment are summarized in **Table 4.7**.

**Table 4.7: Ground Water Infiltration Rate**

Subcatchment	MNF (L/s)	Conversion Rate (%)	GWI (L/s)	Area (ha)	GWI (L/ha/day)
<b>A</b>	2.08	53.4	1.11	197.43	485
<b>B</b>	5.94	57.5	3.42	159.25	1,854

Subcatchment A, which consists of a newer collection system located mostly along the north slope of the City experiences a relatively low GWI rate of 485 L/ha/day. However, Subcatchment B, which consists of an older collection system located in the valley, has a





significantly higher GWI rate of 1,854 L/ha/day. The higher GWI rate in subcatchment B can be attributed to the high local groundwater table, which is the result of the system's close proximity of the Nicola and Coldwater rivers. Due to the high level of uncertainty in the flow monitor readings from Site 3 and Site 4, the GWI rate for the remaining subcatchments could not be accurately defined. For these catchments a GWI rate of 2,000 L/ha/day was applied. This rate of 2,000 L/ha/day is slightly higher than the observed GWI rate of 1,854 L/ha/day in subcatchment B. GWI rates between 1,000 L/ha/day and 3,000 L/ha/day are considered to be acceptable.

#### 4.2.3 Sanitary Loading Rates

Based on the results of the DWF analysis, the following per capita sanitary rates were estimated.

**Table 4.8: Assumed Unit Loading Rates**

Landuse Type	Loading Rate
Residential	200 L/cap/day
Commercial	1,800 L/ha/day
Industrial	1,800 L/ha/day
Institutional	1,800 L/ha/day
Service Commercial	1,800 L/ha/day
City Center	3,600 L/ha/day

**Table 4.9: Total Flows**

Subcatchment	Residential Load (L/s)	Non-Residential Load (L/s)	Total BSF (L/s)	GWI (L/s)	ADWF (L/s)
A	3.47	1.25	4.72	1.11	5.83
B	6.94	0.76	7.71	3.42	11.12
C	1.09	0.20	1.30	1.30	2.60
D	0.14	0.24	0.38	0.21	0.58
E	5.08	1.36	6.44	4.20	10.64
<b>Total</b>	<b>16.73</b>	<b>3.81</b>	<b>20.54</b>	<b>10.24</b>	<b>30.77</b>

Using the landuse information provided and loading rates listed in **Table 4.8**, the total modeled ADWF is 30.77 L/s. The model's ADWF of 30.77 L/s is slightly higher than the observed average flow to the WWTP of 30.7 L/s. Based on the results of the ADWF analysis, GWI accounts for 33% of the total ADWF. This ratio is higher than in typical systems. However, it is consistent with observed field data and historical WWTP flow records.

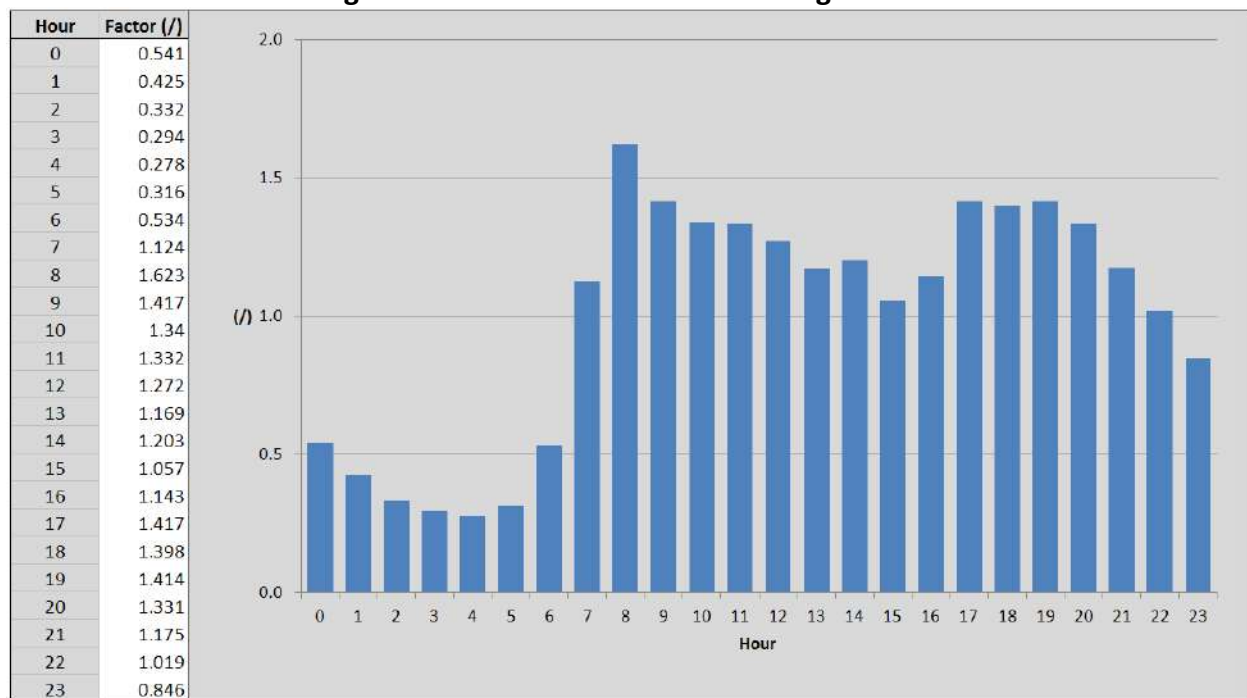


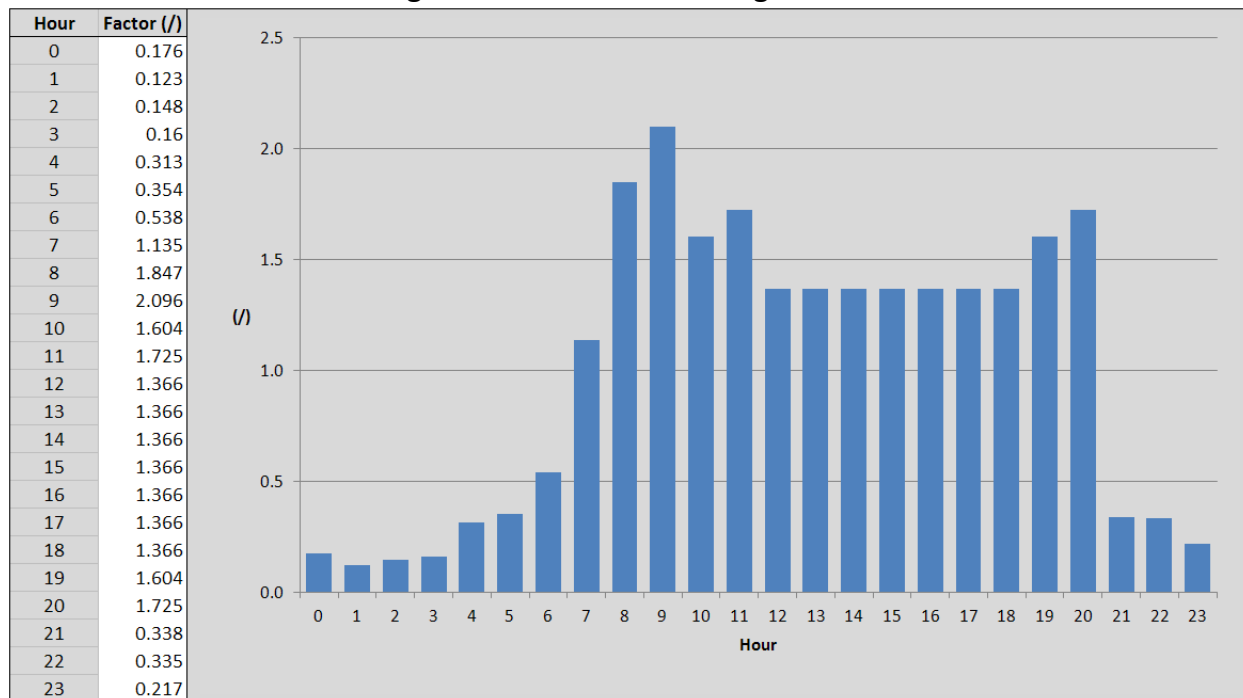
#### 4.2.4 Sanitary Loading Patterns

InfoSWMM uses two components to quantify the loads: base load and pattern. The base load is defined as the average or nominal load at the manhole and the pattern is used to characterize the time varying nature of sanitary demands.

Different land uses have varying sanitary demand patterns. However, developing individual patterns for each individual land use can be a time-consuming and costly endeavor. In most instances, a good representation of system flows can be accomplished using only two (2) or three (3) different patterns. The Merritt model uses two (2) distinct patterns one for residential, and one for ICI. Typical residential and ICI patterns were used as a based and were modified to match the observed field data. **Figure 4.5** and **Figure 4.6** below show the patterns applied to residential and ICI.

**Figure 4.5: Merritt Residential Loading Pattern**



**Figure 4.6: Merrit ICI Loading Pattern**

It should be noted that the above patterns are only applied to the BSF component of ADWF. The GWI is applied separately as a constant rate.

### 4.3 Wet Weather Flow Analysis

The WWF analysis was used to establish the Rainfall Dependent Inflow and Infiltration (RDI&I) rate. The WWF analysis consisted of a stepwise process where Veritec flow data was compared to typical DWF results and rainfall gauge data to determine the design RDI&I rates.

#### 4.3.1 Weather Flow data

A review of Veritec's flow data alongside with the City's rain gauge data was used to select a wet weather flow period. Field data from wet weather days on November 22<sup>nd</sup> to 23<sup>rd</sup>, 2011 and November 27<sup>th</sup>, 2011 have been selected.

**Figure 4.7** and **Figure 4.8** present the November 27<sup>th</sup>, 2011 WWF event for Site 1 and Site 2. The typical DWF flows were subtracted from the observed flows in-order to estimate the contributing RDI&I.



Figure 4.7: Site 1 Wet Weather Flow – Nov 27<sup>th</sup>, 2011

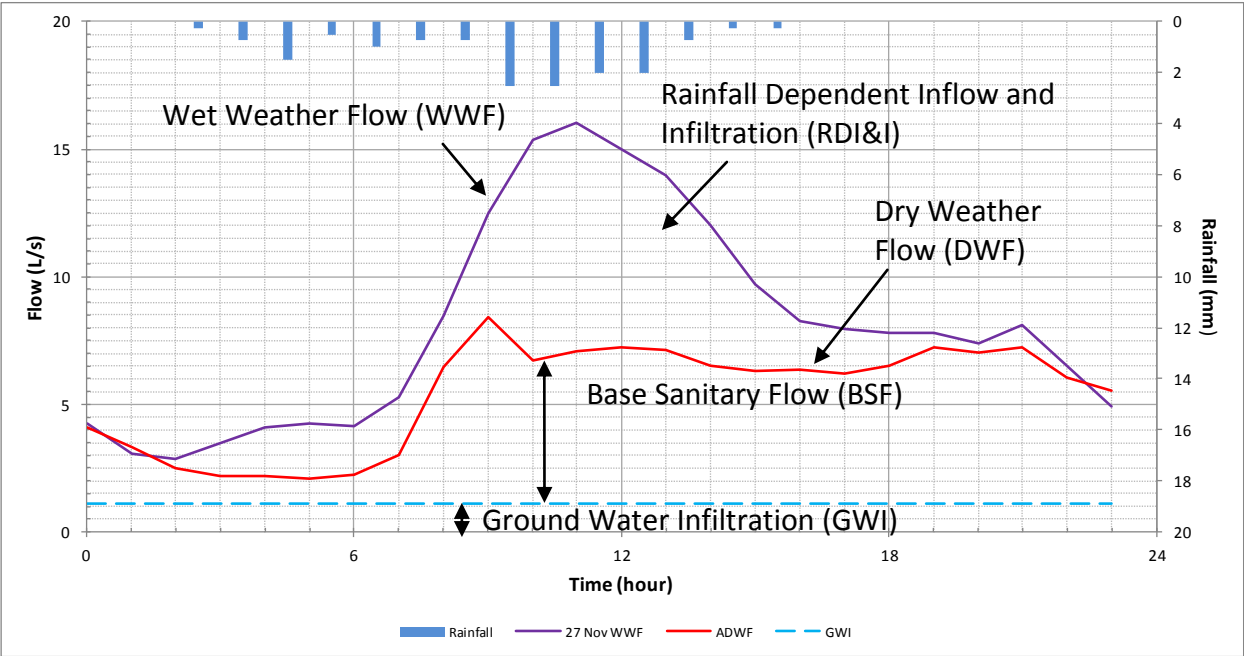
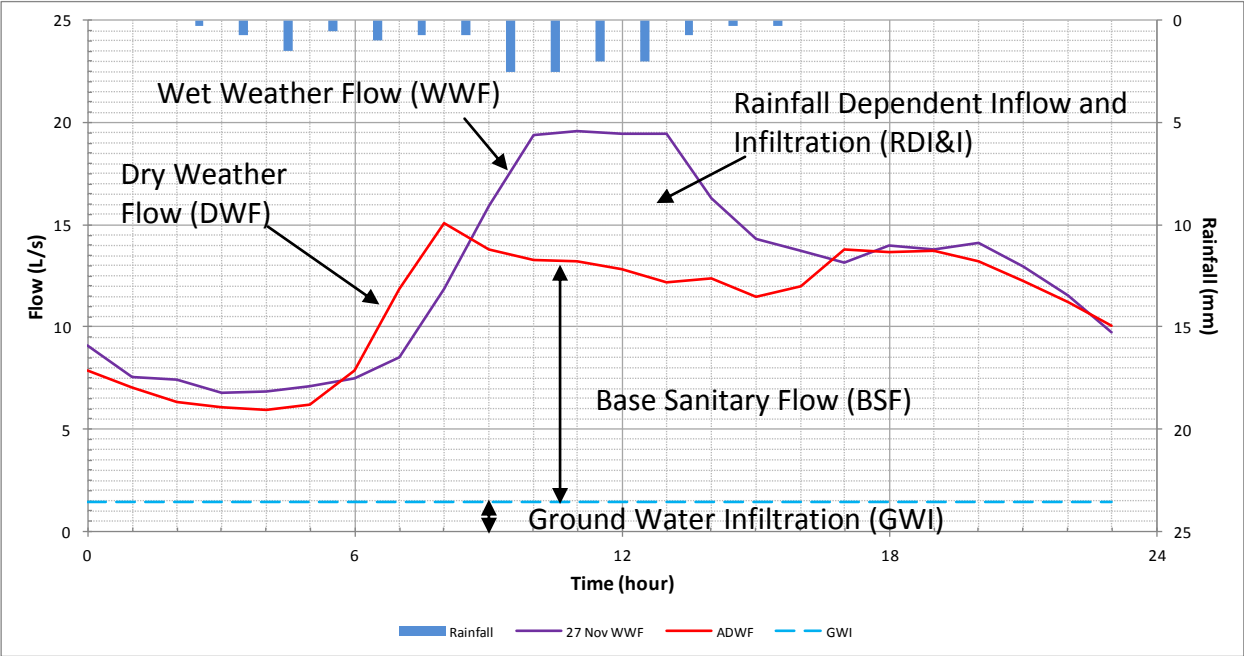


Figure 4.8: Site 2 Wet Weather Flow – Nov 27<sup>th</sup>, 2011



**Table 4.10** summarizes the observed WWF flow event and **Table 4.11** summarizes the corresponding peak 24 hour rainfall.

**Table 4.10: Summary of WWF Results**

Subcatchment	Peak 24hr Flow (L/s)		Peak 24hr Flow (L/ha/day)	
	Nov 22-23, 2011	Nov 27, 2011	Nov 22-23, 2011	Nov 27, 2011
A	2.32	2.88	3,234	4,881
B	1.42	1.57	1,576	3,926

**Table 4.11: Peak 24 hr Rainfall**

Date	Peak 24 Hour Rainfall (mm)
Nov 22-23, 2011	24.23
Nov 27, 2011	15.87

#### 4.3.2 Rainfall Dependent Inflow and Infiltration (RDI&I) Analysis

The envelop method was utilized to estimate the design RDI&I rate. The envelop method used measured RDI&I events to extrapolate the design RDI&I rates. As part of the envelop method, a review of the upper and lower ranges of the measured RDI&I events are utilized to estimate upper and lower bounds of the design RDI&I rates.

Based on the City's modeling standards, existing sanitary facilities are to be assessed using the 5 year 24 hour RDI&I rate, and new facilities are to be assessed using the 25 year 24 hour RDI&I rate.

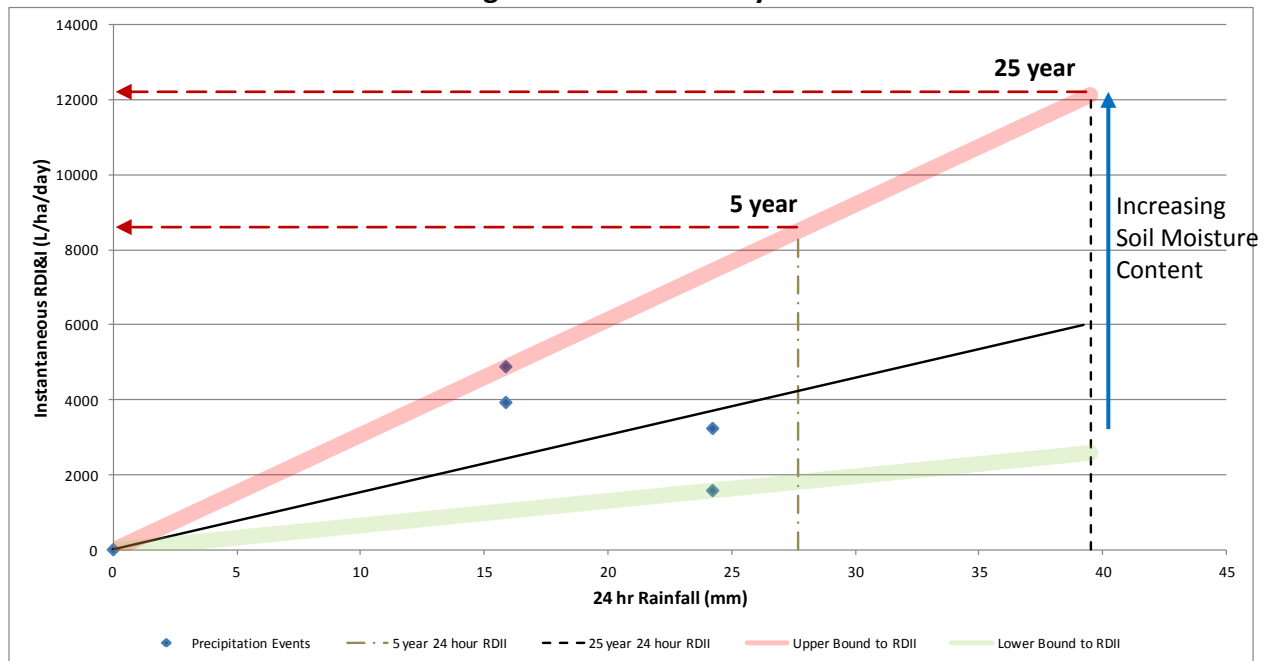
**Figure 4.9** presents a summary of the RDI&I envelop method analysis. **Table 4.12** below summarizes the results.

**Table 4.12: Design RDI&I Rates**

	Dry Antecedent Soil Conditions RDI&I (L/ha/day)	Typical RDI&I (L/ha/day)	Saturate Antecedent Soil Conditions RDI&I (L/ha/day)
5 year 24 hour	1,800	4,230	8,520
25 year 24 hour	2,570	6,040	12,150



Figure 4.9: RDI&amp;I Analysis



Based on the results of the envelop method, existing infrastructure should be assessed using the 5 year 24 hour RDI&I rate of 8,520 L/ha/day. New infrastructure should be assessed using 25 year 24 hour RDI&I rate of 12,150 L/ha/day. These rates apply to all subcatchments. Using the above rates, the 5 year 24 hour and 25 year 24 hour RDI&I flows are estimated to be 59.5 L/s and 84.9 L/s respectively.

In an effort to validate the predicted WWF rates, the typical 5 year 24 hour I&I AWWF flow rate was compared against the WWTP observed peak flow rate of 5,610 m<sup>3</sup>/day (64.9 L/s). The typical AWWF flow rate was utilized instead of the PWWF, as PWWF represents the instantaneous peak flow over the course of the day, whereas the typical AWWF would be representative of the total average flow over the course of the day, as the WWTP plant flows are measured on a daily cycle. The typical AWWF was estimated to be 60.3 L/s, which is in line with the WWTP peak flow rate of 64.9 L/s.



## 5 Model Calibration

Before presenting the calibration results, it is useful to examine why a hydraulic model may not match the field data. Most of the sources of errors or mismatches are:

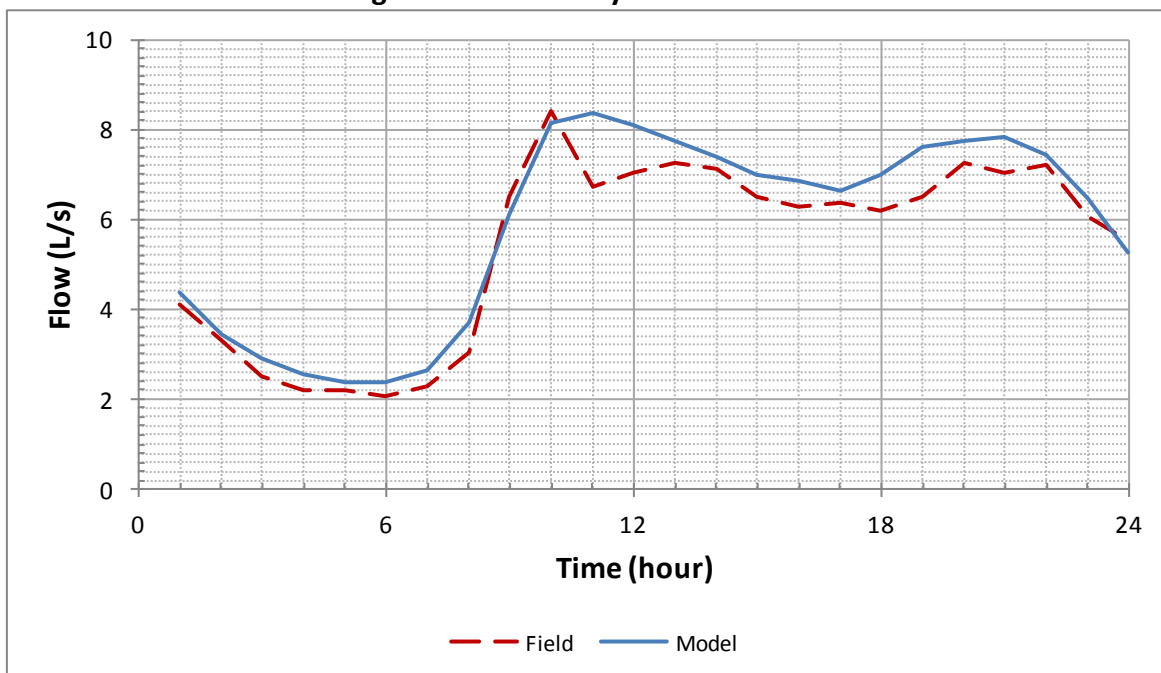
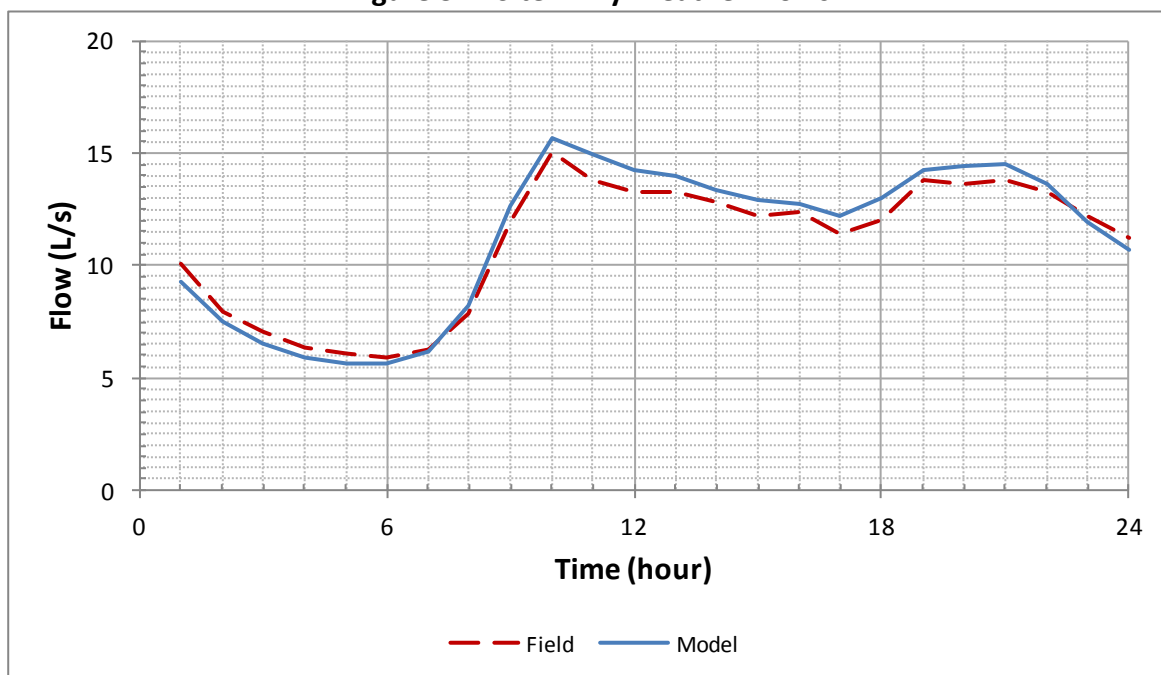
- input data errors
- system loading errors
- invert errors
- operational control errors
- poorly calibrated measuring equipment
- outdated data

The cumulative effect of these areas of uncertainty or “approximation” is that, without verification and validation of the model’s ability to recreate known conditions, it is likely that the modeling results would be grossly misleading.

Main reasons and benefits of a well calibrated model are listed below:

- Confidence: to demonstrate the model’s ability to reproduce existing conditions.
- Understanding: to confirm the understanding of the performance of the system.
- Trouble shooting: to uncover missing information and misinformation or anomalies about the system.

The results of the model calibration are presented below in **Figure 5.1** and **Figure 5.2**.

**Figure 5.1: Site 1 Dry Weather Flows****Figure 5.2: Site 2 Dry Weather Flows**

The model results fit closely to the observed data indicating that the model is well calibrated. As such, there is a high level of confidence that the model will be capable to reproduce existing conditions.





## 6 Conclusions

Key conclusions drawn while performing this study:

- The infoSWMM model (Innovyze Software) was developed using GIS data and as-built drawings. The model consists of an “all pipes” model of the City’s collection system. Existing sewer loading was determined using:
  - City’s wastewater treatment plant flow meter records
  - Veritec’s flow monitoring data
  - Parcel unit counts
- The total base sanitary flow (BSF) was estimated to be 20.54 L/s.
- Existing ground water infiltration (GWI) rate was estimated to be 10.24 L/s.
- Flow monitoring data collected between November 11<sup>th</sup>, 2011 and November 28<sup>th</sup>, 2011 was used estimate the design rainfall dependent inflow and infiltration (RDI&I) rates.
  - The 5 year 24 hour RDI&I rate is estimated to be 8,520 L/ha/day.
  - The 25 year 24 hour RDI&I rate is estimated to be 12,150 L/ha/day.
- The model was calibrated by comparing the simulation results with field data. The hydraulic modeling predictions agree with the values observed in the field.



# SYSTEM ANALYSIS OF THE CITY OF MERRITT SANITARY SEWER COLLECTION SYSTEM

## TECHNICAL MEMORANDUM 3

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Re: Project 2011-026-MER

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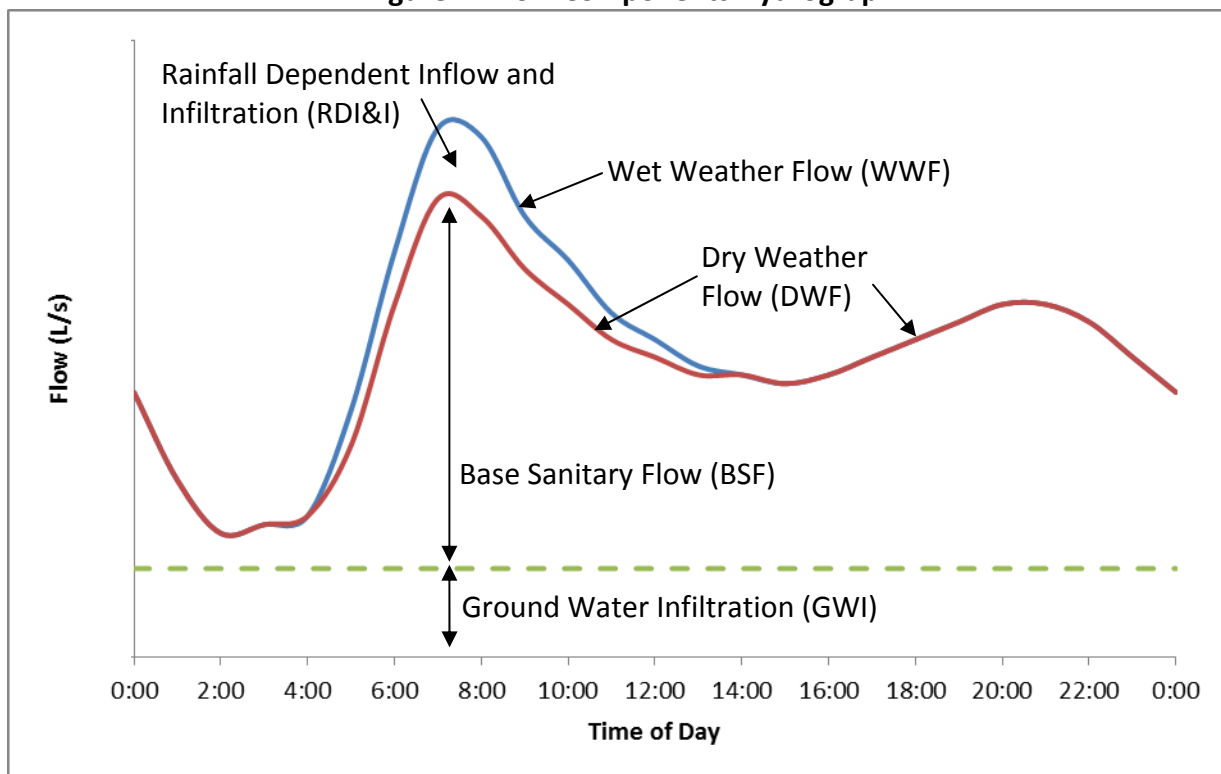


## Definitions

Daily flow conveyed in a sanitary sewer system can be generally divided into five (5) components as shown in **Figure A:**

- Ground Water Infiltration (GWI)
- Base Sanitary Flow (BSF)
- Dry Weather Flow (DWF)
- Rainfall Dependent Inflow and Infiltration (RDI&I)
- Wet Weather Flow (WWF)

**Figure A: Flow Components Hydrograph**



Metro Vancouver has provided definitions for those flow components. These definitions can be found in the *Inflow and Infiltration Reduction Program I/I Analysis Results: 1993 – 1994 Flow Monitoring Sites Volume I, January 1995* and are listed below. These definitions are applied in this report.



Ground Water Infiltration (GWI) – Ground water infiltration results from the movement of ground water in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table.

Base Sanitary Flow (BSF) – All wastewater from residential, commercial, institutional, and industrial sources that the sanitary sewer system is intended to carry.

Dry Weather Flow (DWF) – The portion of the total flow that is composed of BSF and GWI.  
 $DWF = GWI + BSF$ .

Average Dry Weather Flow (ADWF) – The daily average value of the diurnally varying Dry Weather Flow, averaged over a 24-hour period.

Rainfall Dependent I&I (RDI&I) – Rainfall dependent inflow and infiltration equals rainfall-induced infiltration plus all sources of inflow.

Wet Weather Flow (WWF) – All flow contributions carried by the sanitary sewer system during wet weather.  $WWF = GWI + BSF + RDI\&I$ .

Peak Wet Weather Flow (PWWF) – All flow contributions carried by the sanitary sewer system during peak wet weather.

Peak Wet Weather Flow 5-year I&I ( $PWWF_5$ ) – All flow contributions carried by the sanitary sewer system during a 5-year return storm event.

Peak Wet Weather Flow 25-year I&I ( $PWWF_{25}$ ) – All flow contributions carried by the sanitary sewer system during a 25-year return storm event.



## 1 Introduction

The City of Merritt, BC retained GeoAdvice Engineering to develop the City of Merritt's Sanitary Sewer Master Plan (SSMP). A critical component of the SSMP is the assessment of the City's sanitary sewer system's capacity to service both existing and future sanitary loads. This report describes the methodology and assumptions used to assess the sanitary sewer system's capacity using the "all pipe" hydraulic model of the City's sanitary sewer collection system. This Technical Memorandum (TM) builds on the assumptions and findings of *TM 1 – Proposed Flow Monitoring Locations* and *TM 2 – Model Build and Calibration of Merritt Sanitary Sewer Collection System*.

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Mr. Shawn Boven
- Mr. Darrell Finnigan
- Ms. Danielle Cass
- Mr. Kevin Vilac
- Mr. Sean O'Flaherty

## 2 Scope

The scope of this TM covers the following items:

- Development of future development scenarios
  - Calculation and allocation of future sanitary loads
  - Setup of modeling scenarios
- Sewer system evaluation
  - Establish evaluation and planning criteria
  - Sewer system capacity analysis
  - Pump station capacity analysis
- Timing and ranking analysis
- Improvement costing



### 3 Future Sanitary Loads

In consultation with the City, it was determined that a total of four (4) growth scenarios will be considered and evaluated as part of the SSMP.

- 1.1 % growth per year, with growth distributed proportionally based on existing sanitary loads
- 3.5% growth per year, with growth distributed proportionally based on existing sanitary loads
- 1.1 % growth per year, with growth concentrated at Official Community Plan (OCP) development areas
- 3.5 % growth per year, with growth concentrated at OCP development areas

#### 3.1 Growth Scenario

##### 3.1.1 Population Growth

Two (2) population growth scenarios were reviewed, population growth of 1.1% per year and 3.5% per year respectively. Using the values listed in the City's Official Community Plan (OCP), **Table 3.1** summarizes the City's projected population growth.

**Table 3.1: Population Growth Scenarios (1.1% and 3.5%)**

Year	Total Population	
	1.1% Growth	3.5% Growth
2010	7,285	7,285
2015	7,695	8,653
2020	8,127	10,276
2030	9,067	14,497

Presently the City is planning for two major developments, Midday Valley Plan and Gateway 286 Plan. Through consultation with the City, it was determined that the maximum build out population for Midday Valley and Gateway 286 are 667 people and 3,500 people respectively. In addition, it was assumed that growth in the City Center will match overall population growth of 1.1% and 3.5% respectively.

**Table 3.2** presents the future population projections for the two major developments, the City Center, and the remaining areas.



**Table 3.2: Residential Growth Scenarios**

Year	Total Population		Midday Valley		Gateway 286		City Center		Remaining Areas	
	1.1% Growth	3.5% Growth	1.1% Growth	3.5% Growth	1.1% Growth	3.5% Growth	1.1% Growth	3.5% Growth	1.1% Growth	3.5% Growth
2010	7,285	7,285	NA	NA	NA	NA	389	389	6,896	6,896
2015	7,695	8,653	41	167	216	875	411	462	7,027	7,149
2020	8,127	10,276	83	334	433	1,750	434	549	7,177	7,643
2031	9,067	14,497	165	667	865	3,500	484	774	7,553	9,556

### 3.1.2 ICI Growth

Based on the findings of TM #2, current ICI sanitary base flows are 3.81 L/s. Future ICI flows were estimated using the percentage growth of existing ICI sanitary flows.

**Table 3.3** summarizes the estimated future ICI base sanitary flow based on 1.1% and 3.5% growth of existing ICI base sanitary flow.

**Table 3.3: Future ICI Sanitary Loads – Estimated using Growth Percentages**

Year	Total BSF (L/s)	
	1.1% Growth	3.5% Growth
2010	3.81	3.81
2030	4.74	7.58

## 3.2 Allocation of Future Growth

The City's OCP identifies a number of "development areas" for both residential and ICI developments; however, the OCP does not quantify the anticipated growth for these "development areas". In consultation with the City it was decided that two growth distribution scenarios be evaluated, future growth applied proportionally across the City, and future growth concentrated in the new "development areas".

### 3.2.1 Proportion Growth Based on Existing Sanitary loads

In this scenario, the residential and ICI growths (excluding the Midday Valley, Gateway 286, and City Center) are allocated proportionally throughout the existing system based on existing base sanitary flows.



### 3.2.2 Growth Based OCP Development Areas

In this scenario, the residential and ICI growths (excluding the Midday Valley, Gateway 286, and City Center) are allocated based on the OCP “development areas”. The City’s OCP identifies the following “development areas”:

- North Nicola – West (Residential)
- North Nicola – East (Residential)
- North Bench (Residential)
- Airport (Residential)
- East Merritt – South (Residential)
- East Merritt – North (Residential)
- Colletville (ICI)
- East Merritt (ICI)
- Airport (ICI)

**Table 3.4** and **Table 3.5** summarize how the projected growth has been allocated in the model.

**Table 3.4: 2030 Population Distribution – Concentrated at OCP Development Areas**

Residential Areas	Existing Population	1.1% Growth Scenario		3.5% Growth Scenario	
		Population Growth	Total Population	Population Growth	Total Population
North Nicola (West)	0	104	104	492	492
North Bench	0	242	242	1,148	1,148
North Nicola (East)	0	104	104	492	492
Airport	0	34	34	164	164
East Merritt (South)	0	34	34	164	164
East Merritt (North)	0	34	34	164	164
Existing Residential Areas	6,896	104	7,000	491	7,387
City Center	389	96	485	385	774
Midday Valley	0	165	165	667	667
Gateway 286	0	865	865	3,500	3,500
<b>Total</b>	<b>7,285</b>	<b>1,782</b>	<b>9,067</b>	<b>7,212</b>	<b>14,497</b>

**Table 3.5: 2030 ICI Flow Distribution – Concentrated at OCP Development Areas**

ICI Areas	Existing Flow (L/s)	1.1% Growth Scenario		3.5% Growth Scenario	
		Additional Flow (L/s)	Total Flow (L/s)	Additional Flow (L/s)	Total Flow (L/s)
Colletville	0.00	0.29	0.26	1.17	1.17
East Merritt	0.00	0.29	0.26	1.17	1.17
Airport	0.00	0.11	0.10	0.47	0.47
Existing ICI Areas	3.81	0.23	4.02	0.94	4.75
<b>Total</b>	<b>3.81</b>	<b>0.93</b>	<b>4.74</b>	<b>3.77</b>	<b>7.58</b>

### 3.3 Sanitary loading rates

Table 3.6 and Table 3.7 list the existing sanitary loading rates as highlighted in TM #2.

**Table 3.6: Assumed Residential and ICI Loading Rates (Existing Scenarios)**

Landuse Type	Loading Rate
Residential	200 L/cap/day
Commercial	1,800 L/ha/day
Industrial	1,800 L/ha/day
Institutional	1,800 L/ha/day
Service Commercial	1,800 L/ha/day
City Center	3,600 L/ha/day

**Table 3.7: Assumed I&I Loading Rates**

Type	Loading Rate (L/ha/day)
<b>Groundwater Infiltration</b>	
Sub-Catchment A	485
Sub-Catchment B	1,854
All other Areas	2,000
<b>Rainfall Derived Inflow and Infiltration</b>	
5 year 24 hour	8,520
25 year 24 hour	12,150

The existing sanitary loading rates were found to be substantially different that the design rates listed in the City's Subdivision and Development Servicing Bylaw.



### 3.3.1 Average Daily Flow Rate

Based on the results of the dry weather flow analysis, (TM #2), the City's average daily residential flow rate is approximately 200 L/cap/day, which is approximately half of the City's design rates of 365 L/cap/day.

In consultation with the City, it was determined that the existing residential sanitary loading behavior is not anticipated to change; thus, for the 2030 system assessment, existing residential loads will continue to be assessed using the measured flow rate of 200 L/cap/day.

In consultation with the City, it was also determined that the future growth sanitary loading will likely be in line with existing behaviors. However, given the overall uncertainty in estimating the 2030 growth, design flow rate of 365 L/cap/day was also considered. Thus, the additional 2030 residential loads were estimated using two (2) different rates:

- Using the measured flow rate of 200 L/cap/day
- Using the design flow rate of 365 L/cap/day

### 3.3.2 Inflow and Infiltration Allowance.

Based on the results of the dry and wet weather flow analysis, (TM #2), the City's sanitary sewers have an estimated GWI rate of 800-2,000 L/ha/day, and a 5 year RDI&I design rate of 8,520 L/ha/day. This total 5 year I&I design rate of 10,520 L/cap/day is double than the City's current design I&I rate of 5,180 L/cap/day.

In consultation with the City, it was determined that the measured I&I rates be utilized to assess the capacity of the sanitary sewer system.

## 3.4 Model Scenarios

In consultation with the City eight (8) sanitary loading scenarios were developed. **Table 3.8** lists the eight (8) sanitary loading scenarios.

**Table 3.8: Sanitary Loading Scenarios**

Scenario	Population Growth Rate (%)	Future Residential Unit Rate (L/cap/day)	Future Load Allocation
1-A	1.1	200	Proportional Growth
2-A	1.1	200	OCP Development Areas
3-A	1.1	365	Proportional Growth
4-A	1.1	365	OCP Development Areas
5-A	3.5	200	Proportional Growth
6-A	3.5	200	OCP Development Areas
7-A	3.5	365	Proportional Growth
8-A	3.5	365	OCP Development Areas

### 3.4.1 Gateway 286 Development

The Gateway 286 development represents almost 50% of the City's anticipated residential growth. However, the ultimate servicing strategy for the Gateway 286 development is still to be determined. The *Proposed Gateway 286 Development Infrastructure Plan* (Corix Utilities 2008) discusses the option of treating and disposing the sanitary loads on site, with no sanitary discharges into the City's existing system. However, the City has yet to approve this strategy.

In consultation with the City, it was determined that given the magnitude of the Gateway 286 development, and the impact the development's ultimate servicing strategy will have on the City's 2030 system performance, three (3) potential Gateway 286 development servicing options would be reviewed.

- Gateway 286 development connecting to the existing system at Bann Street and Thorpe Road as per *Joeyaska Water and Sewer Report* (Urban Systems 2000) (Baseline Scenario)
- Gateway 286 development connecting to the existing 250 mm diameter sewer at the north end of Douglas Street.
- Gateway 286 development sanitary flows being disposed on-site with no sanitary inflows into the existing system as per *Proposed Gateway 286 Development Infrastructure Plan* (Corix Utilities 2008).

**Table 3.9** lists the additional six (6) Gateway 286 servicing scenarios that were reviewed.



**Table 3.9: Gateway 286 Sanitary Loading Scenarios**

Scenario	Population Growth Rate (%)	Future Residential Demand Rate (L/cap/day)	Future Load Allocation	Gateway 286 Tie-in to Existing system
1-B	1.1	200	Proportional Growth	Excluded
2-B	1.1	200	OCP Development Areas	Excluded
2-C	1.1	200	OCP Development Areas	Douglas Street
5-B	3.5	200	Proportional Growth	Excluded
6-B	3.5	200	OCP Development Areas	Excluded
6-C	3.5	200	OCP Development Areas	Douglas Street

### 3.5 Future Loads

The table below lists the total sanitary loads for each of the fourteen (14) loading scenarios.

**Table 3.10: 2030 Sanitary Loading**

Scenario	Catchment Area (ha)	Residential Load (L/s)	ICI Load (L/s)	GWl (L/s)	5 Year RDI&I (L/s)
1-A	725.5	21.0	4.6	10.0	42.7
1-B	668.5	19.0	4.6	8.7	37.1
2-B	781.5	21.0	4.6	12.0	46.8
2-B	724.5	19.0	4.6	10.7	41.1
2-C	781.5	21.0	4.6	12.0	46.8
3-A	725.5	24.4	4.6	10.0	42.7
4-A	781.5	24.4	4.6	12.0	46.8
5-A	725.5	33.6	7.6	10.0	42.7
5-B	668.5	25.5	7.6	8.7	37.1
6-A	781.5	33.6	7.6	12.0	46.8
6-B	724.5	25.5	7.6	10.7	41.1
6-C	781.5	33.6	7.6	12.0	46.8
7-A	725.5	47.3	7.6	10.0	42.7
8-A	781.5	47.3	7.6	12.0	46.8



### 3.6 PBSF Calculations

As part of the model calibration, (TM#2), a series of diurnal patterns were developed to represent the time varying nature of sanitary loading. These diurnal patterns were used to estimate existing peak base sanitary flows (PBSF) in the system. The current system has a PBSF peaking factor of 1.62 over BSF.

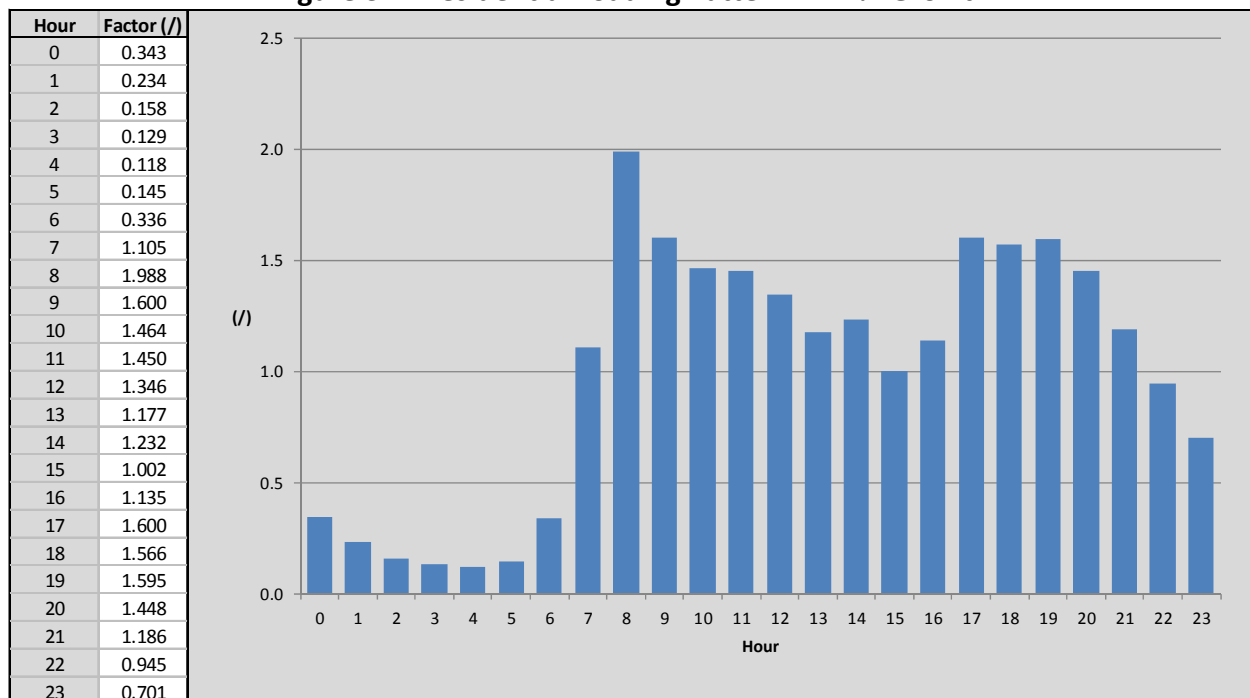
To estimate future PBSF, the City's Subdivision and Development Servicing Bylaw recommends using a modified Harmon peaking equation as shown below.

$$PBSF = BSF \left( \frac{18 + P}{4 + P} \right)$$

Where P represents the total population (actual and equivalent) in thousands. Based on the 2030 population the PBSF has a peaking factor (PF) of 1.99 and 1.69 for the 1.1 % and 3.5% growth scenarios respectively. To accommodate the PBSF in the sanitary sewer model, the calibrated diurnal patterns were scaled up to match the PFS of 1.99 and 1.69 respectively.

**Figure 3.1 to Figure 3.4** below present the patterns used in the 1.1% and 3.5% growth scenarios respectively.

**Figure 3.1: Residential Loading Pattern – 1.1% Growth**



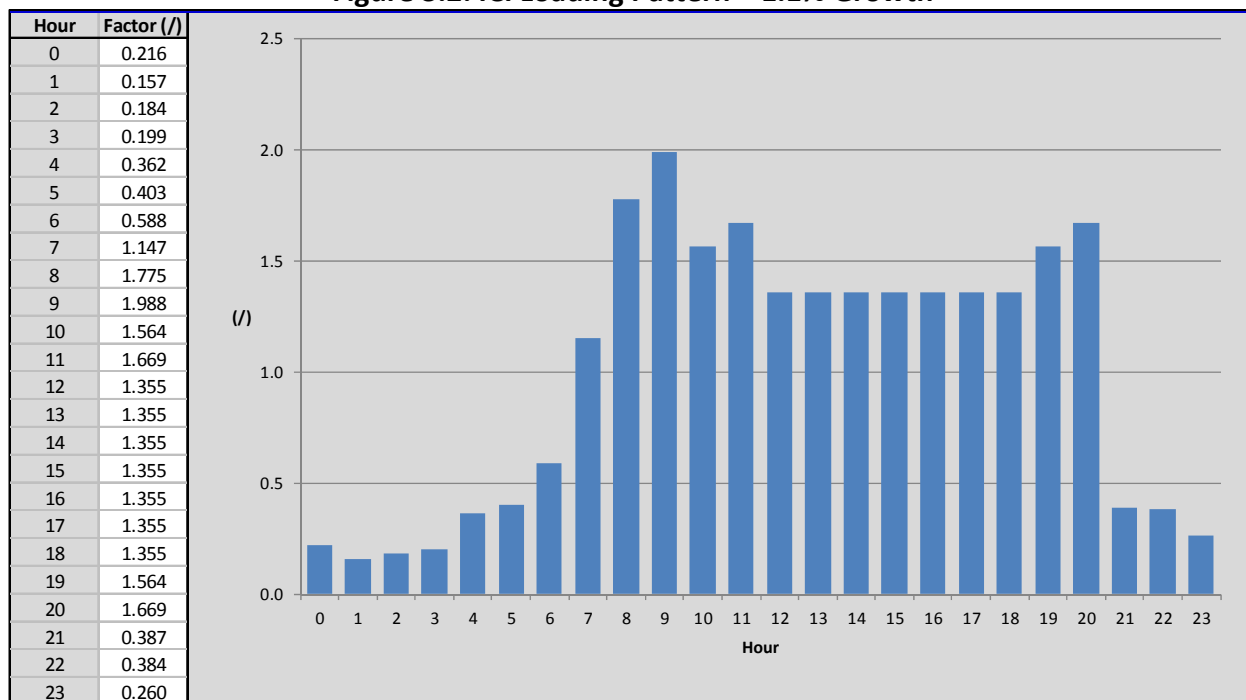
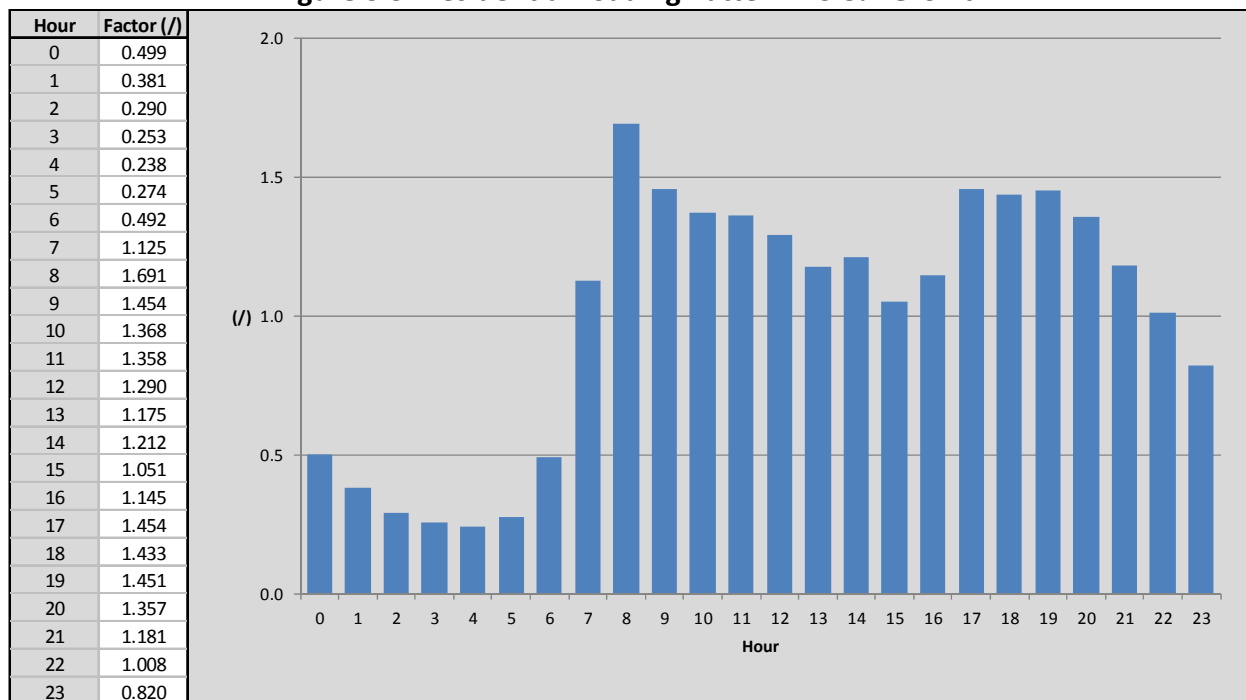
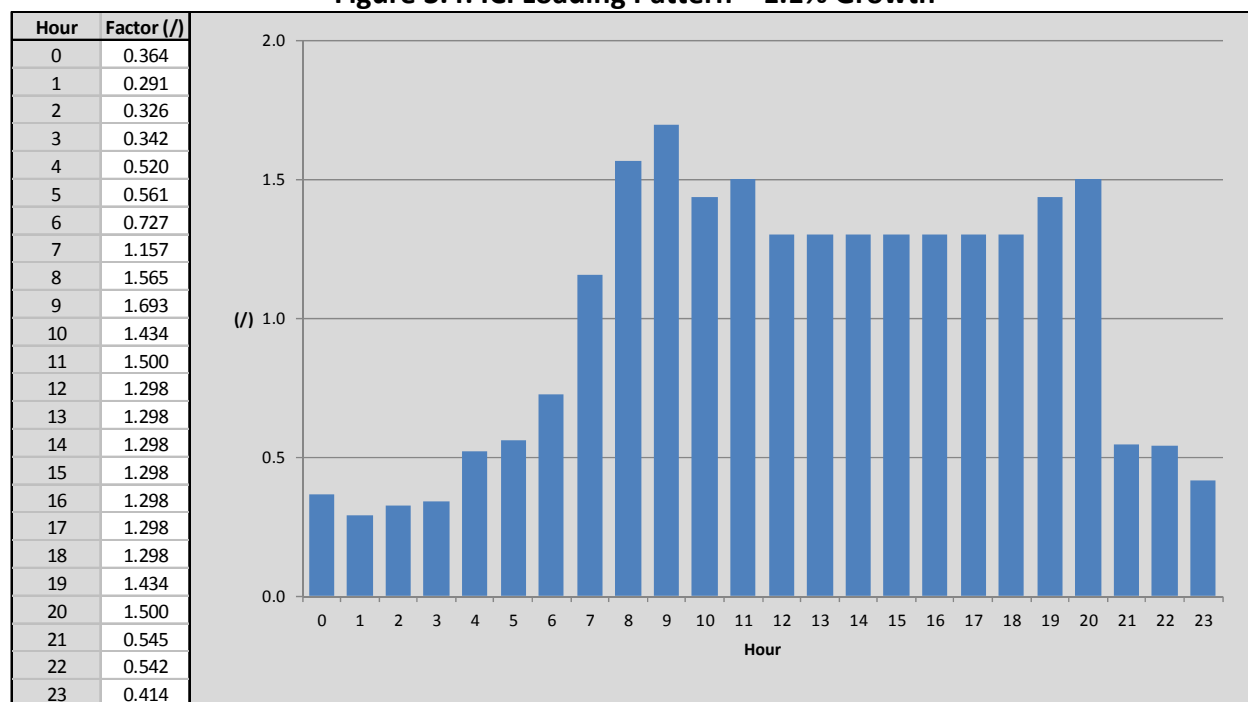
**Figure 3.2: ICI Loading Pattern – 1.1% Growth****Figure 3.3: Residential Loading Pattern – 3.5% Growth**



Figure 3.4: ICI Loading Pattern – 1.1% Growth





## 4 Collection System Performance Review

The capacity analysis was conducted in accordance with the *City's Modeling Best Practices, Standards, Conventions, and Flags for the City of Merritt sanitary Sewer Models* document.

### 4.1 Hydraulic Level of Service Rating Criteria

As outlined in the *City's Modeling Best Practices, Standards, Conventions, and Flags for the City of Merritt sanitary Sewer Models*, gravity mains of varying sizes and locations within the system have different level of service requirements. For example, laterals and collectors at the upstream end of the system are generally designed to flow half-full in order to minimize the risk of service connections backing up and spilling into basements. Larger diameter trunks and interceptor trunks generally do not have service connections and surcharging may be tolerable or even necessary in order to delay costly system upgrades.

To accommodate the varied "Hydraulic Level of Service" (HLoS) requirements, the Standards document recommends using the following criteria to assess the system's performance.

The HLoS system assigns a rating to each gravity main based on three criteria:

- Hydraulic Capacity -  $d/D$  ratio and/or friction slope in surcharged gravity main
- Hydraulic Grade Line - height of HGL with respect to conduit crown and ground elevation
- Velocity - whether minimum scouring velocity is achieved at peak flow

Gravity mains are classified in three categories with different requirements for HLoS criteria:

- Laterals/Collectors - 250 mm diameter and smaller
- Trunks - 300-675 mm diameter
- Interceptors - 750 mm diameter and larger

Based on the above gravity main classifications and the model results of; hydraulic capacity, HGL, and velocity a letter-grade indicating the HLoS rating is determined.





**Table 4.1** and **Table 4.2** list how the HLoS is determined.

**Table 4.1: Hydraulic Level of Service Criteria Scoring**

Rating	Lateral/Collector ≤ 250 mm	Trunk 300-675 mm	Interceptor ≥ 750 mm
<b>Hydraulic Capacity</b>			
$d/D \leq 0.7$	1	1	1
$d/D \leq 1.0$	2	2	2
$d/D = 1.0$	3	3	2
Friction Slope > gravity main Slope + 0.5 %	-	-	3
<b>HGL</b>			
HGL < Crown	1	1	1
HGL ≤ 0.3 m above Crown	2	1	1
HGL ≤ Ground Elevation	3	2	1
HGL > Ground Elevation	3	3	2
<b>Velocity</b>			
$v < 0.75$ m/s	Pass	Fail	Fail
$v \geq 0.75$ m/s	Pass	Pass	Pass

**Table 4.2: Hydraulic Level of Service Ratings**

Grade	Capacity	HGL	Velocity	Description
A	1	1	Pass	Gravity main performing as designed
B	1	1	Fail	Adequate capacity, low velocity may indicate potential sedimentation
C	1	2 or 3	N/A	Adequate capacity, downstream condition causing backwater
D	2	N/A	N/A	Marginal capacity
E	3	2	N/A	Capacity exceeded
F	3	3	N/A	Capacity exceeded and overflow likely

In general, ratings A, B, C, and D will not trigger an immediate upgrade as there is capacity in the gravity main to convey flows. A gravity main receiving an E rating requires an upgrade as the gravity main is flowing full. A rating of F indicates a critical downstream condition causing poor performance upstream, increasing the priority of the upgrade at the critical point.



## 4.2 Gravity Main Design Criteria

Gravity mains determined to be undersized, were upsized using the criteria listed in **Table 4.3**

**Table 4.3: Design Criteria (New Gravity Mains)**

Criteria	Parameter Value
Maximum d/D ratio	$d/D < 0.50$
Hydraulic Grade Line	HGL < Ground elevation
Minimum Velocity	$v > 0.75 \text{ m/s}$
Material	PVC
Roughness Coefficient	Manning $n = 0.013$
Minimum Diameter	200 mm

*\* Assume same slope as existing gravity main*

The existing system was evaluated using 5-year 24-hour RDI&I rate of 8,520 L/ha/day. All new facilities were designed to convey the 25-year 24-hour RDI&I rate of 12,150 L/ha/day.

Due to variation in gravity main slopes, and due to the more stringent capacity requirements for new gravity mains there are several instances where a hydraulically deficient gravity main will have a recommended diameter that is larger than the hydraulic sufficient downstream gravity main. In these situations, we also recommend upsizing the downstream gravity main to match the larger upstream diameter. This upsizing of the gravity main is done to mitigate against the increase risk of major blockages that can occur when the downstream gravity main diameter is smaller than the upstream gravity main diameter. However, as the existing smaller gravity main was already identified as having sufficient hydraulic capacity, these upsized gravity mains were not sized to meet the new gravity main criteria, which may require further upsizing of the new gravity main. This approach was taken to limit the upgrading of already hydraulic sufficient gravity mains.

## 4.3 Gravity Main Capacity Analysis

### 4.3.1 Hydraulic Level of Service

**Figure 4.1** to **Figure 4.15** located in **Appendix A**, highlight the systems HLoS for the various development scenarios. **Table 4.4** further summarizes the system performance. A detailed table listing the HLoS grade for gravity mains in the system is presented in **Appendix A**.

### 4.3.2 Gravity Main Upgrades

**Figure 4.16** to **Figure 4.29** located in **Appendix B**, highlight the gravity sewer upgrades required to address the identified HLoS deficiencies.

**Table 4.5** further summarizes the required upgrades.

**Table 4.4: 2030 System Hydraulic Level of Service**

HLoS	Total Length of Sanitary Sewer (m)													
	1-A	1-B	2-A	2-B	2-C	3-A	4-A	5-A	5-B	6-A	6-B	6-C	7-A	8-A
<b>A</b>	46,141	48,826	44,818	47,503	46,750	45,288	43,669	43,844	46,977	42,706	46,487	45,180	42,631	41,501
<b>B</b>	6,561	6,732	7,435	7,606	6,911	6,450	7,624	6,748	7,044	7,230	7,526	7,303	7,039	7,064
<b>C</b>	87	332	179	423	332	87	179	179	423	179	423	423	179	179
<b>D</b>	2,651	2,219	3,128	2,663	2,783	2,514	2,783	2,814	3,152	3,576	3,296	2,686	2,502	2,031
<b>E</b>	656	310	537	217	310	1,329	1,413	1,798	250	1,907	686	859	1,760	3,746
<b>F</b>	2,750	427	2,750	434	1,759	3,178	3,178	3,463	999	3,247	427	2,394	4,735	4,325
<b>Capacity Exceeded*</b>	<b>3,405</b>	<b>738</b>	<b>3,286</b>	<b>651</b>	<b>2,070</b>	<b>4,507</b>	<b>4,591</b>	<b>5,261</b>	<b>1,249</b>	<b>5,155</b>	<b>1,114</b>	<b>3,253</b>	<b>6,495</b>	<b>8,071</b>

\*HLoS of E or F

**Table 4.5: 2030 System Upgrades**

Diameter (mm)	Total Length of Sanitary Sewer Upgrades (m)													
	1-A	1-B	2-A	2-B	2-C	3-A	4-A	5-A	5-B	6-A	6-B	6-C	7-A	8-A
<b>250</b>	0	0	0	0	932	0	0	0	0	0	0	0	112	112
<b>300</b>	207	1,012	207	1,012	1,012	262	262	957	1,274	957	1,012	1,012	652	652
<b>350</b>	1,078	0	2,168	0	0	808	808	507	0	507	0	1,046	510	510
<b>375</b>	1,218	0	0	0	0	832	832	405	0	1,101	0	0	0	0
<b>450</b>	578	0	706	0	0	1,233	1,149	1,878	0	2,412	1,230	1,230	2,790	4,020
<b>525</b>	0	0	0	0	0	115	199	199	250	199	199	199	115	0
<b>600</b>	0	0	0	0	0	0	0	0	0	0	0	0	84	199
<b>Total Length</b>	<b>3,081</b>	<b>1,012</b>	<b>3,081</b>	<b>1,012</b>	<b>1,944</b>	<b>3,251</b>	<b>3,251</b>	<b>3,946</b>	<b>1,523</b>	<b>5,176</b>	<b>2,442</b>	<b>3,488</b>	<b>4,263</b>	<b>5,493</b>



After the gravity main improvements were implemented in the model, several gravity mains still remained deficient. These are caused by (back water effect):

- flat gravity mains;
- gravity main drops; and
- small lateral connected to larger gravity mains.

The remaining deficiencies were considered non-critical.

#### **4.3.3 Nicola River Siphon**

The model results indicate that upgrades to the Nicola River Siphon are required to resolve the HLoS deficiencies under Scenario 6 and Scenario 8 (3.5% growth with OCP development areas load allocation). However, these upgrades are based on a preliminary hydraulic assessment of the Nicola River Siphon and do not take into consideration potential flow efficiencies that could be achieved through enhancements of the existing siphon. A comprehensive review of the Nicola River Siphon should be undertaken when upstream developments would trigger Critical Section E upgrade.

### **4.4 Pump Station Capacity Analysis**

A pump station's capacity is considered to be deficient when the 2030 PWWF<sub>5</sub> is greater than the firm capacity. Pump upgrades should be sized to meet flows up to the 2030 PWWF<sub>25</sub>. The results from the pump station analysis are summarized in **Table 4.6**. It should be noted that the PWWF flows of the individual pump stations are unaffected by the future servicing of Gateway 286 development.

Based on the above results, the pump stations appear to have sufficient capacity to meet both existing and future loads, and no upgrades of the existing pump stations are recommended.

Given the results of the pump station analysis, an analysis of the forcemain sections has not been undertaken.

**Table 4.6: Existing Pump Capacity vs. 2031 PWWF5**

Scenario	Pump Station	# of Pumps	Existing Firm Capacity* (L/s)	2031 PWWF5** (L/s)	Excess Capacity (L/s)
1A	PS #1 – Nicola	1	16.3	0.8	15.5
	PS #2 – Collettville	2	26.5	17.4	9.1
2A	PS #1 – Nicola	1	16.3	1.2	15.1
	PS #2 – Collettville	2	26.5	18.7	7.8
3A	PS #1 – Nicola	1	16.3	0.8	15.5
	PS #2 – Collettville	2	26.5	17.9	8.6
4A	PS #1 – Nicola	1	16.3	1.6	14.7
	PS #2 – Collettville	2	26.5	19.0	7.5
5A	PS #1 – Nicola	1	16.3	0.9	15.4
	PS #2 – Collettville	2	26.5	19.8	6.7
6A	PS #1 – Nicola	1	16.3	2.7	13.6
	PS #2 – Collettville	2	26.5	21.7	4.8
7A	PS #1 – Nicola	1	16.3	1.1	15.2
	PS #2 – Collettville	2	26.5	22.1	4.4
8A	PS #1 – Nicola	1	16.3	4.3	12.0
	PS #2 – Collettville	2	26.5	23.1	3.4

\* Existing Firm Capacity assumes one pump operating at design point.

\*\* Represents model 2031 PWWF<sub>5</sub> upstream the pump station.

Please note that the pump station's existing firm capacity is typically assessed assuming that one (1) of the pumps is out of service. However, the City's Nicola pump station has only one (1) pump; yielding a firm flow capacity of 0 L/s using the typical methodology. The Nicola pump station using the existing level of service, with no redundancy, has more than sufficient capacity to accommodate the increased flows.





## 5 Improvement Costing

**Table 5.1** below presents the unit costs provided by the City and used to estimate the sewermain upgrade costs.

**Table 5.1: Sanitary Sewer Upgrade Unit Costs**

Diameter (mm)	Cost (2012 \$/m)
200	\$ 500
250	\$ 575
300	\$ 675
350	\$ 725
375	\$ 750
400	\$ 800
450	\$ 850
525	\$ 975
600	\$ 1050
675	\$ 1150
750	\$ 1275
900	\$ 1450

**Table 5.2** presents the estimate upgraded cost for each scenario.

The costs presented in **Table 5.1** and **Table 5.2** are base cost only, and do not include:

- Contractor Markup/Overhead
- Administration
- Engineering
- Contingency

**Table 5.2: Sanitary Sewer Upgrade Cost**

Scenario	Length of Upgrades (m)	Estimated Cost (2012 \$)
1-A	3,081	\$ 2,297,000
1-B	1,012	\$ 683,000
2-A	3,081	\$ 2,276,000
2-B	1,012	\$ 683,000
2-C	1,944	\$ 1,219,000
3-A	3,251	\$ 2,471,000
4-A	3,251	\$ 2,475,000
5-A	3,946	\$ 2,989,000
5-B	1,523	\$ 1,072,000
6-A	5,176	\$ 3,938,000*
6-B	2,442	\$ 1,837,000 *
6-C	3,488	\$ 2,595,000 *
7-A	4,263	\$ 3,286,000
8-A	5,493	\$ 4,284,000 *

\*Excludes Nicola River Siphon Upgrades



## 6 Collection System Performance Analysis

This section discusses the relative impacts of the various growth scenarios on the overall system performance and upgrades.

### 6.1 Critical Sewer Sections

The capacity analysis highlights eight (8) critical sanitary sewer sections. For each of the fourteen (14) scenarios reviewed, all the identified capacity deficiencies can be traced to capacity deficiencies within one or all of the eight (8) critical sections. **Figure 6.1** highlights the eight (8) critical sanitary sewer sections, listed below:

- Critical Section A: Coutlee Ave and Blair St
- Critical Section B: Coldwater Ave
- Critical Section C: Menzies St, Granite Pl. and Douglas St
- Critical Section D: Clapperton Ave. and Menzies St.
- Critical Section E: Main St. and Quilchena Ave.
- Critical Section F: Chapman St., 1 Ave., Cleasby St., Nicola Ave., Spring St., Quilchena Ave.
- Critical Section G: Laneway north of Princeton-Kamloops Hwy. / South of Mamette Ave.
- Critical Section H: Bann St. and Scott Pl.

The capacity analysis also indicates that the system performance is highly sensitive to magnitude and location of the anticipated growth.

### 6.2 Growth Scenarios

As expected the 2030 system performance under the 3.5% growth scenario shows a significant reduction in the overall HLoS when compared to the 1.1% growth scenario. **Table 6.1** compares the relative performance between the 1.1% and 3.5% growth scenarios.

**Table 6.1: Growth Scenario Comparison – Growth Rate**

1.1% Scenario	3.5% Scenario	HLoS Exceeds Capacity (m)			Upgrade Cost (2012 \$)		
		1.1% Scenario	3.5% Scenario	Relative Increase	1.1% Scenario	3.5% Scenario	Relative Increase
1-A	5-A	3,405	5,261	54%	\$ 2,297,000	\$ 2,989,000	30%
1-B	5-B	738	1,249	69%	\$ 684,000	\$ 860,000	26%
2-A	6-A	3,286	5,155	57%	\$ 2,277,000	\$ 3,939,000	73%
2-B	6-B	651	1,114	71%	\$ 684,000	\$ 1,837,000	169%
2-C	6-C	2,070	3,253	57%	\$ 1,220,000	\$ 2,596,000	113%
3-A	7-A	4,507	6,495	44%	\$ 2,472,000	\$ 3,301,000	34%
4-A	8-A	4,591	8,071	76%	\$ 2,476,000	\$ 4,285,000	73%





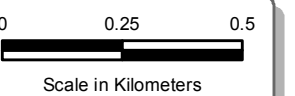
### Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole

### Conduits

#### Critical Sections

-  A
-  B
-  C
-  D
-  E
-  F
-  G
-  H
-  Existing Pipe



Project Title:

City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: **2011-026-MER**

Date: **April 20, 2012**

Client: City of Merritt, BC

### Critical Sections

Figure 6.1





In general, the total length of deficient gravity mains under the 3.5% scenario is generally 50-75% higher than in the 1.1% scenario. When growth is anticipated to grow proportionally (Scenarios 5 and 7) the additional cost for the 3.5% scenario is more modest, as the recommended upgrades cover the same general extent only using larger diameters. However, when growth is anticipated to occur in the OCP development areas (Scenario 6 and 8) the increased flows from the North Nicola area trigger upgrades to critical section F in the 3.5% scenario. Upgrades to critical section F significantly increase the relative upgrade cost.

### 6.3 Load Allocation Scenarios

The capacity and upgrade analysis indicates that the total system performance is not significantly impacted by the spatial allocation of future growth. **Table 6.2** presents the relative performance between the two (2) load allocation scenarios:

- OCP
- Proportional

**Table 6.2: Growth Scenario Comparison – Load Allocation Methodology**

Pro. Growth	OCP	HLoS Exceeds Capacity (m)			Upgrade Cost (2012 \$)		
		Pro. Growth	OCP	Relative Increase	Pro. Growth	OCP	Relative Increase
1-A	2-A	3,405	3,286	-3%	\$ 2,297,000	\$ 2,277,000	-1%
1-B	2-B	738	651	-12%	\$ 684,000	\$ 684,000	0%
3-A	4-A	4,507	4,591	2%	\$ 2,472,000	\$ 2,476,000	0%
5-A	6-A	5,261	5,155	-2%	\$ 2,989,000	\$ 3,939,000	32%
5-B	6-B	1,249	1,114	-11%	\$ 860,000	\$ 1,837,000	114%
7-A	8-A	6,495	8,071	24%	\$ 3,301,000	\$ 4,285,000	30%

Under the 1.1% growth scenario, the system performs marginally better if growth was to occur concentrated within the identified OCP development areas. However, under the 3.5% growth scenario, there is a noticeable reduction in the HLoS along critical section F, under the OCP growth scenario. The critical section F, is the key trunk main servicing the North Nicola areas. These increased flows ultimately trigger the upgrading of critical section F, and the Nicola river siphon crossing upgrades, which would not be required if growth were to occur proportionally throughout the existing system. The required upgrading of critical section F significantly increases the upgrade costs.

### 6.4 Per Capita Demand

As expected, when assuming a higher per capita rate of 365 L/cap/day, the model demonstrates a significant deterioration in the system's HLoS. The additional upgrades needed to accommodate the increased loads are marginal under the 1.1% growth scenario; however,





under the 3.5% growth scenario, the increased per capita flow triggers upgrades to critical section H. **Table 6.3** presents the relative system performance of the future per capita loads.

**Table 6.3: Growth Scenario Comparison – Per Capita Demand Rate**

		HLoS Exceeds Capacity (m)			Upgrade Cost (2012 \$)		
200 L/cap/d	365 L/cap/d	200 L/cap/d	365 L/cap/d	Relative Increase	200 L/cap/d	365 L/cap/d	Relative Increase
1-A	3-A	3,405	4,507	32%	\$ 2,297,000	\$ 2,472,000	8%
2-A	4-A	3,286	4,591	40%	\$ 2,277,000	\$ 2,476,000	9%
5-A	7-A	5,261	6,495	23%	\$ 2,989,000	\$ 3,301,000	10%
6-A	8-A	5,155	8,071	57%	\$ 3,939,000	\$ 4,285,000	9%

## 6.5 Gateway 286 Development

The system capacity analysis indicates that the most significant driver in terms of overall system performance and total length of upgrades is the Gateway 286 Development. If the Gateway 286 development was to treat and dispose all sanitary flows on site, as proposed in **Table 6.4**, the scope of system upgrades can be limited to critical section A, in the 1.1% growth scenario, and to critical section A, and critical section C or critical section F under the 3.5% growth scenario.

**Table 6.4: Growth Scenario Comparison – 286 Gateway Development Servicing**

		HLoS Exceeds Capacity (m)			Upgrade Cost (2012 \$)		
Included	Excluded	Included	Excluded	Relative Increase	Included	Excluded	Relative Increase
1-A	1-B	3,405	738	-78%	\$ 2,297,000	\$ 684,000	-70%
2-A	2-B	3,286	651	-80%	\$ 2,277,000	\$ 684,000	-70%
2-A	2-C	3,286	2,070	-37%	\$ 2,277,000	\$ 1,220,000	-46%
5-A	5-B	5,261	1,249	-76%	\$ 2,989,000	\$ 860,000	-71%
6-A	6-B	5,155	1,114	-78%	\$ 3,939,000	\$ 1,837,000	-53%
6-A	6-C	5,155	3,253	-37%	\$ 3,939,000	\$ 2,596,000	-34%

However, if the Gateway 286 development sanitary loads do end up discharging into the City's system, the City and/or the developer may wish to explore alternative connections to the City system. The model results indicate that much of critical sections A B,C,D are at or near capacity and if an alternate connection can be made, upgrading of critical sections B, critical section C, and critical section D can potentially be avoided.



## 7 System Upgrade Staging Analysis

Given the uncertainty in the development scenarios it is not practical to use the traditional approach of using set time frames for determining the various system upgrades. However, based on the capacity analysis it is possible to determine which potential development will trigger the selected system upgrades. **Table 7.1** presents a summary of the project triggers for each of the identified critical sections.

**Table 7.1: Staging Summary**

Critical Section	Project Trigger	Total Length (m)
A	Existing Deficiency	<b>320</b>
B	Servicing of Gateway 286 – All Scenarios	<b>1,080</b>
C	Servicing of Gateway 286 – All Scenarios	<b>130</b>
D	Servicing of Gateway 286 – 3.5% Growth	<b>200</b>
E	Servicing of Gateway 286 – 3.5% Growth and/or 365 L/cap/day	<b>750</b>
F	Development of North Bench and/or North Nicola OCP Development Area	<b>470</b>
G	Alternate Servicing of Gateway 286	<b>1,520</b>
H	Servicing of Gateway 286 – 3.5% Growth at 365 L/cap/day	<b>1,010</b>

With the exception of critical section A, which is deficient under the existing scenario, all the identified critical section upgrades can be attributed to individual developments.



## Appendix A – Hydraulic Level of Service

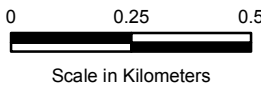


**Legend**

- WWTP
- Pump
- Flow Split
- Manhole

**Gravity Main HLOS**

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**  
Existing System

Figure 4.1



## Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole

## Gravity Main HLoS

-  Grade A
-  Grade B
-  Grade C
-  Grade D
-  Grade E
-  Grade F



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street

Project Title:

City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID:

2011-026-MER

Date:

September 2012

Client:

City of Merritt, BC

## Gravity Main Hydraulic Level of Service

2030 Scenario No. 1-A

Midday Valley  
Development  
Inflow

Gateway 286  
Development  
Inflow







Figure 4.2

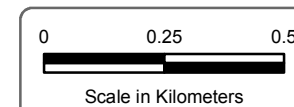


## Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole

## Gravity Main HLOS

-  Grade A
-  Grade B
-  Grade C
-  Grade D
-  Grade E
-  Grade F



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Excluded

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**

2030 Scenario No. 1-B

**Midday Valley  
Development  
Inflow**

Figure 4.3

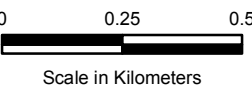


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 2-A

Figure 4.4

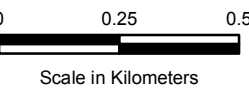


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Excluded

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 2-B

Figure 4.5

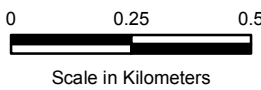


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Douglas Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 2-C

Figure 4.6



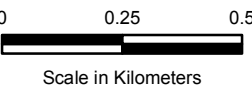
Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F

Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street



Project Title:  
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Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 3

Figure 4.7



## Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole

## Gravity Main HLoS

-  Grade A
-  Grade B
-  Grade C
-  Grade D
-  Grade E
-  Grade F



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

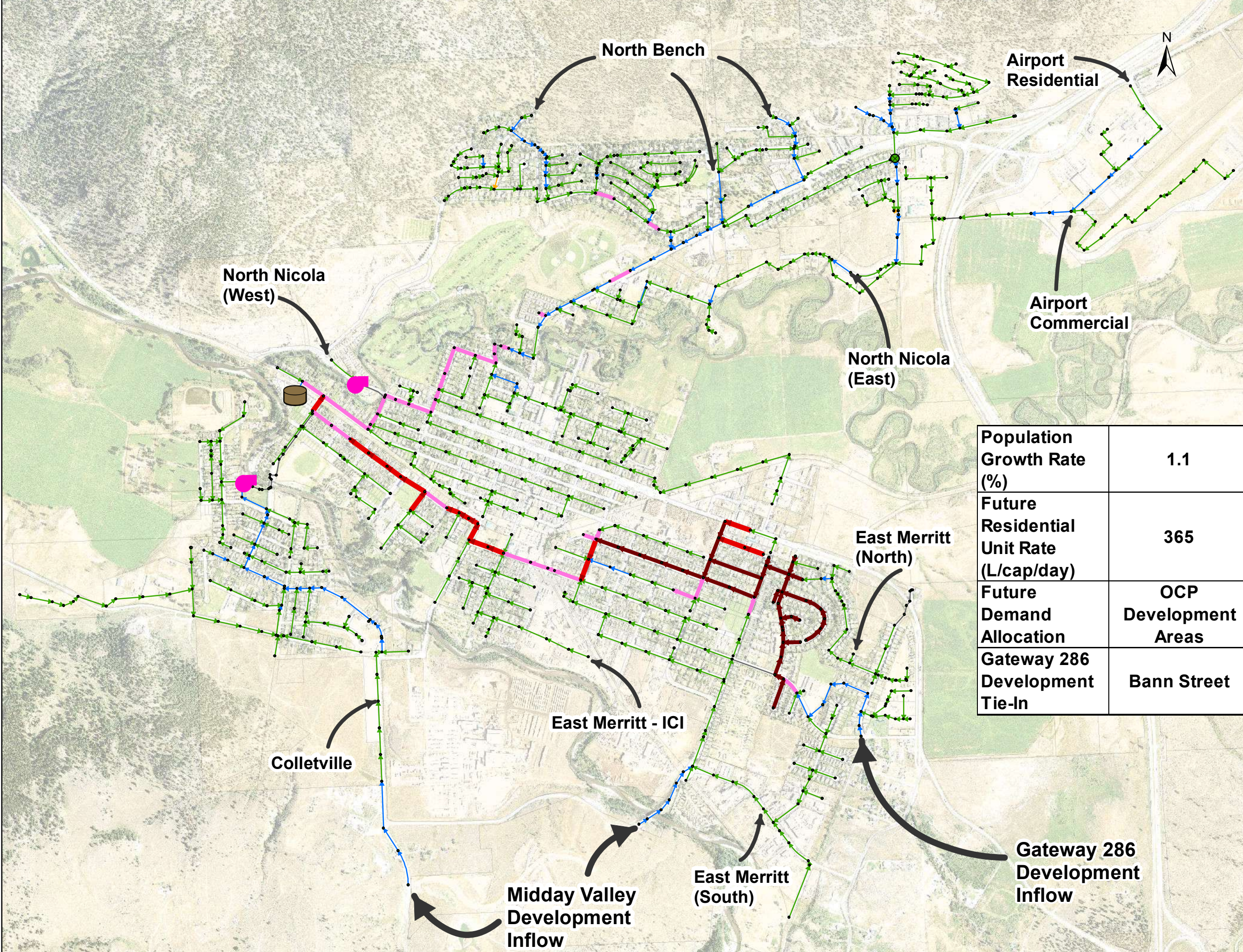
Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**  
2030 Scenario No. 4

Figure 4.8





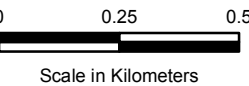
Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F

Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street



Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 5-A

Figure 4.9



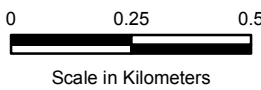
Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F

Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Excluded



Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 5-B

Figure 4.10

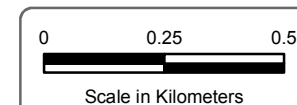


### Legend

- WWTP
- Pump
- Flow Split
- Manhole

### Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

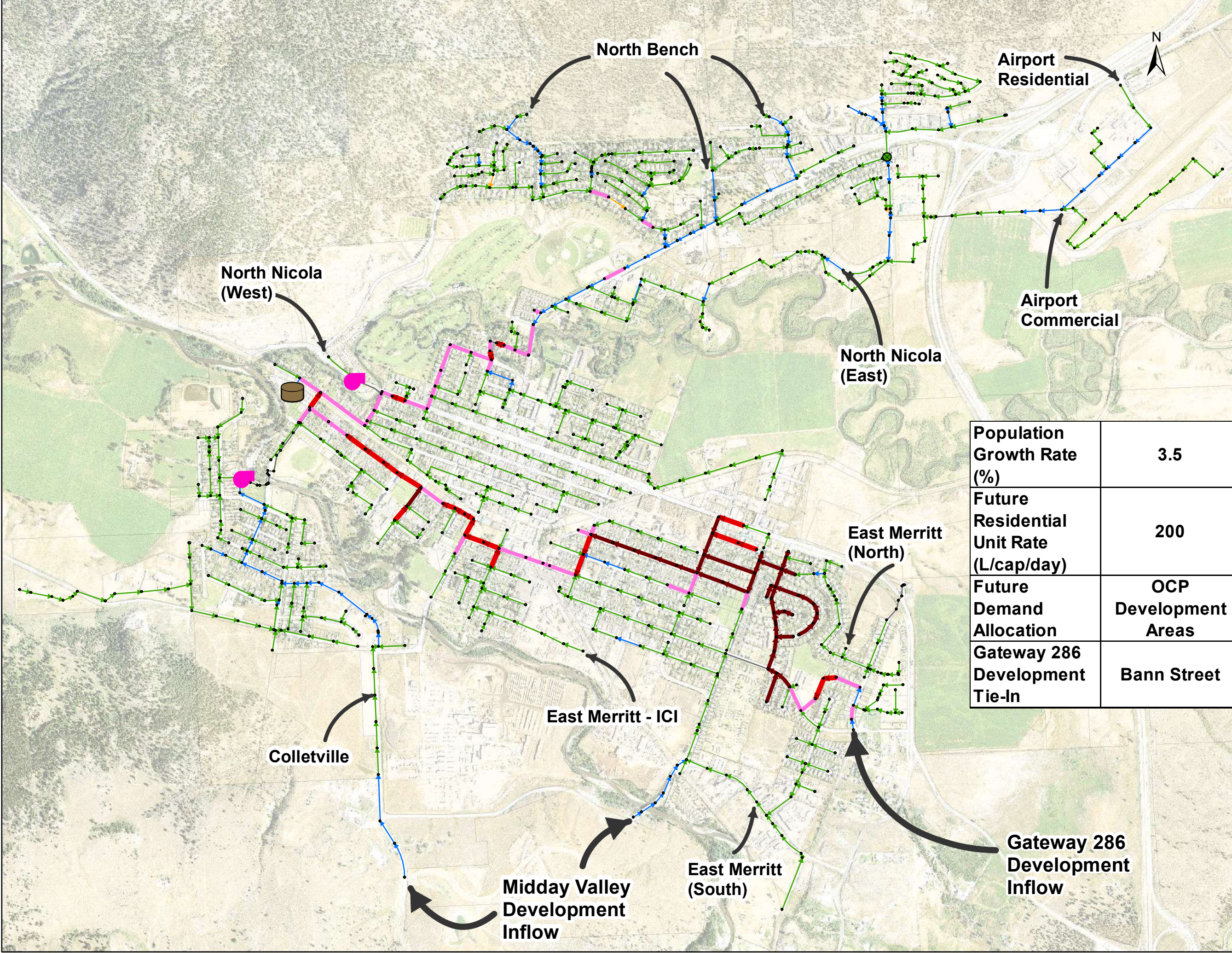
Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**  
2030 Scenario No. 6-A

Figure 4.11



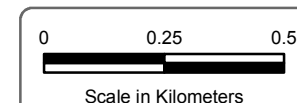


## Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole

## Gravity Main HLoS

-  Grade A
-  Grade B
-  Grade C
-  Grade D
-  Grade E
-  Grade F



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Excluded

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

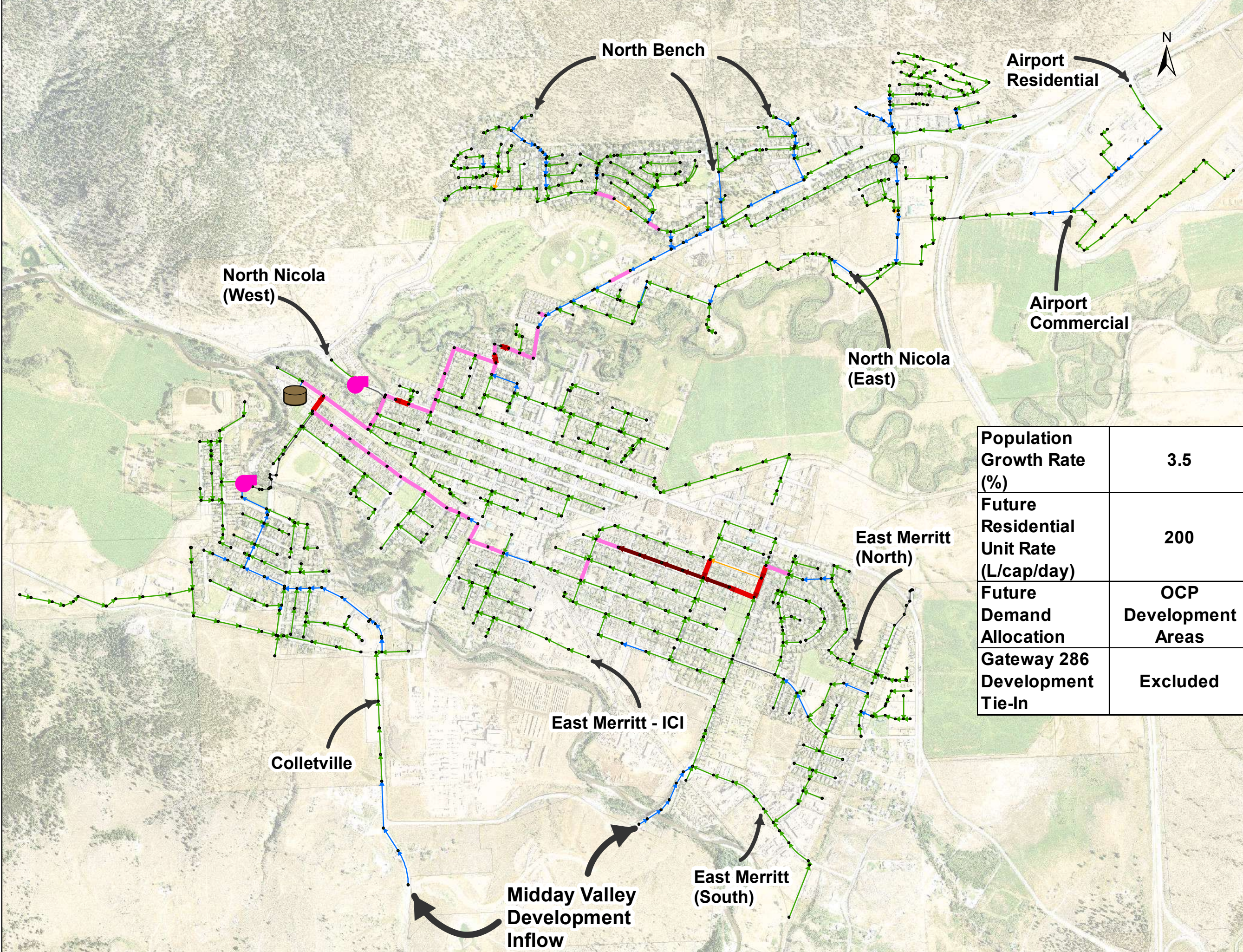
Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**

2030 Scenario No. 6-B

Figure 4.12



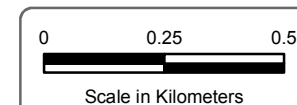


### Legend

- WWTP
- Pump
- Flow Split
- Manhole

### Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Douglas Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

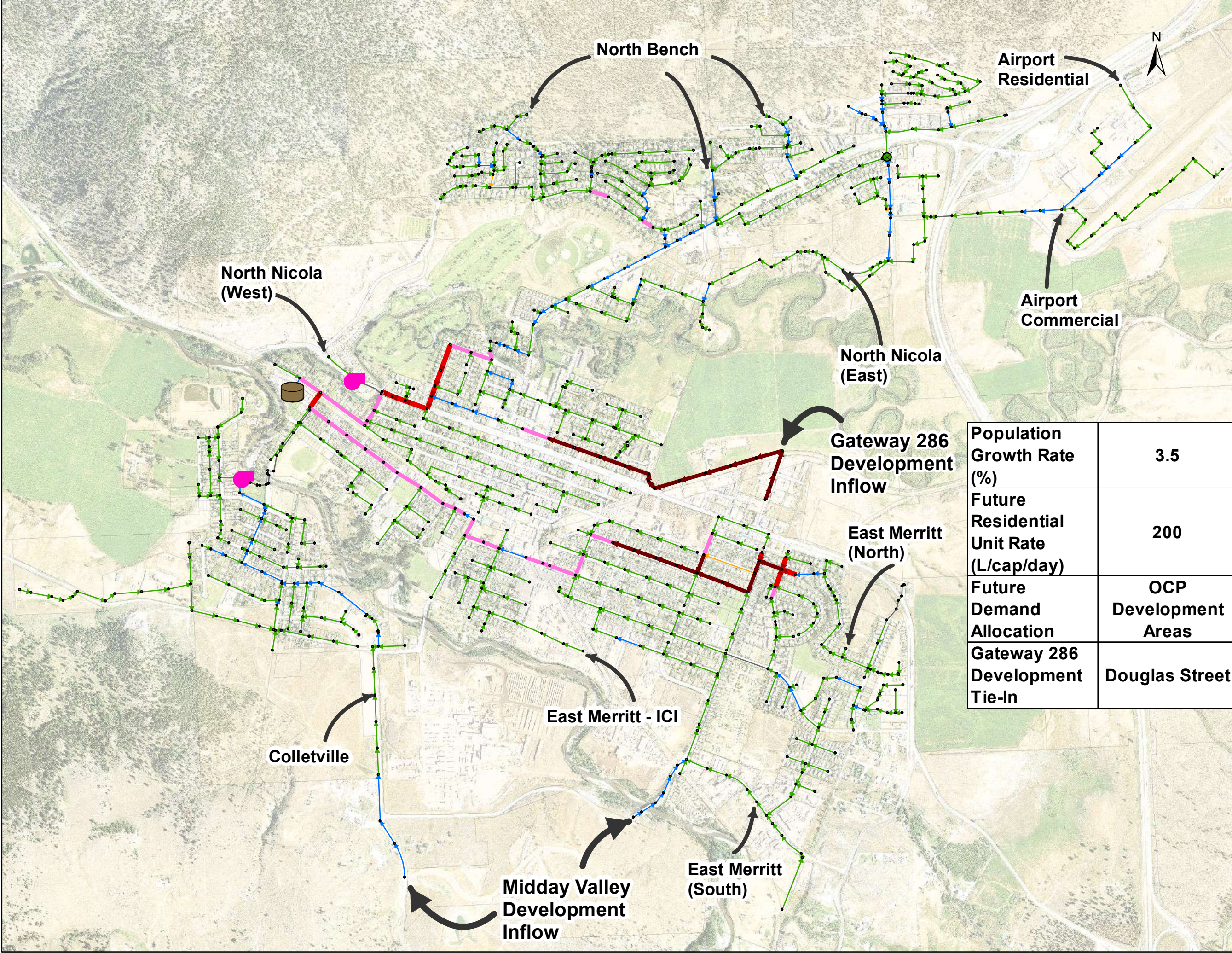
Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**

2030 Scenario No. 6-C

Figure 4.13



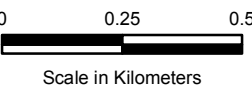


**Legend**

- WWTP
- Pump
- Flow Split
- Manhole

**Gravity Main HLoS**

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

**Gravity Main  
Hydraulic Level of Service**  
2030 Scenario No. 7

Figure 4.14

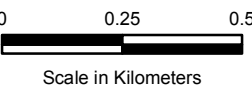


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main HLoS

- Grade A
- Grade B
- Grade C
- Grade D
- Grade E
- Grade F



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: September 2012

Client: City of Merritt, BC

Gravity Main  
Hydraulic Level of Service  
2030 Scenario No. 8

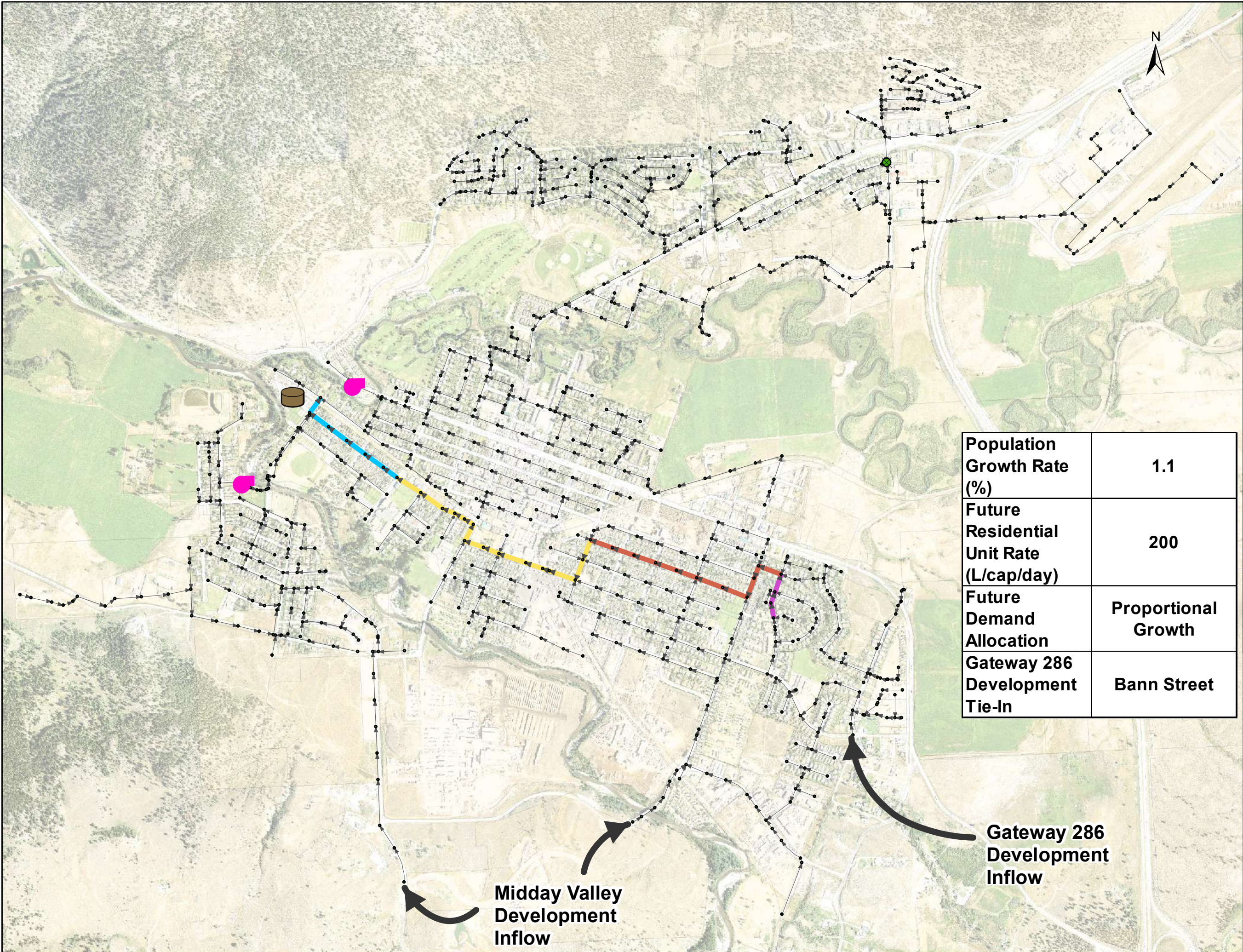
Figure 4.15





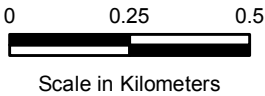
## **Appendix B – System Upgrades**





**Legend**

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)**
  - 250
  - 300
  - 350
  - 375
  - 450
  - 525
  - 600
  - 675
  - Existing Pipe



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street

Project Title: City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

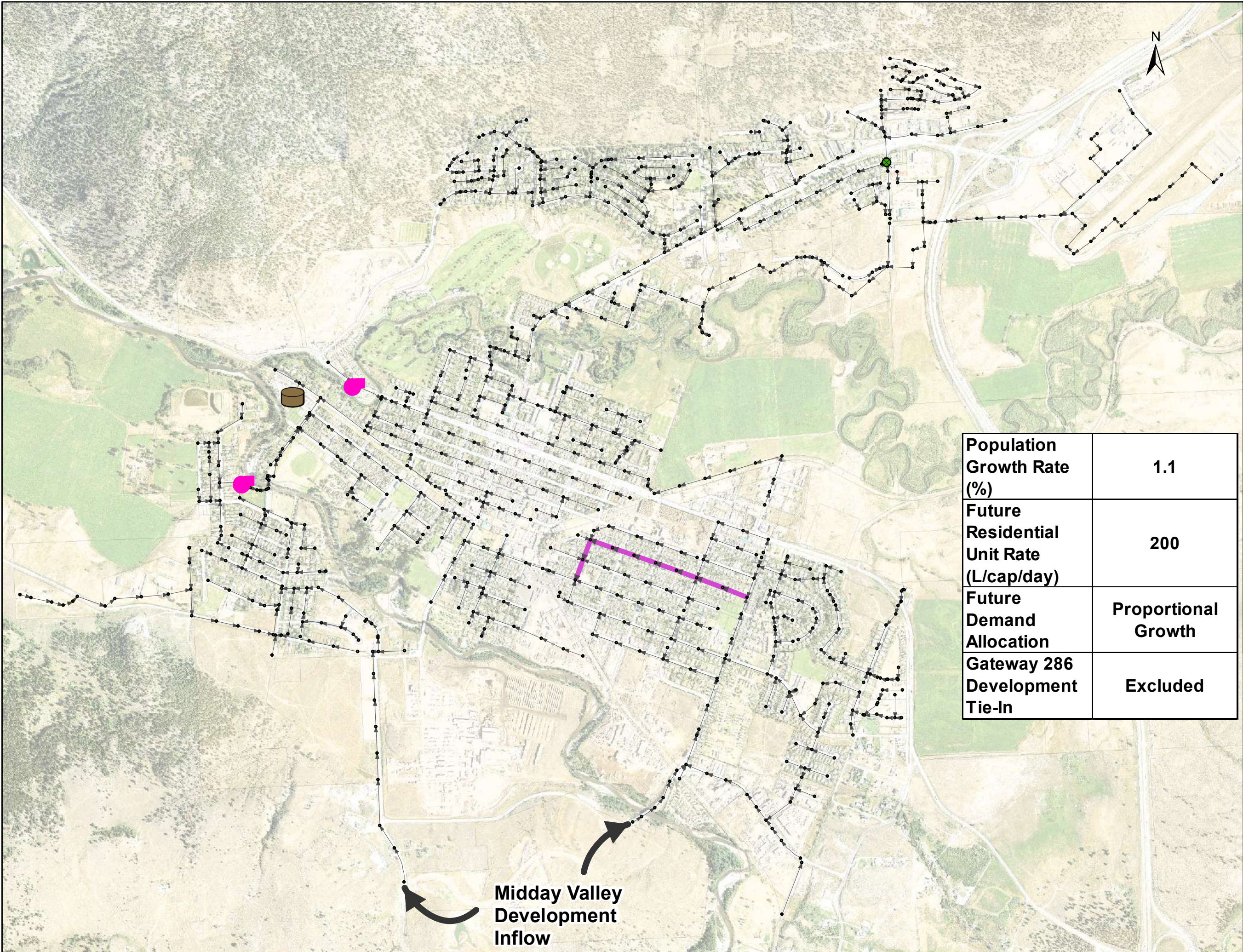
Client: City of Merritt, BC

**Recommended Gravity  
Main Upgrades**

2030 Scenario No. 1-A

Figure 4.16

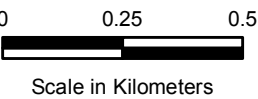




Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Excluded

**Legend**

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)**
  - 250
  - 300
  - 350
  - 375
  - 450
  - 525
  - 600
  - 675
  - Existing Pipe



Project Title: City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC

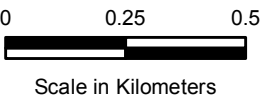
**Recommended Gravity Main Upgrades**  
2030 Scenario No. 1-B

Figure 4.17



Legend

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)**
- 250
- 300
- 350
- 375
- 450
- 525
- 600
- 675
- Existing Pipe



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC

**Recommended Gravity Main Upgrades**

2030 Scenario No. 2-A

Figure 4.18

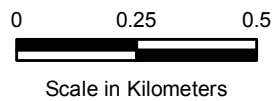


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main  
Diameter (mm)

- 250
- 300
- 350
- 375
- 450
- 525
- 600
- 675
- Existing Pipe



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Excluded

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC














**Recommended Gravity  
Main Upgrades**

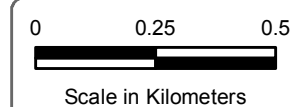
2030 Scenario No. 2-B

Figure 4.19



### Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole
- Gravity Main Diameter (mm)**
  -  250
  -  300
  -  350
  -  375
  -  450
  -  525
  -  600
  -  675
  -  Existing Pipe



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Douglas Street

Project Title: City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

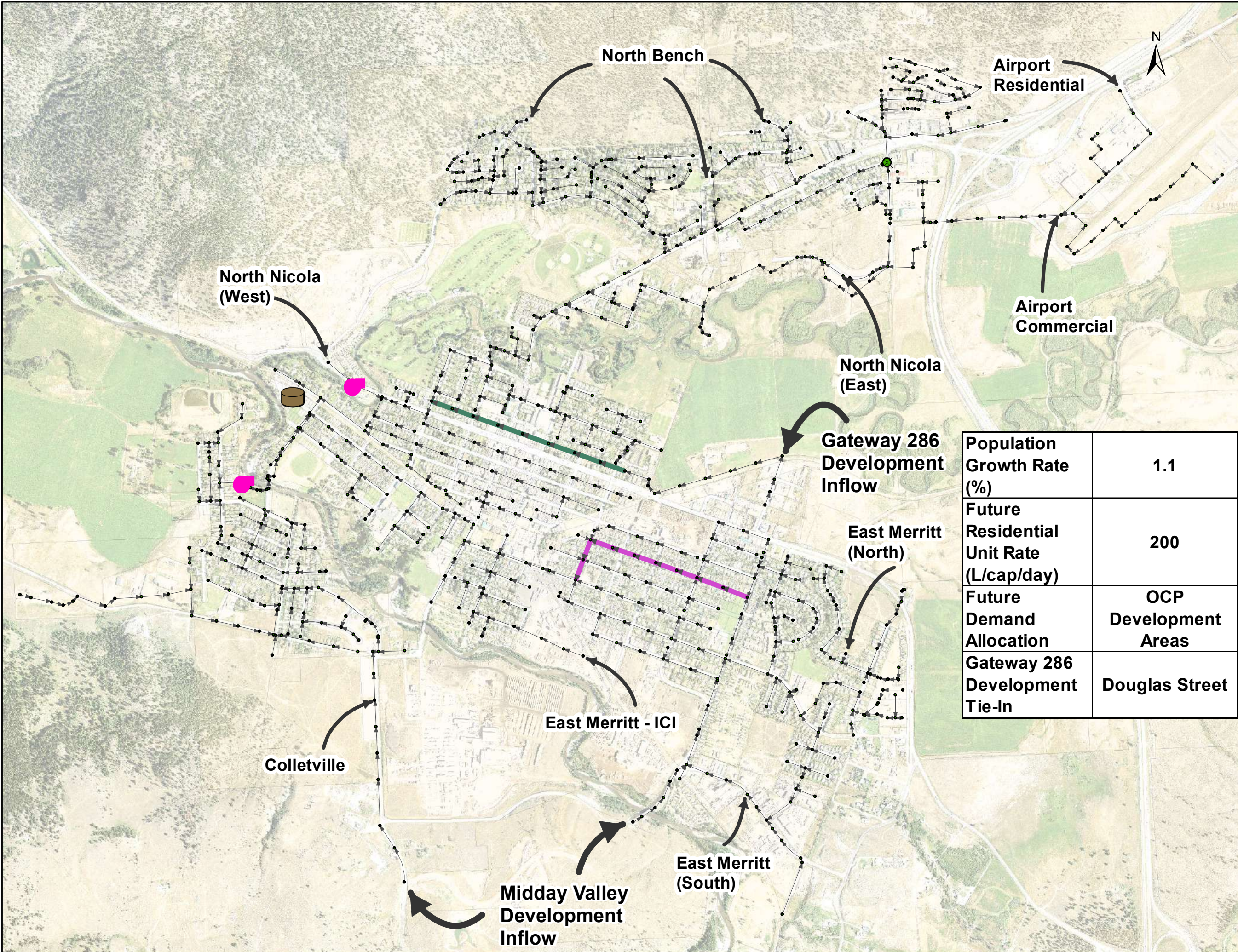
Date: April 20, 2012

Client: City of Merritt, BC

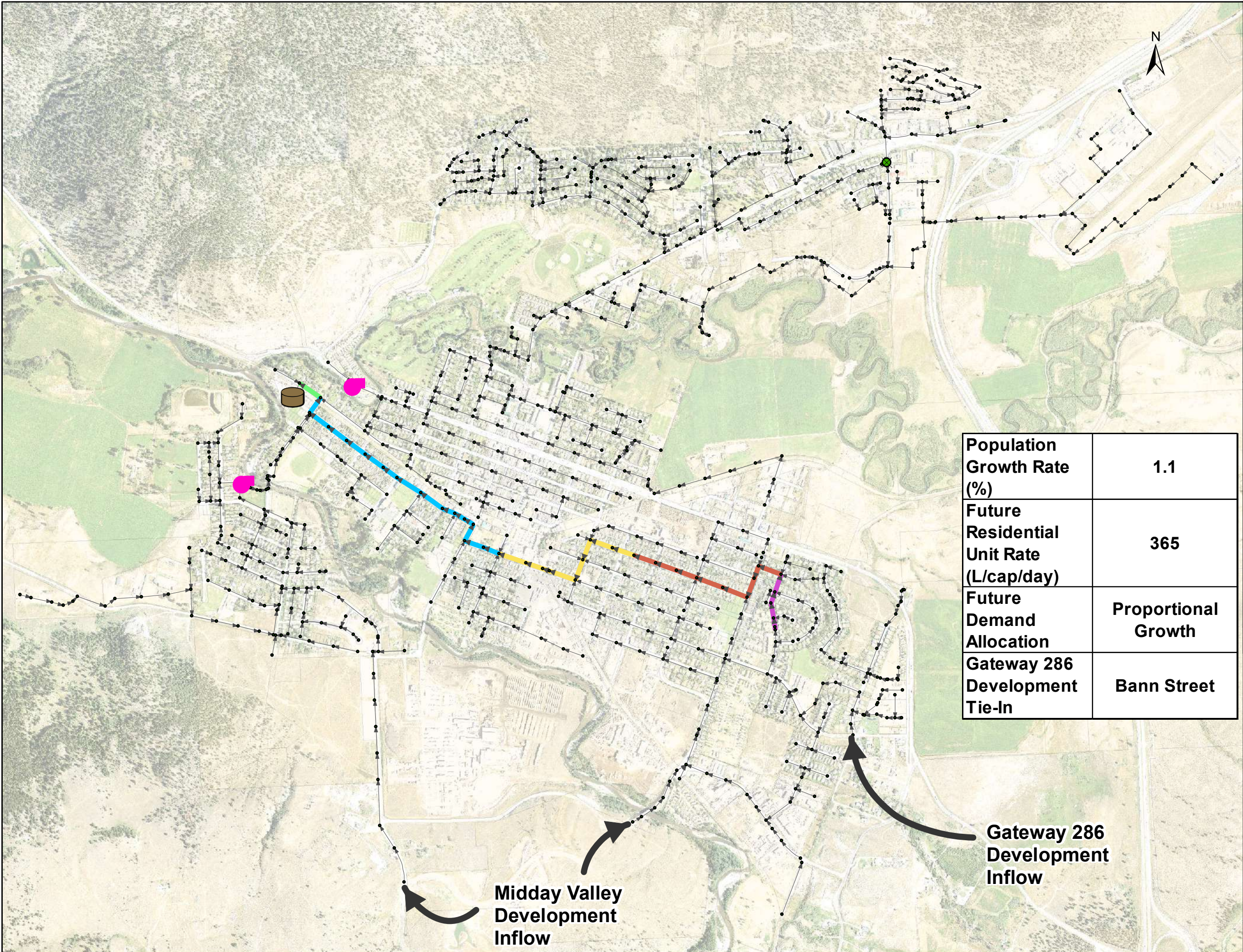
**Recommended Gravity Main Upgrades**

2030 Scenario No. 2-C

Figure 4.20



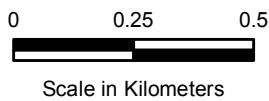




Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street

**Legend**

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)**
  - 250
  - 300
  - 350
  - 375
  - 450
  - 525
  - 600
  - 675
  - Existing Pipe



Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: **2011-026-MER**

Date: **April 20, 2012**

Client: **City of Merritt, BC**

**Recommended Gravity  
Main Upgrades**

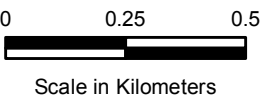
2030 Scenario No. 3

Figure 4.21



Legend

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)**
- 250
- 300
- 350
- 375
- 450
- 525
- 600
- 675
- Existing Pipe



Population Growth Rate (%)	1.1
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC

**Recommended Gravity Main Upgrades**

2030 Scenario No. 4

Figure 4.22

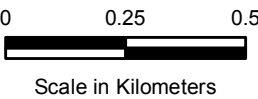


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main  
Diameter (mm)

- 250
- 300
- 350
- 375
- 450
- 525
- 600
- 675
- Existing Pipe



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

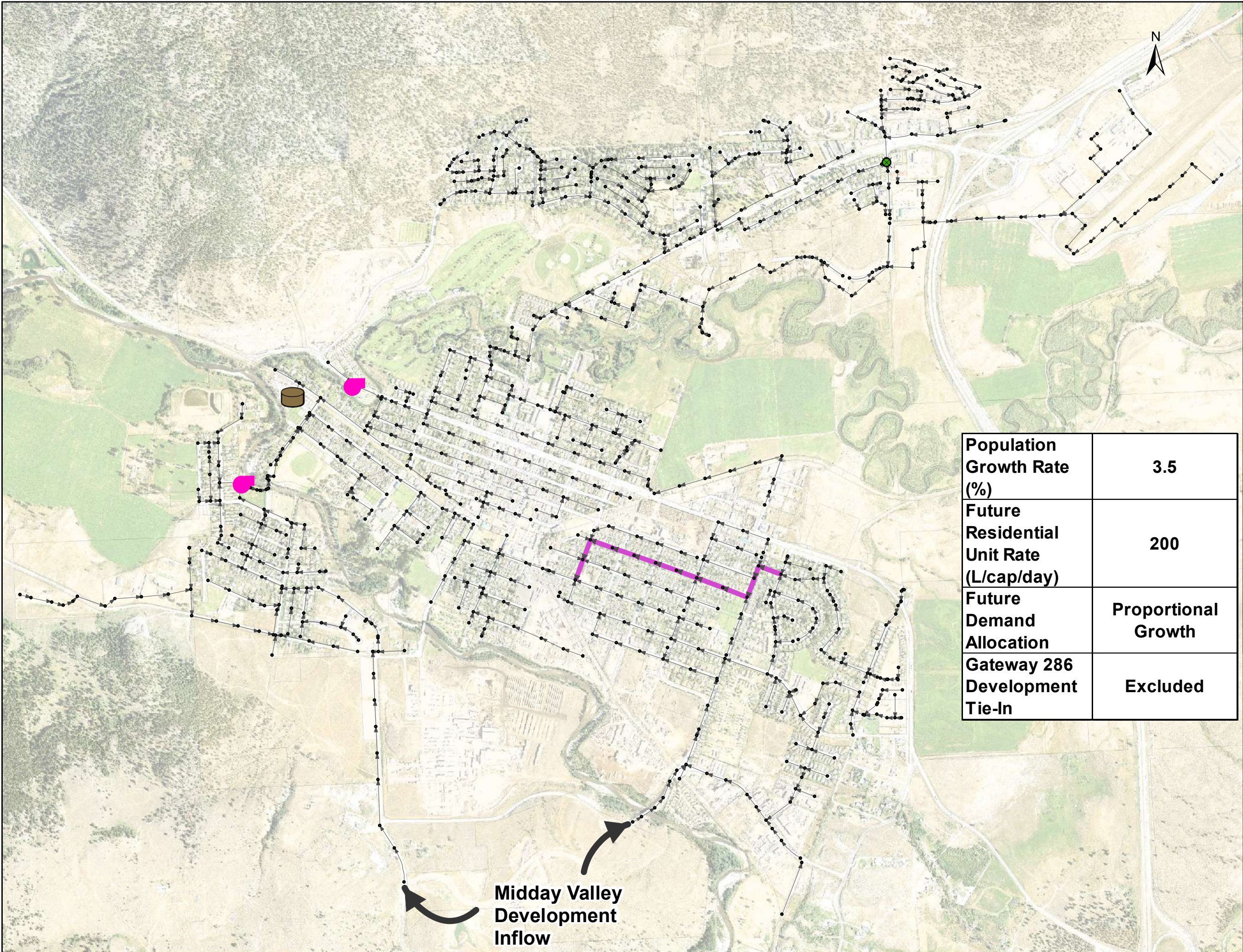
Client: City of Merritt, BC

Recommended Gravity  
Main Upgrades

2030 Scenario No. 5-A





Figure 4.23














Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Excluded

**Legend**

-  WWTP
-  Pump
-  Flow Split
-  Manhole

**Gravity Main Diameter (mm)**

-  250
-  300
-  350
-  375
-  450
-  525
-  600
-  675
-  Existing Pipe

00.250.5

Scale in Kilometers

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012














Client: City of Merritt, BC

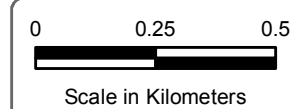
**Recommended Gravity Main Upgrades**  
2030 Scenario No. 5-B

Figure 4.24



### Legend

-  WWTP
-  Pump
-  Flow Split
-  Manhole
- Gravity Main Diameter (mm)**
-  250
-  300
-  350
-  375
-  450
-  525
-  600
-  675
-  Existing Pipe



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title: City of Merritt  
Sanitary Sewer Utility Master Plan

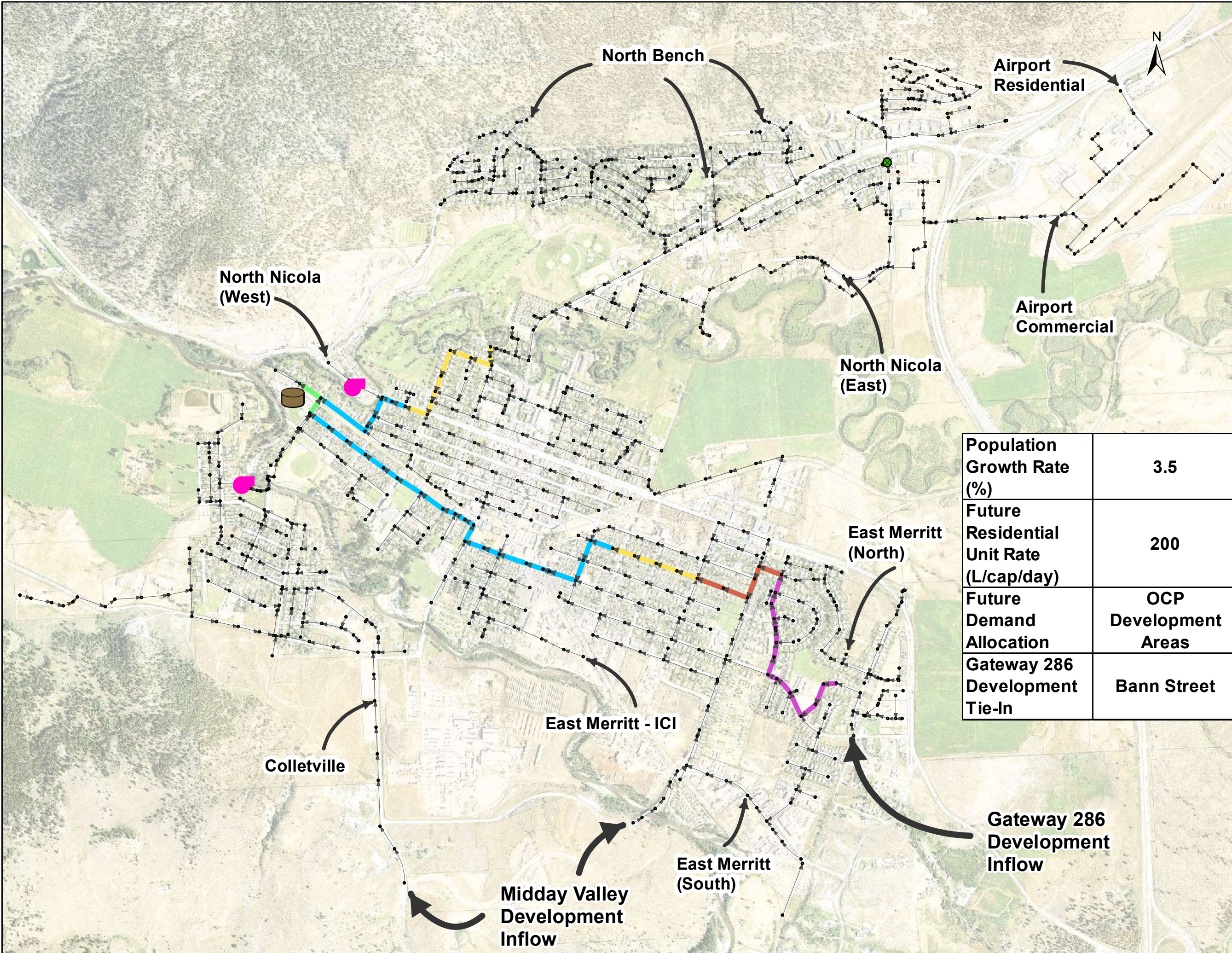
Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC

**Recommended Gravity Main Upgrades**  
2030 Scenario No. 6-A

Figure 4.25



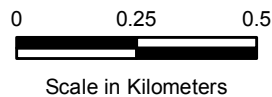


Legend

- WWTP
- Pump
- Flow Split
- Manhole

Gravity Main  
Diameter (mm)

- 250
- 300
- 350
- 375
- 450
- 525
- 600
- 675
- Existing Pipe



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Excluded

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC














Recommended Gravity  
Main Upgrades

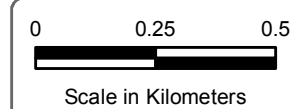
2030 Scenario No. 6-B

Figure 4.26



### Legend

-  WWTP
  -  Pump
  -  Flow Split
  -  Manhole
- Gravity Main Diameter (mm)**
-  250
  -  300
  -  350
  -  375
  -  450
  -  525
  -  600
  -  675
  -  Existing Pipe



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	200
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Douglas Street

Project Title: City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

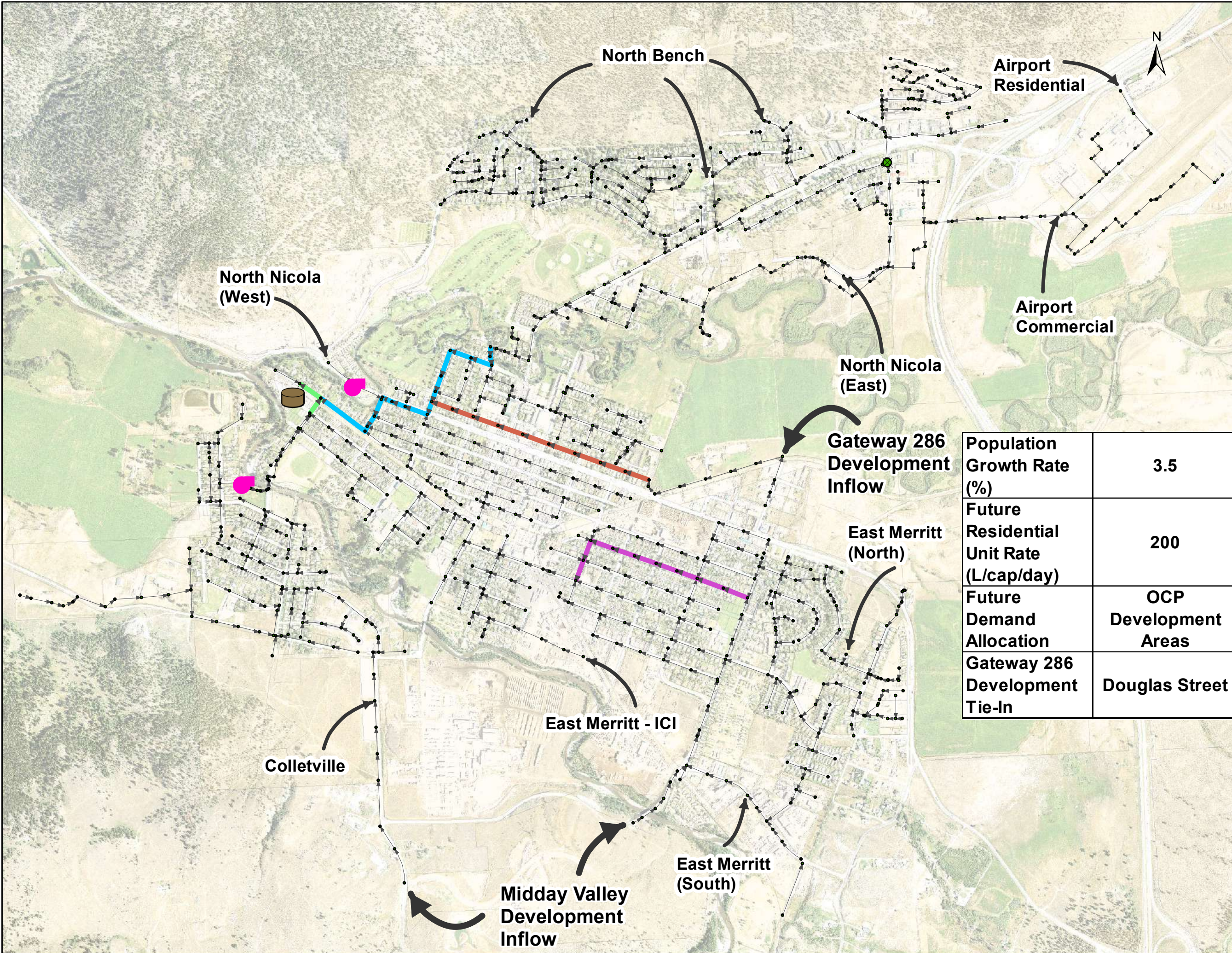
Date: April 20, 2012

Client: City of Merritt, BC

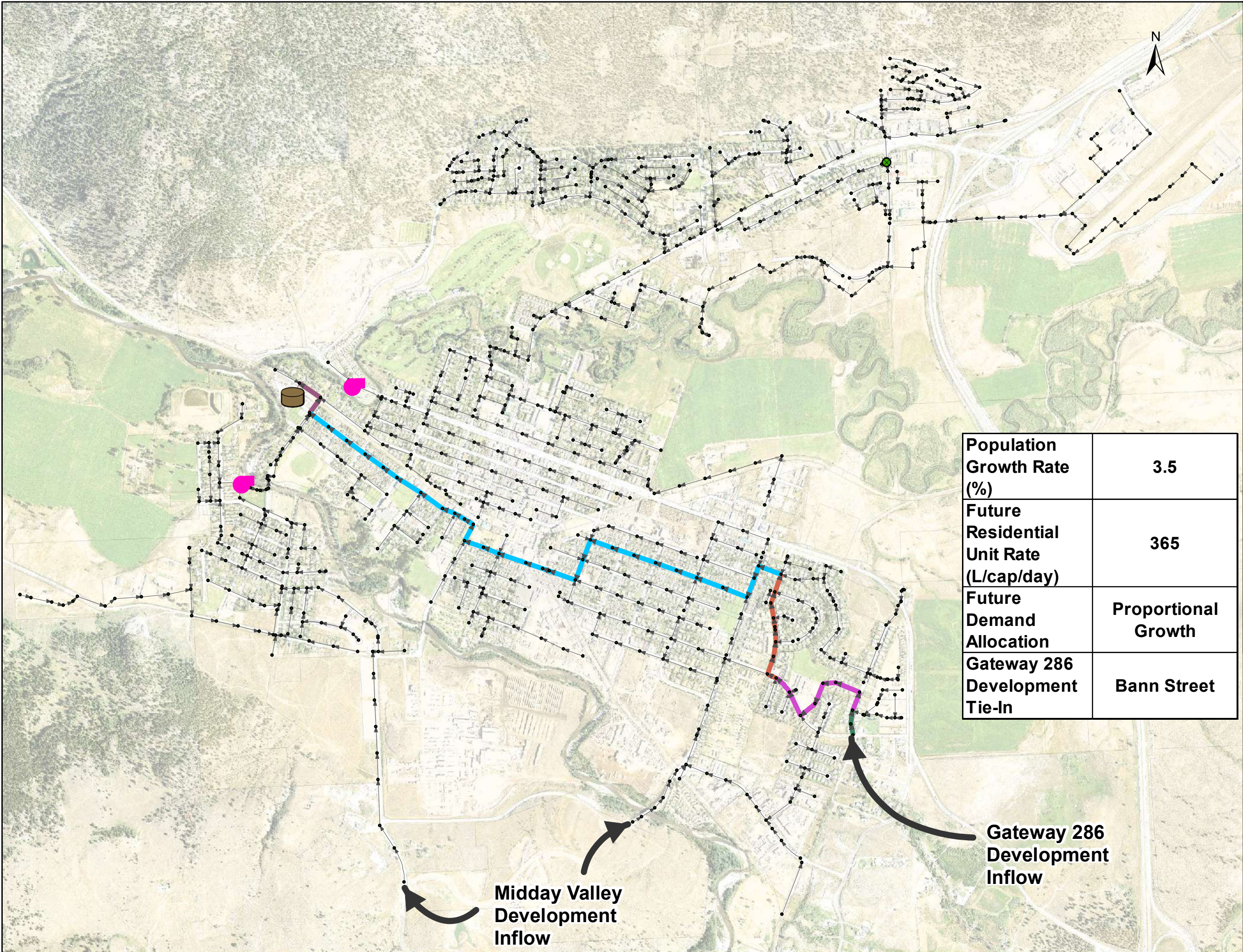
**Recommended Gravity Main Upgrades**

2030 Scenario No. 6-C

Figure 4.27







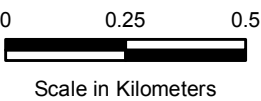
Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	Proportional Growth
Gateway 286 Development Tie-In	Bann Street



GeoAdvice Engineering Inc.

Legend

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)
  - 250
  - 300
  - 350
  - 375
  - 450
  - 525
  - 600
  - 675
- Existing Pipe



Project Title: City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC

Recommended Gravity Main Upgrades

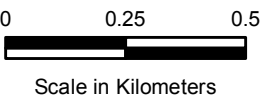
2030 Scenario No. 7

Figure 4.28



Legend

- WWTP
- Pump
- Flow Split
- Manhole
- Gravity Main Diameter (mm)**
- 250
- 300
- 350
- 375
- 450
- 525
- 600
- 675
- Existing Pipe



Population Growth Rate (%)	3.5
Future Residential Unit Rate (L/cap/day)	365
Future Demand Allocation	OCP Development Areas
Gateway 286 Development Tie-In	Bann Street

Project Title:  
City of Merritt  
Sanitary Sewer Utility Master Plan

Project ID: 2011-026-MER

Date: April 20, 2012

Client: City of Merritt, BC

**Recommended Gravity Main Upgrades**

2030 Scenario No. 8

Figure 4.29





# CITY OF MERRITT SANITARY SEWER COLLECTION SYSTEM FINANCIAL MODELING AND ANALYSIS

## TECHNICAL MEMORANDUM 4

**Prepared for:**

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**Contact:** Mr. Werner de Schaetzen, Ph.D., P.Eng.  
Re: Project 2011-026-MER

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# 1 Introduction

A financial model was developed to determine whether the existing utility rates are capable of providing sufficient funds for operation, maintenance, repair, rehabilitation and upgrading the City's sewerage system and to recommend new utility rates if the existing rates are insufficient. The financial model takes into account factors such as growth, financing interest and inflation rates, present reserve fund balances and timing of capital projects (DCC, Non-DCC and Asset Repair/Renewal).

The financial model is divided into four modules:

- **Revenue Module** – Identifies the various sources of revenue.
- **Operation & Maintenance Module** – Identifies the expenditures associated with operating and maintaining the City's sewerage system.
- **Capital Works Module** – Identifies the timing and cost of the various DCC, Non-DCC and Asset Repair/Renewal projects.
- **Cash Flow Module** – Incorporating the above three modules, the cash flow module determines the year-end balance of the various funds and reserves to assess the City's financial stability and the capability to operate, maintain, repair, rehabilitate and upgrade the sewerage system.

The financial model extends out to a 100 year horizon to assess long term viability, however, only the first 20 years should be closely reviewed. Identifying future infrastructure costs and developing appropriate utility rates will avoid unexpected future rate increases. The following sections provide additional details and outline the assumptions used in each module.





## 2 Financial Modules

### 2.1 Revenue Module

The Revenue Module outlines the various sources of revenue collected by the City from providing sewerage services. The 2007 to 2012 Sewer Operating Budgets and the 2011 Financial Statements provided by the City were used to determine the initial revenues, revenue growth rates and to define the various classifications of revenue as shown in **Table 2.1**.

**Table 2.1: Revenue Module – Initial Values**

Revenue Sources	2011 Revenue*	Growth Rate
Utility Revenue	\$ 811,379	Population Growth Rate + Inflation
Property Taxation		
Parcel Tax	\$ 947,330	Population Growth Rate + Inflation
NE Sector Specified Area	\$ 33,400	Constant
Collettville Specified Area	\$ 43,760	Constant
Connection Charges	\$ 1,500	Inflation
Rent-Compost Site	\$ 6,000	Inflation
Interest	\$ 2,500	Inflation
Other Revenues	\$ 1,000	Inflation

\*From 2011 Financial Statement/2012 Preliminary Budget

For each subsequent year, it is assumed that the Utility Revenue and Parcel Tax Revenues will increase at a growth rate equal to the population growth rate plus the inflation rate. NE Sector and Collettville Property Tax revenues will end in 2012 and 2016 respectively. It is assumed that increases in Connections Charges, Rent-Compost Site, Interest and Other Revenues will match inflation.





## 2.2 O&M Module

The Operation & Maintenance (O&M) Module outlines the various expenditures incurred through operating and maintaining the City's sewerage system. The 2007 to 2012 Sewer Operating Budgets provided by the City were used to determine the initial expenditures, expenditure growth rates and to define the various classifications of expenditures as shown in **Table 2.2**.

**Table 2.2: O&M Module – Initial Values**

Expenditure Source	2011 Expenditure*	Growth Rate
Administration	\$ 375,780	Population Growth Rate + Inflation
Utility Mapping	\$ 17,070	Population Growth Rate + Inflation
Treatment & Disposal	\$ 535,230	Population Growth Rate + Inflation
Lift Station Maintenance	\$ 10,150	Population Growth Rate + Inflation
Collection System Maintenance	\$ 94,480	Population Growth Rate + Inflation
Service Connections Maintenance	\$ 9,840	Population Growth Rate + Inflation

\*From 2012 Sewer Preliminary Budget

For each subsequent year, the expenditures are assumed to grow at the population growth rate plus the inflation rate.





## 2.3 Capital Works Module

The Capital Works Module outlines the timing and costs associated with proposed infrastructure improvements (DCC and non-DCC projects) and asset renewal and rehabilitation projects. Scenario 4-A from Technical Memorandum #3 was used to determine the required hydraulic capacity improvements as shown in **Table 2.3** below.

**Table 2.3: Proposed Improvements of Scenario 4-A**

Critical Section	Address	Project Trigger	Year	Cost
A	Coutlee Avenue and Blair Street	Existing Deficiency	2012	\$ 745,680
B	Coldwater Avenue and Vought Street	Servicing of Gateway 286 – All Scenarios	N/A	\$ 1,252,045
C	Menzies Street, Douglas Street and Granite Place	Servicing of Gateway 286 – All Scenarios	N/A	\$ 365,946
E	Main Street and Quilchena Avenue	Servicing of Gateway 286 – 3.5% Growth and/or 365 L/cap/day	N/A	\$ 194,175

### 2.3.1 Capital Works Projects

The cost and timing of the proposed non-DCC capital works identified during the hydraulic capacity modeling analysis are summarized in the following table.

**Table 2.4: Non-DCC Infrastructure Improvements Timing and Costs**

Critical Section	Year	Cost (2012 \$)
A	2012	\$ 745,680

### 2.3.2 DCC Projects

Critical Sections B, C and E are triggered by the Gateway 286 development and can be considered DCC projects. The City of Merritt's 5-year capital plan identifies two additional DCC projects ("Reconfigure Rapid Infiltration Basin" and "Aeration Basin #3"). These additional projects were included in the financial model. The cost and timing of proposed DCC projects is summarized in **Table 2.5**.



**Table 2.5: DCC Infrastructure Improvements Timing and Costs**

DCC Projects	Year	Cost (2012 \$)	% Attributable to Growth
Critical Section B	2015*	\$ 1,252,045	100 %
Critical Section C	2015*	\$ 365,946	100 %
Critical Section E	2015*	\$ 194,175	100 %
Reconfigure Rapid Infiltration Basin	2016	\$ 420,000	40 %
Aeration Basin #3	2016	\$ 1,800,000	100 %

\*Assumed 2015

In the financial model, DCC revenue was assigned for the year in which the DCC project is to be undertaken. The DCC revenue is dependent on the percent attributable to growth. For example, “Reconfigure Rapid Infiltration Basin” is 40 % attributable to new growth, therefore 40 % of the cost will be funded by the developer and DCC revenue of \$168,000 (\$ 420,000 x 40 %) was assigned to 2016.

### 2.3.3 Asset Renewal Projects

An asset renewal program identifying the timing and cost of replacing pipes, manholes, cleanouts and inspection chambers was developed based on the current age and life span of the assets. Sewer mains and manholes are assumed to have a useful life of 75 years. Inspection chambers and cleanouts are assumed to have a useful life of 60 years. The replacement costs for sewer mains, manholes, cleanouts and inspection chambers are shown in the table below as provided by the City.

**Table 2.6: Sewer Asset Replacement Costs**

Asset Type	Cost (2012 \$)
Sewer Mains: 50 – 100 mm	\$ 200/m
Sewer Mains: 150 – 200 mm	\$ 250/m
Sewer Mains: 250 – 300 mm	\$ 300/m
Sewer Mains: 350 – 400 mm	\$ 325/m
Sewer Mains: 450 – 600 mm	\$ 350/m
Sewer Manholes	\$ 3,500/each
Inspection Chamber	\$ 1,590/each
Cleanout	\$ 1,590/each





**Table 2.7** and **Table 2.8** summarize the cost and timing of the asset renewal program.

**Table 2.7: Pipe Renewal and Rehabilitation Costs**

Year	Pipe Length (km)	# Pipes	Cost (2012 \$)
2037	1,407	12	\$ 381,996
2038	40,027	539	\$ 10,276,840
2039	4,028	54	\$ 996,288
2068	240	2	\$ 59,968
2069	3,579	42	\$ 1,028,668
2070	5,940	90	\$ 1,519,212
2071	2,149	36	\$ 542,355
2072	393	7	\$ 98,149
2079	144	3	\$ 40,431
2081	963	15	\$ 287,582
2082	943	15	\$ 250,042
2084	130	1	\$ 16,900
2085	259	2	\$ 34,200

**Table 2.8: Manhole, Cleanout and Inspection Chamber Renewal and Rehabilitation Costs**

Year	Cleanout	Inspection Chamber	Manhole
2023	\$ 750,480	\$ 260,760	-
2038	-	-	\$ 2,261,000
2068	-	-	\$ 3,500
2071	-	-	\$ 49,000
2072	-	-	\$ 10,500

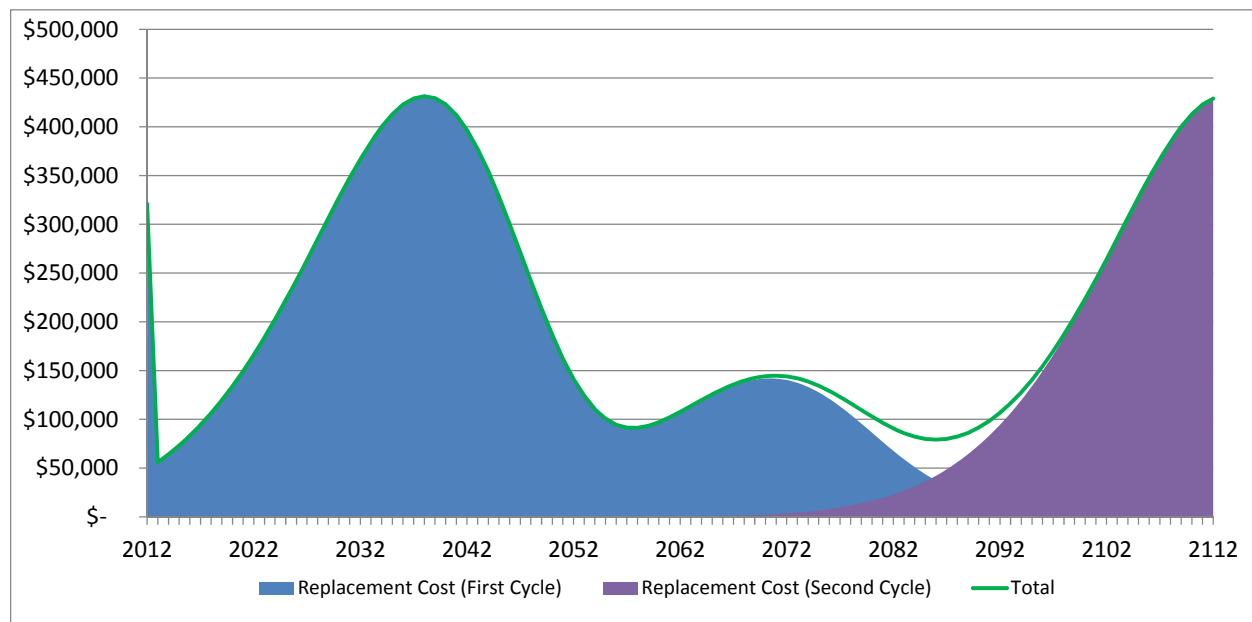
As a vast majority (40.0 km/60.2 km = 66 %) of the sewer mains have an installation year of 1964 with a life-span of 75 years, in reality some assets will fail before their useful life-span and some will fail after. The failure of assets generally follows a statistical pattern that can be approximated with the Weibull function. A Weibull Distribution was used to determine the asset failure instead of assuming a constant life-span of 75 years.





The Weibull Distribution assumes that the likelihood of failure increases over time. Two cycles were used to assess the impact of the asset renewal costs. Assuming a useful life-span of 60 years (inspection and cleanouts) and 75 years (service mains and manholes), assets may be replaced twice within the 100 year timeframe. The second cycle applies to assets that are replaced a second time within the 100 year timeframe. The following graph illustrates the Weibull Distribution applied to the sewer main renewal program. Proposed sewer mains for DCC projects have been excluded from the sewer main replacement program.

**Figure 2.1: Sewer Main Anticipated Replacement Cost**



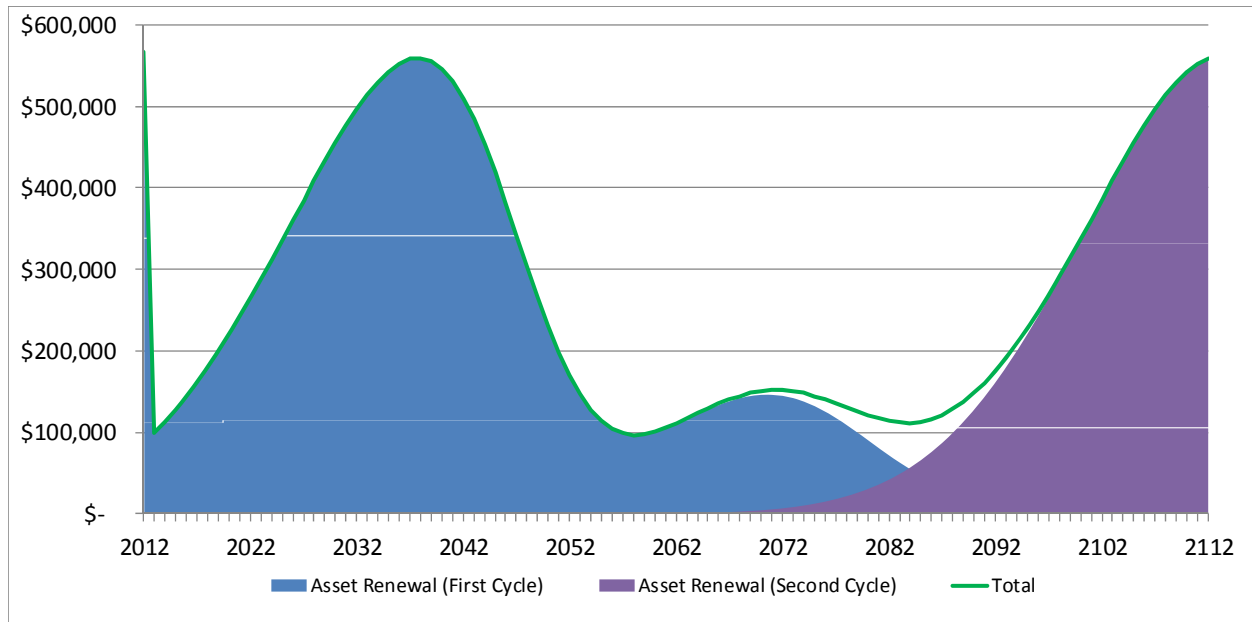
It is apparent from the above figure that the sewer main replacement cost is concentrated around 2038 with a peak investment of approximately \$425,000 required in 2038. Additionally, the portion of the Weibull distribution that is before 2012 has been accumulated and applied as an existing cost. This assumes that the current system likely has sewer mains that have failed (i.e. cracked pipes) but are not significantly impacting the system conveyance capacity.

The total anticipated replacement costs for the asset renewal program using the Weibull Distribution is shown in **Figure 2.2**.





**Figure 2.2: Asset Renewal Anticipated Replacement Cost**







## 2.4 Cash Flow Module

As the cost of capital works varies each year, it is important to assess the different funds and reserves to ensure enough capital is available to undertake these projects. Incorporating the data from the Revenue, O&M and Capital Works modules, a surplus (or deficit) is calculated for each fund/reserve. The year-end balance of each fund/reserve is calculated to assess the City's financial stability of operating and maintaining the sewerage system.

The following funds and reserves are considered in the cash flow module:

- DCC Reserves
- Future Capital Expenditures Reserve

Additionally, the Cash Flow Module integrates the current debt balance and the issuance of possible future debt. Existing debt is expected to be paid off by 2016. The 2012 balance for the funds/reserves and debt was provided by the City and is shown in the table below.

**Table 2.9: Fund, Reserves and Debt Balances – Initial Values**

Funds, Reserves and Debt	2011 Year-End Balances
DCC Reserves	\$ 1,447,679
Future Capital Expenditures Reserves	\$ 366,805
Debt	\$ 147,464





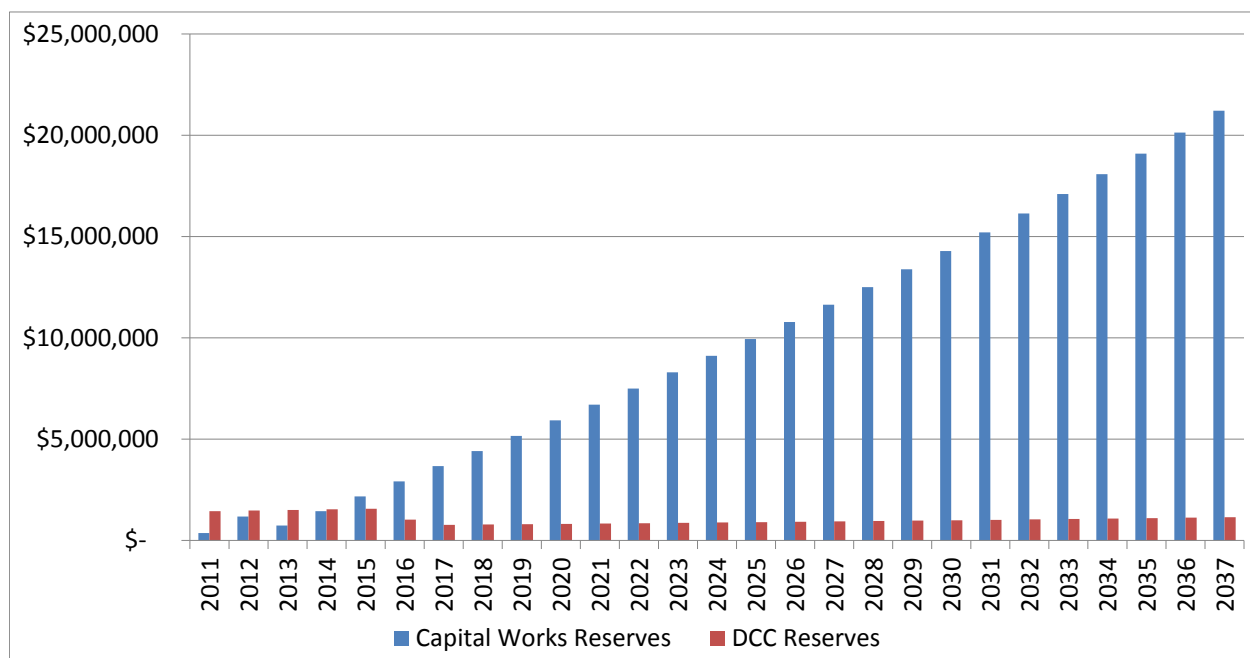
### 3 Financial Analysis and Recommended Sewer Utility Rates

The main purpose of developing the financial model is to establish reasonable sewer utility rates that will ensure the City's long term financial stability to operate, maintain, renew and upgrade its sewerage system.

The recommendation of existing and future sewer utility rates is highly sensitive to timing of projects. Timing of when projects are implemented has a significant impact on the financial bottom line. To keep the sewer utility rates at the most effective levels, timing must be set out so that there is minimal financing and good foresight in planning and implementation of projects.

To determine whether the existing utility rates are sufficient, the Capital Works and DCC Reserves were assessed.

**Figure 3.1: Capital Works and DCC Reserves**



Given the assumptions made and at the current utility rates, the sewer system will be adequately funded over the next 25 years with Capital Works Reserves and DCC Reserves of approximately \$ 21,000,000 and \$ 1,000,000 respectively in 2037.

It is recommended that the City reviews and updates the Financial Model every 5 years.



# **Modeling Best Practices, Standards, Conventions, and Flags for the City of Merritt Sanitary Sewer Models**

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**Fist Issue Date:** December 2, 2011

**Revised Issue Date:** September 20<sup>th</sup>, 2012

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Mr. Tom Barnard, Ph.D., P.E.

Mr. Jonathan Hung, E.I.T.

Mr. Deng-Ke Fan, E.I.T.

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## 1 INTRODUCTION

This document was compiled by GeoAdvice Engineering Inc. to establish new modeling rules to observe when building, analyzing or updating the City of Merritt InfoSWMM (Innovyze) models. The standards, conventions and checks outlined herein provide a framework for the correct execution of modeling tasks to ensure conformity, accuracy and confidence in the City InfoSWMM models (irrespective of the modeler).

Throughout this document there are a number of key points emphasized in each section. They are prefixed by (Geo) Rule or (Geo) Advice according to their level of importance, and are both **bold and underlined** so as not to be missed.

**(Geo)Rules denote standards and conventions to be used with all City of Merritt InfoSWMM models, and are immutable unless first discussed with the City of Merritt.**

**(Geo)Advice highlights information useful to the modeler and techniques which are recommended, however not mandatory.**

This document is intended to provide experienced modelers with standards and conventions for sanitary sewer collection system model development, calibration and maintenance. This document is not a replacement for modeling software user guides or comprehensive training programs. As such, it is directed towards people already experienced with InfoSWMM.

A reference InfoSWMM model accompanies this document which contains proper modeling and naming conventions as presented in this document.

### **Background**

The City of Merritt is responsible for the design, operation and maintenance of the sewer collection system that collects and conveys sanitary loads to the waste water treatment plant. In performing its mission the City contracts with consultants to construct numerical models that simulate the hydraulic processes that control the movement of sanitary sewers through the City. These models are used to analyze the hydraulic performance of the collection system and to design upgrades to existing facilities and new infrastructure. As part of long term planning studies, models are also used to evaluate alternative designs and management strategies.



## 2 RULES FOR USING THE CITY OF MERRITT INFOSWMM MODELS

Before proceeding to work on any existing Merritt InfoSWMM model several rules exist designed to preserve the integrity and accuracy of the model that all modelers must heed.

**(Geo)Rule 1 - The coordinate system used for the model is UTM NAD 83 Zone 10.**

**(Geo)Rule 2 - All elevations are measured using the geodetic datum.**

**(Geo)Rule 3 - The unit system used in the City's model must be SI Metric as in Table 2.1.**

**Table 2.1: InfoSWMM Units of Measurement**

Parameter	SI Metric
Loading	LPS (liters / sec)
Diameter (Pipes)	millimeters
Diameter (Wetwells)	meters
Depth	meters
Area	square meters
Elevation/Invert	meters
Flow	LPS (liters / sec)
Head	meters
Length	meters
Velocity	meters / second
Volume	cubic meters
Manning's N	dimensionless
Water Age	hours

**(Geo)Advice 1 - No modifications should be made to the existing elements unless the change is specified in the City GIS or by the City staff.**

This includes:

- Modeling parameters (hydraulic parameters such as diameter, roughness, length, material, etc.)
- Information parameters (description, year installed, elevation, etc.)
- Spatial information (nodes are not to be moved/changing pipe connectivity or redrawing are not allowed)

**(Geo)Advice 2 - It is not recommended to insert nodes into an existing pipe.**

This can create confusion because the insertion of a new node into an existing pipe will split the pipe into two new pipe segments, one that retains the previous pipe information and the other that is assigned a new modeling ID.



## 2.1 Naming Convention for Existing Elements

**(Geo)Advice 3 - The InfoSWMM element ID is limited to 32 characters in length (the space character is not allowed).**

**(Geo)Rule 4 - Existing element IDs are composed of an element type prefix and a location identifier for facilities (wet well, pump, etc.) or a unique numerical identifier for conduits and junctions separated by a dash.**

Table 2.2 lists the recommended element prefix IDs.

**Table 2.2: Element Prefix IDs**

Element Prefix	Description
JCT-	Junction
MHL-	Manhole
CDT-	Conduit
GMN-	Gravity Main
FMN-	Force Main
PMP-	Pump
STU-	Storage Unit
WWL-	Wet Well
DIV-	Divider
OUT-	Outfall

**Ex)** The model ID for an existing conduit/pipe could appear as: CDT-503040

The model ID for an existing wet well in Millstone could appear as: WWL-MILLSTONE

## 2.2 Naming Convention for New Elements

Proposed elements are frequently appended to an existing model to evaluate the behavior of a sewer collection system under future conditions.

**(Geo)Rule 5 - The model ID for proposed elements is composed of an element type prefix, a prefix “P-” (Proposed) and a location identifier for facilities (wet well and pump) or a unique numerical identifier for conduits and junctions.**

**Ex)** The model ID for a proposed gravity main could appear as: GMN-P-000001

The model ID for a proposed wet well in Millstone could appear as: WWL-P-MILLSTONE

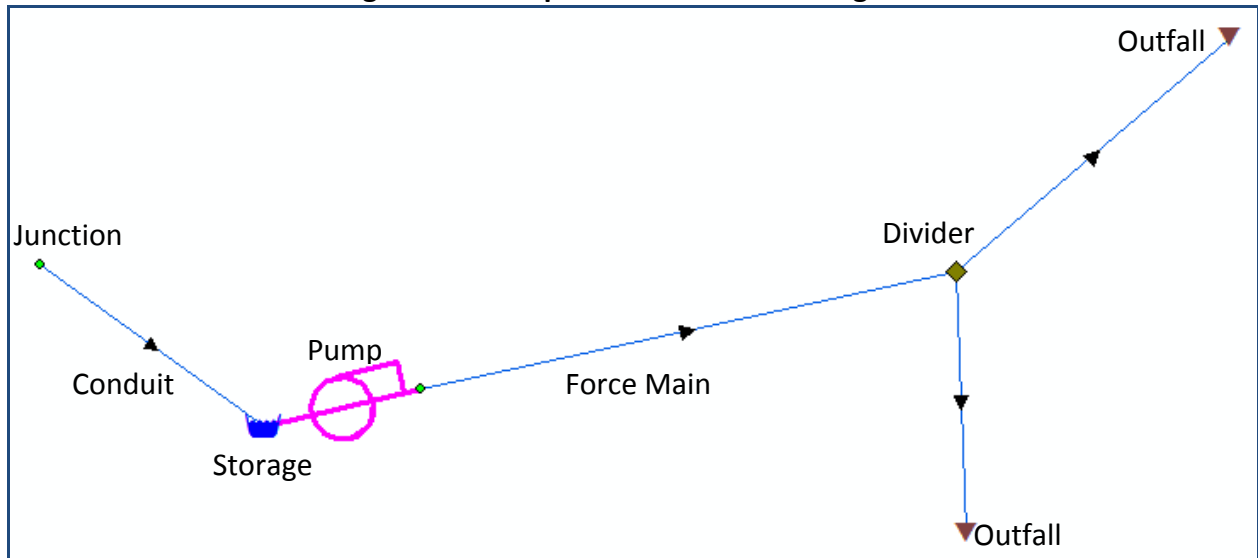


### 3 PHYSICAL DATA

The following physical elements are modeled in InfoSWMM:

- **Junctions** represent nodes in the collection system where conduits are joined together.
- **Conduits** are pipes (gravity and force mains) or channels that move water from one node to another in a collection system.
- **Storage units** are wet well nodes that provide storage volume.
- **Pumps** are links used to lift water to higher elevations.
- **Outfalls** are terminal nodes of the collection system.
- **Flow Dividers** are nodes that divert inflows to a specific conduit in a prescribed manner.

**Figure 3.1: Sample Model Network Diagram**



#### 3.1 Junction Nodes

Junctions represent manholes in a sewer system, or pipe connection fittings. External inflows can enter the system at junctions. Excess water at a junction can become partially pressurized while connecting conduits are surcharged and can either be lost from the system or be allowed to pond atop the junction and subsequently drain back into the junction.



The principal input parameters for a junction are:

- Invert elevation
- Maximum depth (ground level to invert)
- Ponded area when flooded (optional)
- External inflow data (optional)

The following are standards for creating junction data:

- Junction description in an InfoSWMM model is optional.
- The ground elevation (e.g. the ground level of the junction) is optional.
- Locked manhole covers should be identified in the system and correctly modeled (refer to **Section 4.4**).

**(Geo)Advice 4 - Known surcharge locations, pipe splits and diversions etc. should be reviewed in the field.**

**(Geo)Advice 5 - The actual diameter of the manhole should be supplied through the City GIS database and if not available use a default diameter of 1.05m which corresponds to a surface area of 0.866m<sup>2</sup> (refer to Section 5.1.3).**

**(Geo)Advice 6 - Manhole ground elevations should be supplied through the City GIS database and if not available by interpolating from ground elevation contours or DEM.**

**(Geo)Advice 7 - The use of dummy junctions should be avoided wherever possible.**

## **3.2 Conduits**

The principal input parameters for a conduit data are:

- Upstream and downstream node IDs
- Conduit diameter
- Offset heights of the conduit above the upstream and downstream node inverts
- Conduit length
- Manning's or Hazen Williams roughness coefficient
- Cross-sectional geometry
- Entry/exit loss coefficient



The following are standards for creating conduit data:

- Conduit lengths should be imported from GIS and validated using the conduit length calculator in the model. If the lengths are not available in GIS, the lengths should be calculated in the model.
- Conduit description in an InfoSWMM model is optional.
- City GIS conduit ID is to be used.

**(Geo)Advice 8 - The Manning equation is employed for gravity mains while the Hazen-Williams equation is used for force mains.**

**(Geo)Advice 9 - Nominal pipe diameters to be used for gravity and force mains.**

**(Geo)Advice 10 - In InfoSWMM, user can add identical parallel pipes by setting the number of barrels in the Attribute Browser as shown in Figure 3.2.**

**Figure 3.2: Attribute Browser**

<input checked="" type="checkbox"/> Modeling	
Length (m)	200.000
Manning's N	0.0110
Upstream Offset (m)	0.000
Downstream Offset (m)	0.000
Initial Flow (lps)	
Entry Loss Coeff.	
Exit Loss Coeff.	
Average Loss Coeff.	
Flap Gate Installed	No
Shape	0: Circular
Diameter (mm)	250.000
Number of Barrels	2
Transect	
Max. Flow (lps)	
Shape Curve	

It is imperative to model pipe connectivity and direction accurately to ensure that modeled flows match the routing of actual flows. This is especially important around hydraulic facilities (pump stations, storage units, etc.) as well as bifurcations and temporary storages.

**(Geo)Advice 11 - Connectivity around all facilities should be manually checked against GIS and available drawings.**



Conduit sizes should remain largely unchanged during the entire modeling process. Exceptions to this could include:

- Obvious data entry error
- Additional surveys highlighting different values
- Calibration techniques to replicate restrictions

**(Geo)Rule 6 - If the City GIS supplies pipe material and/or roughness values these must be input into the model.**

**(Geo)Advice 12 - If only the pipe material is supplied then Table 3.1 should be used to generate appropriate roughness coefficients.**

**Table 3.1: Typical Pipe Roughness Coefficients**

Pipe Material	Age	Force Main Hazen Williams	Gravity Main Manning
Asbestos Cement	> 30 Years	130	0.015
	< 30 Years	140	0.011
Brass	> 30 Years	130	0.013
	< 30 Years	140	0.009
Ductile Iron	> 30 Years	130	0.015
	< 30 Years	140	0.012
Concrete	> 30 Years	120	0.017
	< 30 Years	140	0.012
Copper	> 30 Years	130	0.015
	< 30 Years	140	0.011
Steel	> 30 Years	110	0.019
	< 30 Years	150	0.010
Plastic	> 30 Years	140	0.015
	< 30 Years	150	0.009
Vitrified Clay Pipe	> 30 Years	110	0.017
	< 30 Years	140	0.011
Wood Stave	> 30 Years	115	0.014
	< 30 Years	125	0.010

Manning's roughness coefficient depends on type and condition of the conduit and changes considerably with age, diameter, material, soil type, and water quality characteristics.

**(Geo)Advice 13 - There will be areas where inverts will obviously be incorrect for whatever reason. These values should be 'cleaned up' and appropriately flagged to the City.**



### **3.3 Storage Unit Data**

Storage units are used by InfoSWMM to model the wet wells within a lift station. The volumetric properties of a storage unit are described by a function or a table of surface area versus height.

The principal input parameters for a storage unit data are:

- Invert elevation
- Maximum depth (ground level to invert)
- Depth-surface area data
- Ponded area when flooded (optional)
- External inflow data (optional)

The following are standards for creating storage unit data:

- Storage elevations should be derived from record drawings or GPS surveys.
- Wet well shapes are typically cylindrical or rectangular.
- If a storage unit has an irregular shape, a Depth vs. Surface Area curve should be used.

### **3.4 Pump Data**

The principal input parameters for a pump data are:

- Upstream and downstream node IDs
- Pump curve ID
- Selection of an ideal or non-ideal pump
- Startup and shutdown depth settings



The following are standards for creating pump data:

- Pump elevations should be derived from record drawings or GPS surveys and should reflect the actual elevation of the pump, not the ground surface elevation.
- Pumps should be represented by manufacturer's pump curves and verified with field data.
- Composite pump curves may be used to represent multiple pumps operating at the same station.
- Pumps with missing curve or test data may be represented by a design point.
- Time-based pump controls may only be used when trying to duplicate actual conditions in a system, such as during calibration.
- Pumps are represented as links in the InfoSWMM model.

**(Geo)Advice 14 - Minor losses should not be neglected at pump stations with higher velocities and many fittings and is modeled using the conduit entry and loss coefficients in InfoSWMM.**

**(Geo)Advice 15 - Centerline elevation of the pump should be used to define the pump elevation parameter.**

**(Geo)Advice 16 - Pumps should be tested after a certain period of time to indicate if its curve (flow vs. head) still agrees with the manufacturer's pump curve.**

**(Geo)Advice 17 - The pump station design documents and operation logs should be reviewed. Pump curve, wet well invert, volume, drawings, and start stop levels must be used in the model.**

**(Geo)Advice 18 - The default pump speed setting is one (pump speed ratio of 1). Select a pump and click the pump efficiency icon  to change the speed ratio.**

Pump curve describes the relation between a pump's flow rate and conditions at its inlet and outlet nodes. Four different types of pump curves are supported in InfoSWMM:

1. An off-line pump with a wet well where flow increases incrementally with available wet well volume.
2. An in-line pump where flow increases incrementally with inlet node depth.
3. An in-line pump where flow varies continuously with head difference between the inlet and outlet nodes.
4. A variable speed in-line pump where flow varies continuously with inlet node depth.



### 3.5 Outfall Nodes

Outfalls are used to define the final downstream boundaries in the model. Only one link can be incident on an outfall node.

The principal input parameters for outfalls include:

- Invert elevation
- Boundary condition type and stage description
- Presence of a flap gate to prevent back flow through the outfall

InfoSWMM allows six options of outfall types:

- **Free:** outfall stage determined by minimum of critical flow depth and normal flow depth in the connecting conduit.
- **Normal:** outfall stage based on normal flow depth in connecting conduit
- **Fixed:** outfall stage set to a fixed value
- **Tidal:** outfall stage given by a table of tide elevation versus time of day
- **Time series:** outfall stage supplied from a time series of elevations
- **Stage-flow:** The stage-flow curve would enable the user to define flow through the outfalls as a function of stage (head) at the outfall.

**(Geo)Advice 19 - There should be at least one outfall node in the model.**

**(Geo)Advice 20 - In the event of missing information, free discharge should be assumed at the outfalls.**

### 3.6 Flow Divider Nodes

A flow divider is used to model pipe splits in the City's sewer system. It can have no more than two conduit links on its discharge side. There are four types of flow dividers, defined by the manner in which inflows are diverted:

1. **Cutoff Divider:** diverts all inflow above a defined cutoff value.
2. **Overflow Divider:** diverts all inflow above the flow capacity of the non-diverted conduit.
3. **Tabular Divider:** uses a table that expresses diverted flow as a function of total inflow.
4. **Weir Divider:** uses a weir equation to compute diverted flow.

**(Geo)Advice 21 - Flow divider data should be manually field verified.**



**(Geo)Advice 22 - No more than two links can leave a flow divider in InfoSWMM.**

**(Geo)Advice 23 - The modeler should not 'force fit' the flow volumes within flow splits.**



## 4 NON-PHYSICAL DATA

InfoSWMM employs informational objects to describe the operational behavior of a sewer collection system. The informational objects such as loads, curves, patterns, and controls are described in this section.

### 4.1 Dry Weather Flow

Dry Weather Flows (DWF) are composed of base sanitary flows (BSF) and Ground Water Infiltration (GWI). BSF are flows generated from domestic and industrial sources and are population-based. GWI results from the movement of ground water in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table.

**(Geo)Rule 7 - The base sanitary loading rate is assumed to be 200 L/d/cap.**

### 4.2 Wet Weather Flow

Wet Weather Flows (WWF) are all sanitary flow contributions made during a wet weather. Wet weather flows are composed of Dry Weather Flows (Base Sanitary Flow + GWI) and Rainfall Dependent Inflow and Infiltration (RDI&I).

Refer to **Section 4.5** for more standards on Inflow and Infiltration (I&I).

### 4.3 Catchment Areas

**(Geo)Advice 24 - For calculating the I&I unit rates in L/d/ha (GWI and RDI&I), use the catchment contributing area instead of the total catchment area. The contributing area should only consist of land that generates flow to the sewer collection system.**

**(Geo)Advice 25 - Future total catchment areas should be determined using elevation contours which show all lands that can drain into the sewer collection system.**

### 4.4 Manhole Sealing

Manhole sealing is a description of the manhole cover type. It can be locked or unlocked depending on its design. In InfoSWMM, this physical property can be modeled using the Surchage Depth field. If the manhole is unlocked, set the Surchage Depth to zero (0) and this will allow flooding. If the manhole is locked, set the Surchage Depth to a positive value as shown in **Table 4.1** and this will prevent flooding and keep the pipe under pressure. However, there will still be flooding if the water surface elevation reaches the sum of maximum depth and surcharge depth.



**Figure 4.1: Surcharge Depth**

<input checked="" type="checkbox"/> Modeling	
Invert Elevation (m)	115.000
Max Depth (m)	2.000
Initial Depth (m)	
Surcharge Depth (m)	1.300
Ponded Area (m2)	
Flood Type	0: None
Flood Discharge Coeffici	


**(Geo)Advice 26 - If the manhole cover is completely sealed, set Surcharge Depth to a dummy value of 999m.**

**(Geo)Advice 27 - The default manhole Surcharge Depth should be set to “0” as most of the City’s manholes are unlocked and not sealed.**

#### **4.5 Inflow/Infiltration (GWI + RDI&I)**

Inflow and Infiltration (I&I) loads are area-based loads representing the additional loading on the sanitary sewer system during dry and wet weather. I&I consist of the combined flows from Ground Water Infiltration (GWI) and Rainfall Dependent Inflow and Infiltration (RDI&I).

RDI&I is the entry of extraneous water into the sewer system indirectly through the ground. Typically, the soil must be completely saturated in order for RDI&I to occur. This usually happens during consecutive rainfall events (e.g. after 100 mm of rainfall).

For the City of Merritt’s InfoSWMM model, GWI is modeled as external inflow to a junction and RDI&I is modeled using the RDI&I module shown below. Select a junction and click the ‘Inflow’ icon  in the InfoSWMM **Attribute Browser** to bring up the **Node Inflow Editor** as shown in **Figure 4.2**.



**Figure 4.2: Node Inflow Editor**

Node Inflow Editor - MH444 (NOT DEFINED)

**External** Dry Weather **RDII**

Constituent: FLOW

Baseline:

Baseline Pattern:

Time Series:

Scale Factor: 1.0

Inflow Type: CONCEN

Pollutant Mass Conversion Factor:

Inflow = (Baseline Value \* Baseline Pattern) + (Time Series Value \* Scale Factor)

If Baseline or Time Series is left blank its value is 0. If Baseline Pattern is left blank its value is 1.0

Erase Create Cancel

**(Geo)Advice 28 - RDI&I is combined with GWI to form a constant inflow and infiltration rate which is then assigned to the manholes in InfoSWMM.**

**(Geo)Advice 29 - The I&I rates are applied to the model based on the following City standards:**

- Peak inflow and infiltration (I&I) for existing infrastructure shall be calculated based on a minimum rate of 10,520 litres per hectare of design tributary area per day, or at rates set by the City of Merritt for the general tributary area, for I&I from a 1:5 year, 24 hour storm.
- Peak inflow and infiltration (I&I) for the design of new infrastructure shall be calculated based on a minimum rate of 14,150 litres per hectare of design tributary area per day, or at rates set by the City of Merritt for the general tributary area, for I&I from a 1:25 year, 24 hour storm.



## 4.6 Control Data and Settings

InfoSWMM provides operational control schemes to accurately simulate the hydraulic behavior of a sewer collection system. During an extended period simulation (EPS), controls specify the status or settings of selected pumps as a function multiple attributes as illustrated in **Section 4.6.1**.

### 4.6.1 Operational Control

Operational controls change the status or setting of a pump based on:

- The node depth
- The node head
- The node inflow
- The link flow
- The link depth
- The pump status (ON or OFF)
- The pump flow
- The simulation time
- The simulation date/time

The operational controls in InfoSWMM only allows simple controls, meaning only simple operational control strategies, those that can be specified in terms of single operational condition, are allowed. An example would be “Turn off the pump if the wet well depth becomes less than 2m”, this is captured in **Figure 4.3**.



**Figure 4.3: Simple Control**

**Simple Control Data - PMP-MILLSTONE, Millstone Wet Well**

Control Rules


Disable	Status/Setting	Condition	Priority
No	Closed	if Node WwL-MILLSTONE Depth < 2	1

Replace Insert Delete Clear

Rule Property

Rule Priority: 1 ☐ Disable the Current Rule During Simulation


Status


Status 

☒ Closed ☐ Open

Erase

Control By

Type: Node Depth 

Control Node: WwL-MILLSTONE 

Value

Operator: <

Node Depth: 2

Update Cancel

(Geo)Advice 30 - The default startup and shutdown node depth can be set in the pump's attribute browser.

(Geo)Advice 31 - It is important to set the Rule Priority for each rule so as to keep track of what rules are used during simulations.

## 4.7 Pattern and Curve Data

(Geo)Advice 32 - Pattern and curve descriptions should include the pattern/curve type as well as the units of the data.

### 4.7.1 Time Pattern

Time patterns describe how a quantity (e.g. inflow) changes with time (e.g. hourly). They can be used to model Dry Weather Flow (DWF) in InfoSWMM simulation runs, allowing it to vary in a periodic fashion. They consist of a set of adjustment factors applied as multipliers to a baseline DWF flow rate. If the duration of a pattern is less than the total duration of the simulation, the pattern will repeat itself and wrap around to its first period again.



**(Geo)Advice 33 - InfoSWMM only allows stepwise patterns.**

A stepwise pattern is one that assumes a constant multiplication factor for each pattern time period. Within each time period a quantity remains at a constant level equal to the product of its nominal value and the pattern's multiplier for that time period. The different pattern types are shown in **Table 4.1**.

**Table 4.1: Time Pattern Types**

Pattern Types	X-Y Axis	Unit (SI)
Load	Time - Load Factor	hr - (/)
Variable Pump Speed	Time - Speed Setting	hr - (/)

**(Geo)Advice 34 - In Time Patterns, the X axis always represents the time.****(Geo)Advice 35 - Table 4.2 lists the suggested Pattern prefix definitions.****Table 4.2: Recommended Pattern Prefix Definitions**

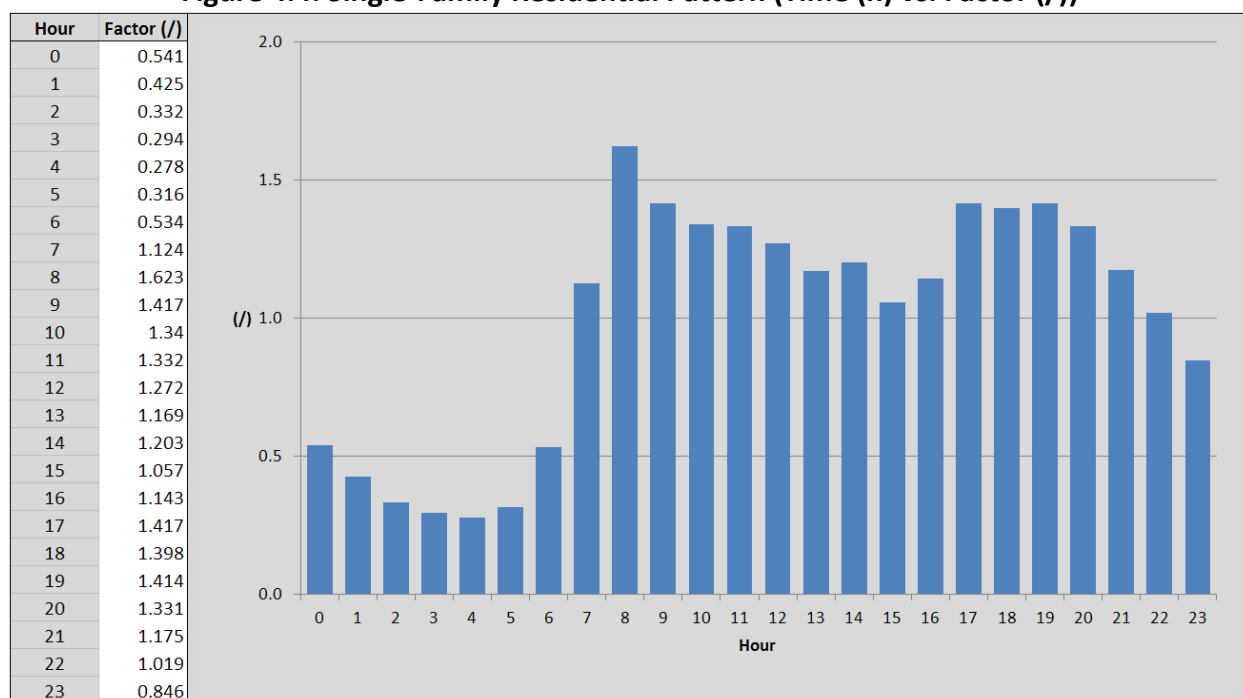
Prefix	Element	Pattern Types
LDG-	Manhole	Manhole Load Pattern
SPD-	Pump	Variable Pump Speed Setting Pattern

Different patterns can be applied to individual manholes or groups of manholes to accurately represent actual loading categories (e.g. low density residential, commercial, and industrial).

**(Geo)Advice 36 - Use the following diurnal patterns (Figure 4.4 to Figure 4.8) if none is available.**

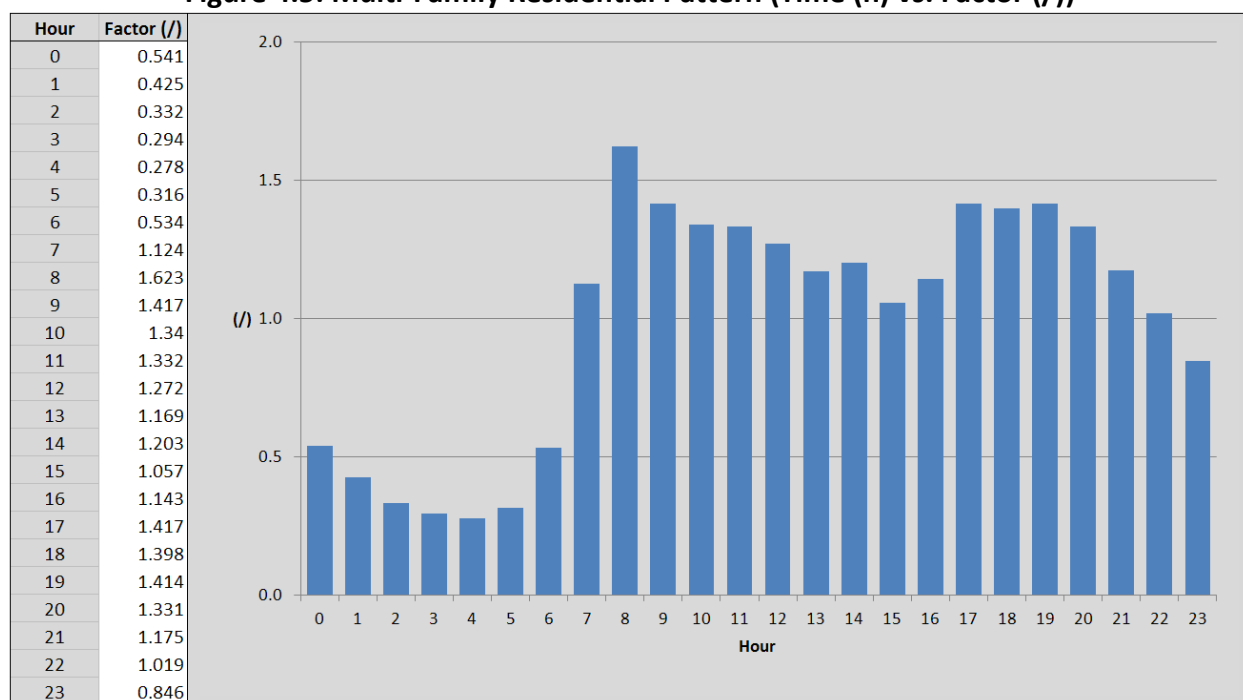


**Figure 4.4: Single-Family Residential Pattern (Time (h) vs. Factor (/))**



Source: City of Nanaimo

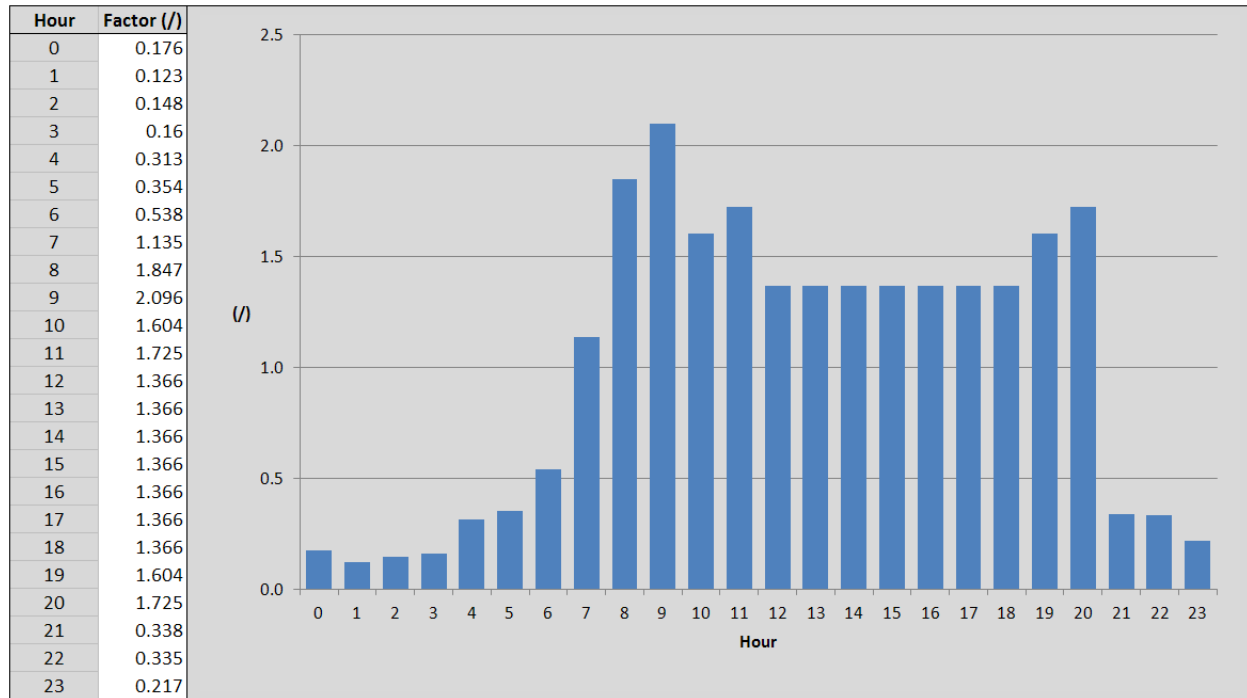
**Figure 4.5: Multi-Family Residential Pattern (Time (h) vs. Factor (/))**



Source: City of Nanaimo

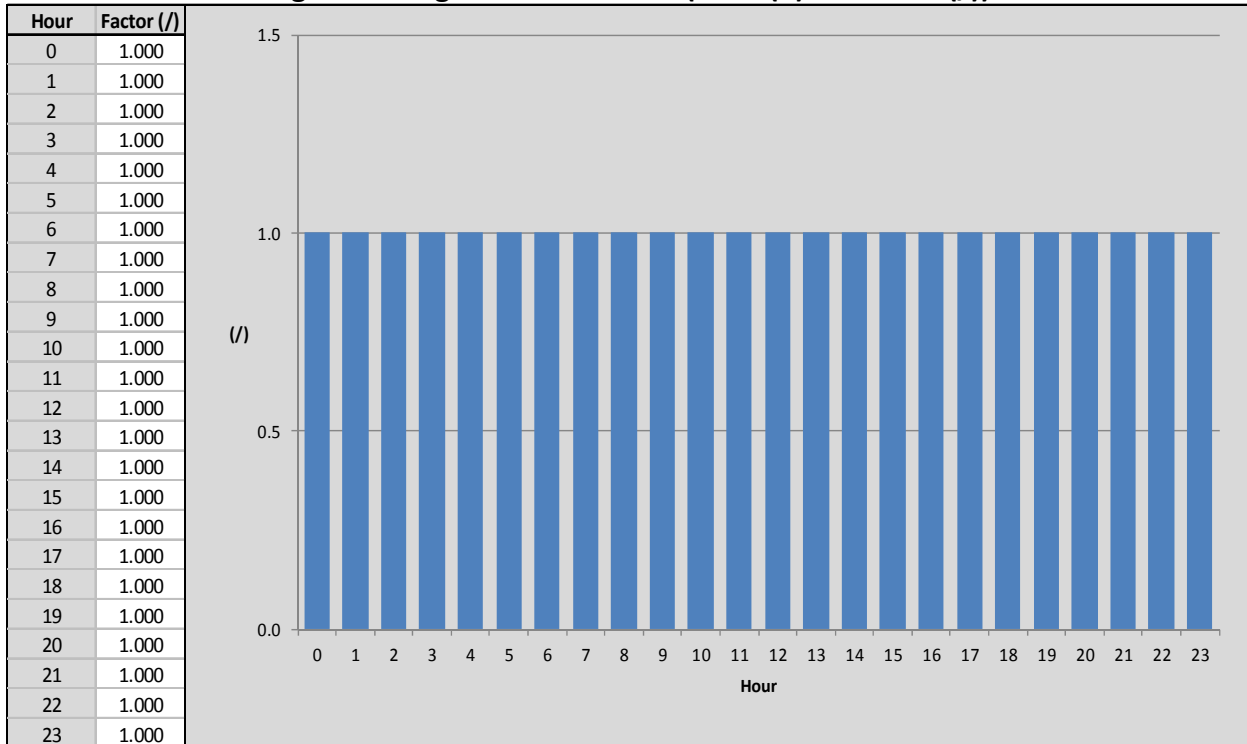


**Figure 4.6: Commercial and Institutional Patterns (Time (h) vs. Factor (/))**



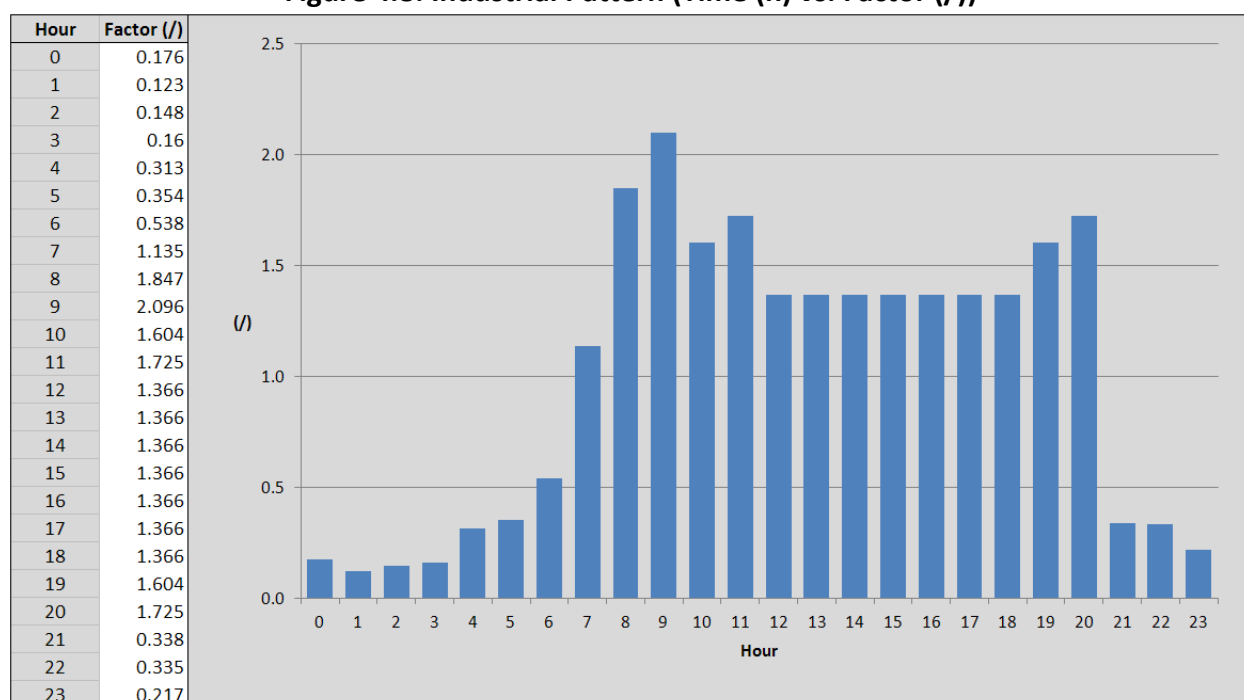
Source: City of Nanaimo

**Figure 4.7: Agricultural Pattern (Time (h) vs. Factor (/))**



Source: Constant pattern



**Figure 4.8: Industrial Pattern (Time (h) vs. Factor (/))**

Source: City of Nanaimo

Curves are objects that contain data pairs representing a relationship between two quantities. The InfoSWMM model has different types of curves and a few examples are shown in **Table 4.3**.

**Table 4.3: Curve Types**

Curve Type	X-Y Axis	Unit (SI)
Storage Shape Curve - for Wet Wells	Water Depth - Surface Area	m - m <sup>2</sup>
Diversion Curve - for Flow Divider Nodes	Total Inflow - Diverted Outflow	L/s - L/s
Tidal Curve - for Outfall Nodes	Hour of Day - Elevation Stage	hr - m
Pump Curve - for Pumps	Head - Flow	m - L/s
Pump Curve - for Pumps	Volume - Flow	m <sup>3</sup> - L/s
Pump Curve - for Pumps	Depth - Flow	m - L/s



Each curve must be given a unique name and can be assigned any number of data pairs.

**Table 4.4: Curve Prefix Definitions**

Prefix	Element	Curve Type
WWL-	Wet Well	Storage (Depth vs. Surface Area)
DIV-	Divider	Diversion (Total Inflow vs. Diverted Outflow)
OUT-	Outfall	Tidal (Hour of Day vs. Elevation Stage)
PHF-	Pump	Pump (Head vs. Flow)
PVF-	Pump	Pump (Volume vs. Flow)
PDF-	Pump	Pump (Depth vs. Flow)

(Geo)Advice 37 - Table 4.4 lists the suggested Curve prefix definitions.



## 5 SIMULATION

### 5.1 Simulation Options

This section illustrates the simulation options used with the City of Merritt's sewer models.

#### 5.1.1 General Tab

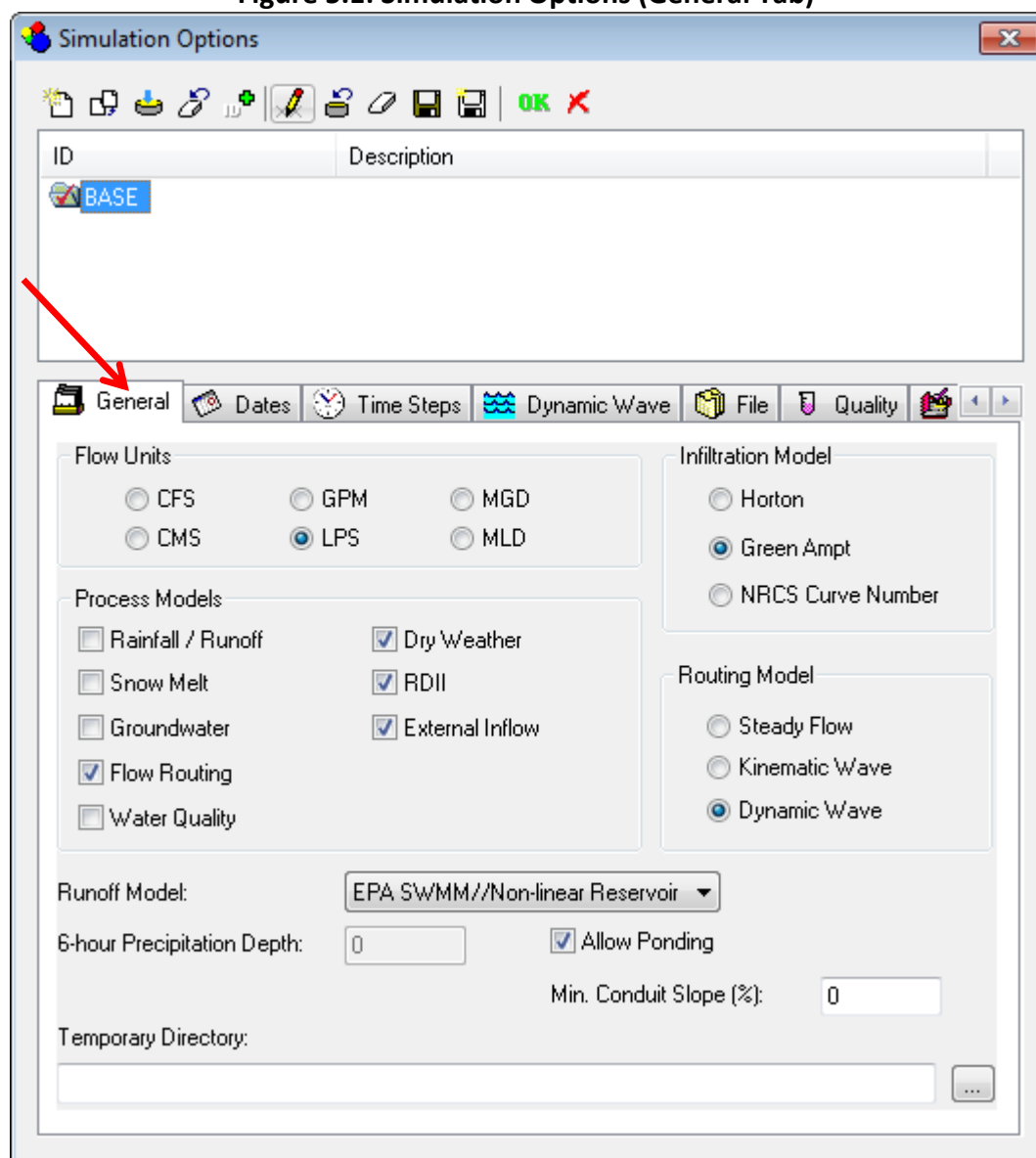
**(Geo)Rule 8 - Table 5.1 shows the Simulation Options that must be used with the City of Merritt sewer models.**

**Table 5.1: Simulation Options (General Tab)**

Simulation Options	Value
Flow Units	LPS (liters / sec)
Infiltration Model	Green Ampt
Process Models - Flow Routing	Checked
Process Models - Dry Weather	Checked
Process Models - RDII	Checked
Process Models - External Inflow	Checked
Routing Model	Dynamic Wave
Runoff Model	EPA SWMM/Non-linear Reservoir
Allow Ponding	Checked



**Figure 5.1: Simulation Options (General Tab)**





### 5.1.2 Dates & Time Steps Tab

The modules Dates and Time Steps in Simulation Options allow the modeler to change simulation time parameters. A different simulation time option can be set up for each unique scenario within InfoSWMM.

**Table 5.2** lists the recommended simulation time settings which should be in the InfoSWMM model.

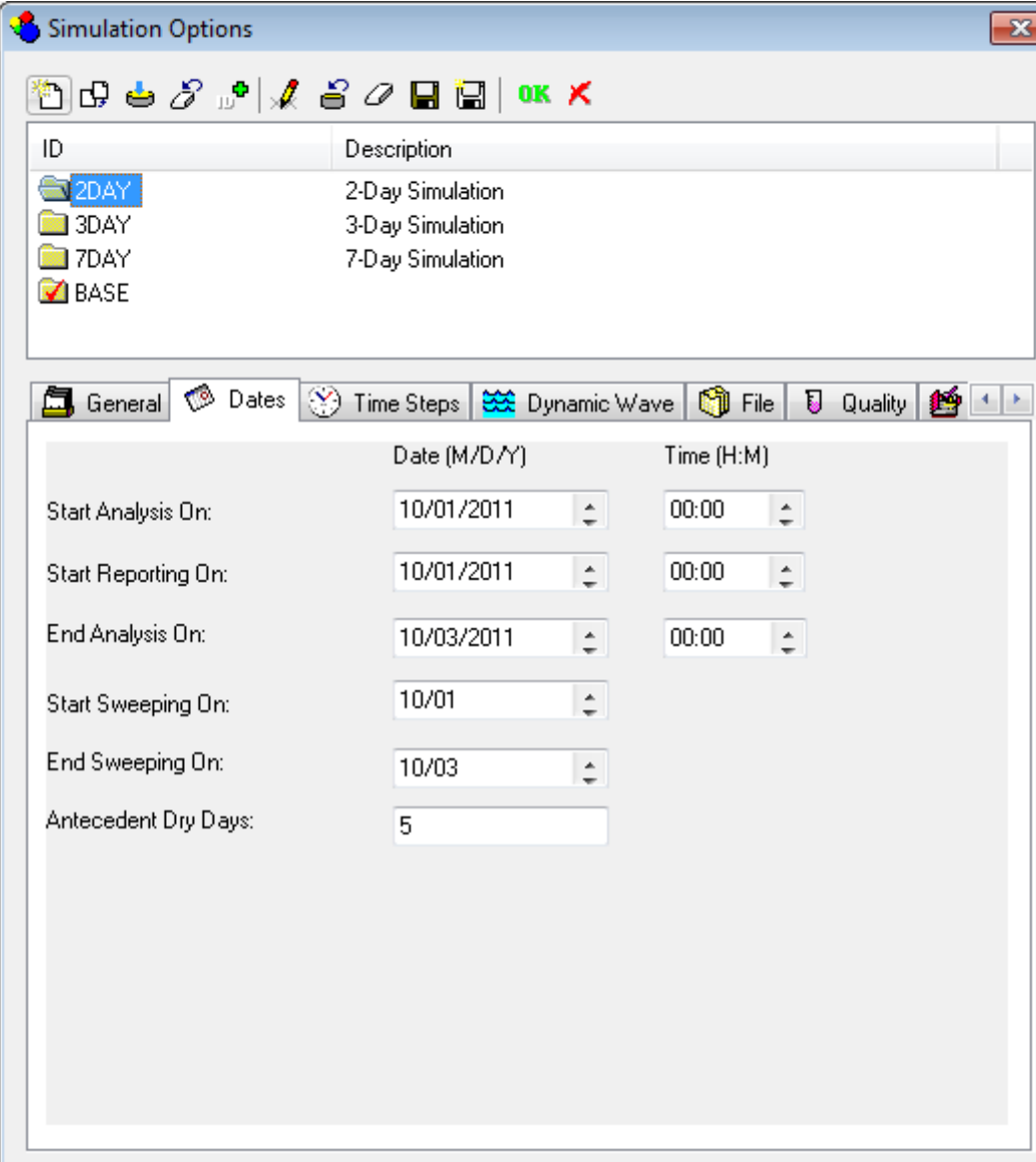
**Table 5.2: Recommended Simulations Time Setting**

Name	Description
2DAY	2-Day Simulation
3DAY	3-Day Simulation
7DAY	7-Day Simulation

**Figure 5.2** and **Figure 5.3** show the date and time settings for a 2-Day simulation.



**Figure 5.2: Simulation Options (Dates)**



The screenshot shows the 'Simulation Options' dialog box with the 'Dates' tab selected. The 'Dates' tab contains a table for setting simulation parameters. The table has two columns: 'Date (M/D/Y)' and 'Time (H:M)'. The rows are for 'Start Analysis On:', 'Start Reporting On:', 'End Analysis On:', 'Start Sweeping On:', 'End Sweeping On:', and 'Antecedent Dry Days:'. The values are as follows:

	Date (M/D/Y)	Time (H:M)
Start Analysis On:	10/01/2011	00:00
Start Reporting On:	10/01/2011	00:00
End Analysis On:	10/03/2011	00:00
Start Sweeping On:	10/01	
End Sweeping On:	10/03	
Antecedent Dry Days:	5	



**Figure 5.3: Simulation Options (Time Steps)**

The screenshot shows the 'Simulation Options' dialog box with the 'Time Steps' tab selected. The dialog has a title bar with a close button and a toolbar with icons for file operations and simulation control. Below the toolbar is a list of simulation options with columns for ID and Description. The 'BASE' option is selected. Below the list is a tabbed interface with 'General', 'Dates', 'Time Steps', 'Dynamic Wave', 'File', and 'Quality' tabs. The 'Time Steps' tab is active, showing settings for 'Runoff Time Steps' and 'Time Steps'.

ID	Description
2DAY	2-Day Simulation
3DAY	3-Day Simulation
7DAY	7-Day Simulation
<input checked="" type="checkbox"/> BASE	

**Runoff Time Steps**

	Days	Time
Dry Weather:	2	01:00:00
Wet Weather:	0	00:05:00

**Time Steps**

	Days	Time
Reporting Time Step:	0	00:05:00
Routing Time Step (seconds):	300	
Maximum Total Report Steps (use 0 for default):	8808	



### 5.1.3 Dynamic Wave Tab

If manhole diameter is not available, a default diameter of 1.05m should be applied (equivalent to surface area of  $\pi*(d/2)^2 \sim 0.866m^2$ ). This value should be set to the field outlined in **Figure 5.4**.

**Table 5.3: Simulation Options (Dynamic Wave)**

Simulation Options	Value
Inertial Terms	Keep
Variable Time Step	Checked
Safety Factor (%)	75
Time Step for Conduit Lengthening (sec)	0
Minimum Surface Area	0.866
Use Normal Flow Limit	when water surface slope < conduit slope
Force Main Equation	Hazen-Williams
Maximum Number of Iterations	4
Stopping Tolerance	0.005



**Figure 5.4: Simulation Options (Dynamic Wave)**

**Simulation Options**

ID Description

BASE

General Dates Time Steps **Dynamic Wave** File Quality

Inertial Terms: ☒ Keep ☐ Dampen ☐ Ignore

Variable Time Step: ☒ Safety Factor (%): 75

Time Step for Conduit Lengthening (sec): 0 (Use 0 for No Lengthening)

**Minimum Surface Area: 0.866** (Use 0 for Default)

Use Normal Flow Limit

- ☒ when water surface slope < conduit slope
- ☐ when Froude Number > 1.0
- ☐ Both

Force Main Equation

- ☒ Hazen-Williams
- ☐ Darcy-Weisbach

Picard Iterations

Maximum Number of Iterations: 4

Stopping Tolerance: 0.005



## 5.2 Report Options

Reporting options can be set for different simulation runs. The figure below illustrates the recommended reporting options used.

**Figure 5.5: Simulation Report Options**

The screenshot shows the 'Simulation Report' dialog box. At the top, there is a toolbar with icons for file operations and a status bar with 'OK' and 'X' buttons. Below the toolbar is a table with two columns: 'ID' and 'Description'. The first row has 'BASE' in the 'ID' column and 'Base Simulation Report' in the 'Description' column. Below this table is a section titled 'Report Parameters' with four checkboxes: 'Include Input' (unchecked), 'Report Continuity' (checked), 'Report Flow Statistics' (checked), and 'Report Control Actions' (checked). Below the 'Report Parameters' section are three tabs: 'Nodes', 'Links', and 'Subcatchments'. The 'Links' tab is selected and highlighted with a red dashed box. Below the 'Links' tab is a 'Report Link:' label followed by a dropdown menu set to 'All', which is also highlighted with a red dashed box. Below the dropdown is a table with a header 'Link ID' and a list of numbers from 1 to 9. To the right of the table are several buttons: 'Insert+', 'Delete', 'Clear All...', 'Insert Rows...', 'Delete Rows', and 'Set Rows...'.

ID	Description
BASE	Base Simulation Report

Report Parameters

☐ Include Input ☒ Report Continuity

☒ Report Flow Statistics ☒ Report Control Actions

Nodes Links Subcatchments

Report Link: All

Link ID
1
2
3
4
5
6
7
8
9

Insert+  
Delete  
Clear All...  
Insert Rows...  
Delete Rows  
Set Rows...

**(Geo)Advice 38 - Set option to report all nodes and links.**



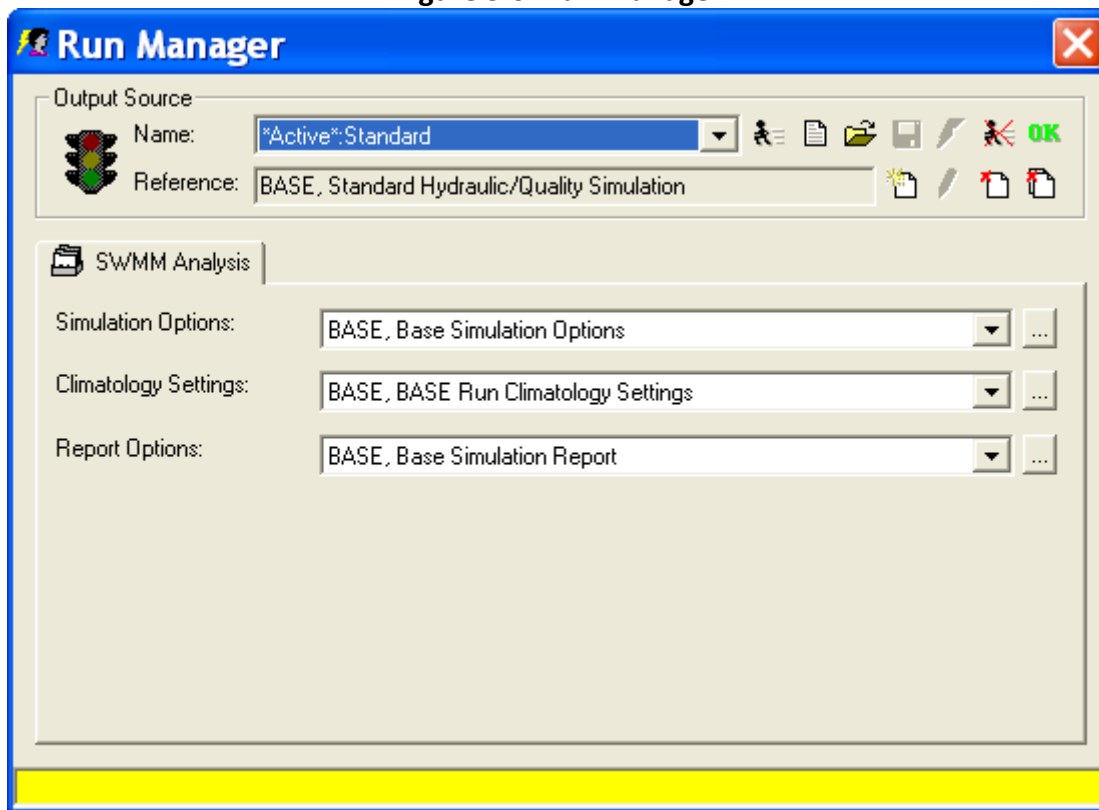
### 5.3 Dynamic Simulation

A Dynamic Simulation recreates the characteristics of the system over a period of time. The simulation uses diurnal patterns to peak base sanitary loads. InfoSWMM allows different diurnal peaking patterns at any given loading node.

### 5.4 Run Manager Settings

Upon successful completion of the simulation, the status stoplight on the **Run Manager** should show green, indicating successful completion of the simulation run.

Figure 5.6: Run Manager

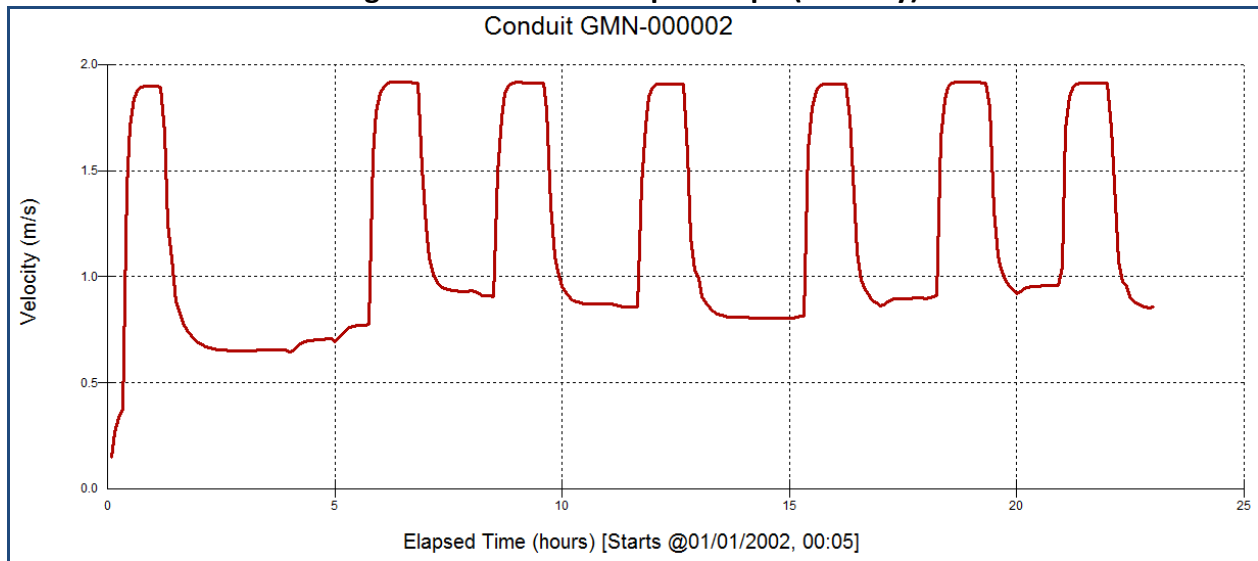


**(Geo)Advice 39 - Always review modeling results to make sure that they are reasonable.**

- Open the **Junction Summary** report to review the simulation results (min, max, total).
- Open the **Conduit Summary** report to review the simulation results (min, max, total).

All the hydraulic data such as flow, depth, velocity etc. are available to output as graph such as that shown in **Figure 5.7**.



**Figure 5.7: Conduit Output Graph (Velocity)**

A yellow light will be displayed on the **Run Manager** (traffic signal) when a model run contains warning messages. InfoSWMM will generate a detailed report of warning conditions which alert the user to various situations. When one or more errors occur, the status stoplight on the **Run Manager** dialog box indicates red.

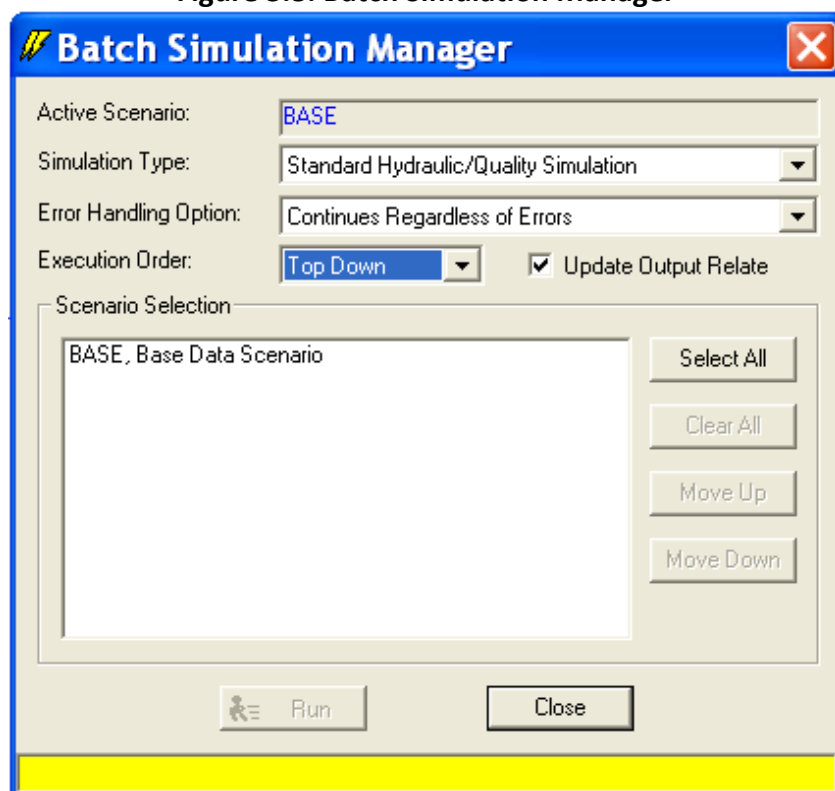
### 5.5 Batch Simulation Manager

The **Batch Simulation Manager** is used to run models for numerous user-selected scenarios in a single operation. This command is especially useful where several simulations are simultaneously required for a large model. With the **Batch Simulation Manager**, the user can select the desired scenarios and run each model in a "batch" process.

- The Batch Simulation Manager is located under **Tools → Batch Simulation**.



Figure 5.8: Batch Simulation Manager



After a batch simulation is run, the last scenario simulated will be available as the **\*Active\***: **Standard** output source. Other scenarios simulated will be available and loaded as user-defined output sources identified by the scenario names, for example **Future1: Standard** and **Future2: Standard**. To review results associated with those scenarios, from the **Output Report Manager**, choose the desired output source from the **All Output Sources** box and select either graph or report.

## 6 ADVANCED MODELING DATA AND TOOLS

### 6.1 DB Query

With InfoSWMM, the user is able to select network components and related data by creating logical query statements through the **DB Query** feature.

**(Geo)Advice 40 - Table 6.1 lists the recommended DB Query prefix definitions.**

**Table 6.1: Recommended DB Query Prefix Definitions**

Element	Prefix
JCT-	Junction
MHL-	Manhole
CDT-	Conduit
GMN-	Gravity Main
FMN-	Force Main
PMP-	Pump
STU-	Storage Unit
WWL-	Wet Well
DIV-	Divider
OUT-	Outfall

**(Geo)Advice 41 - DB Queries should always be validated by clicking the “Validate” button in the DB Query editing window.**

### 6.2 Query Set

A Query Set is a collection of individual DB Queries stored as a unique set of data. Query sets are used to group logical expressions for InfoSWMM network elements (gravity mains, manholes, etc.) for network management and graphical presentation purposes.

**Table 6.2: List of Recommended Query Sets**

Query Set Name	Description
Diameter	Colour coded map based on pipe diameter
Material	Colour coded map based on pipe material
Catchment	Colour coded map based on Catchment IDs

### 6.3 Selection Set

Selection Sets are collections of data elements that can be saved and later recalled for activation. Selection Sets may be used to define domains and facility sets.



**(Geo)Advice 42 - To validate a Selection Set, use the Domain Manager. In addition, Selection Sets should have descriptions.**

**(Geo)Advice 43 - DB Queries should be used instead of Selection Sets.**

## 6.4 Project Preferences

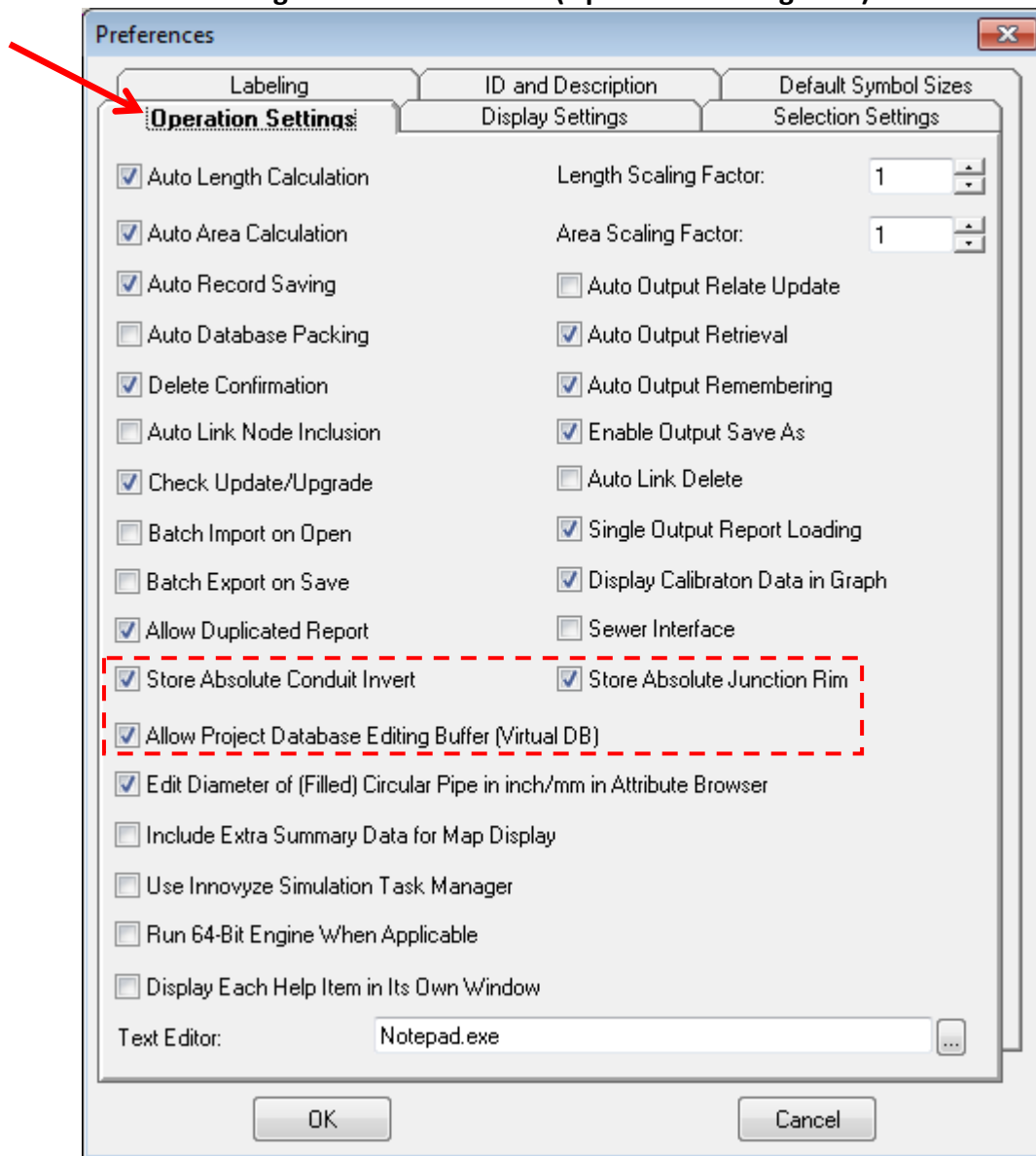
**Table 6.3** lists the recommended Project Preferences - Operation Settings (under **Tools** → **Project Preferences** → **Operation Settings** tab).

**Table 6.3: Recommended Project Preferences - Operation Settings**

Project Preference	Value
Auto Length Calculation*	Checked
Auto Area Calculation	Checked
Auto Record Saving	Checked
Auto Database Packing	Unchecked
Delete Confirmation	Checked
Auto Link Node Inclusion	Unchecked
Check Update/Upgrade	Checked
Batch Import on Open	Unchecked
Batch Export on Save	Unchecked
Allow Duplicated Report	Checked
Store Absolute Conduit Invert	Checked
Allow Project Database Editing Buffer (Virtual DB)	Checked
Edit Diameter of (Filled) Circular Pipe in inch/mm in Attribute Browser	Checked
Include Extra Summary Data for Map Display	Unchecked
Use Innovyze Simulation Task Manager	Unchecked
Run 64-Bit Engine When Applicable	Unchecked
Display Each Help Item in Its Own Window	Unchecked
Length Scaling Factor	1
Area Scaling Factor	1
Auto Output Relate Update	Unchecked
Auto Output Retrieval	Checked
Auto Output Remembering	Checked
Enable Output Save As	Checked
Auto Link Delete	Unchecked
Single Output Report Loading	Checked
Display Calibration Data in Graph	Checked
Sewer Interface	Unchecked
Store Absolute Junction Rim	Checked
Text Editor	Notepad.exe

\*Auto-Length Calculation should be checked when pipe lengths are accurately represented by GIS data. If lengths are to be assigned manually to pipes in the model for whatever reason (e.g. dummy pipes connected to pumps), this option should be unchecked.

**Figure 6.1: Preferences (Operation Settings Tab)**



**(Geo)Advice 44 - It is recommended that the “Store Absolute Conduit Invert” be checked. All link offsets will be stored as absolute elevations and not depth offsets.**

**(Geo)Advice 45 - It is recommended that the “Store Absolute Junction Rim” be checked. The rim elevation of the manholes will be in absolute elevation and not maximum depth.**

**(Geo)Advice 46 - It is recommended that the “Allow Project Database Editing Buffer (Virtual DB)” be checked. This option allows the creation of a backup of the Project Database.**

**Table 6.4** lists the recommended Project Preferences - Display Settings (under **Tools** → **Preferences** → **Display Settings** tab).



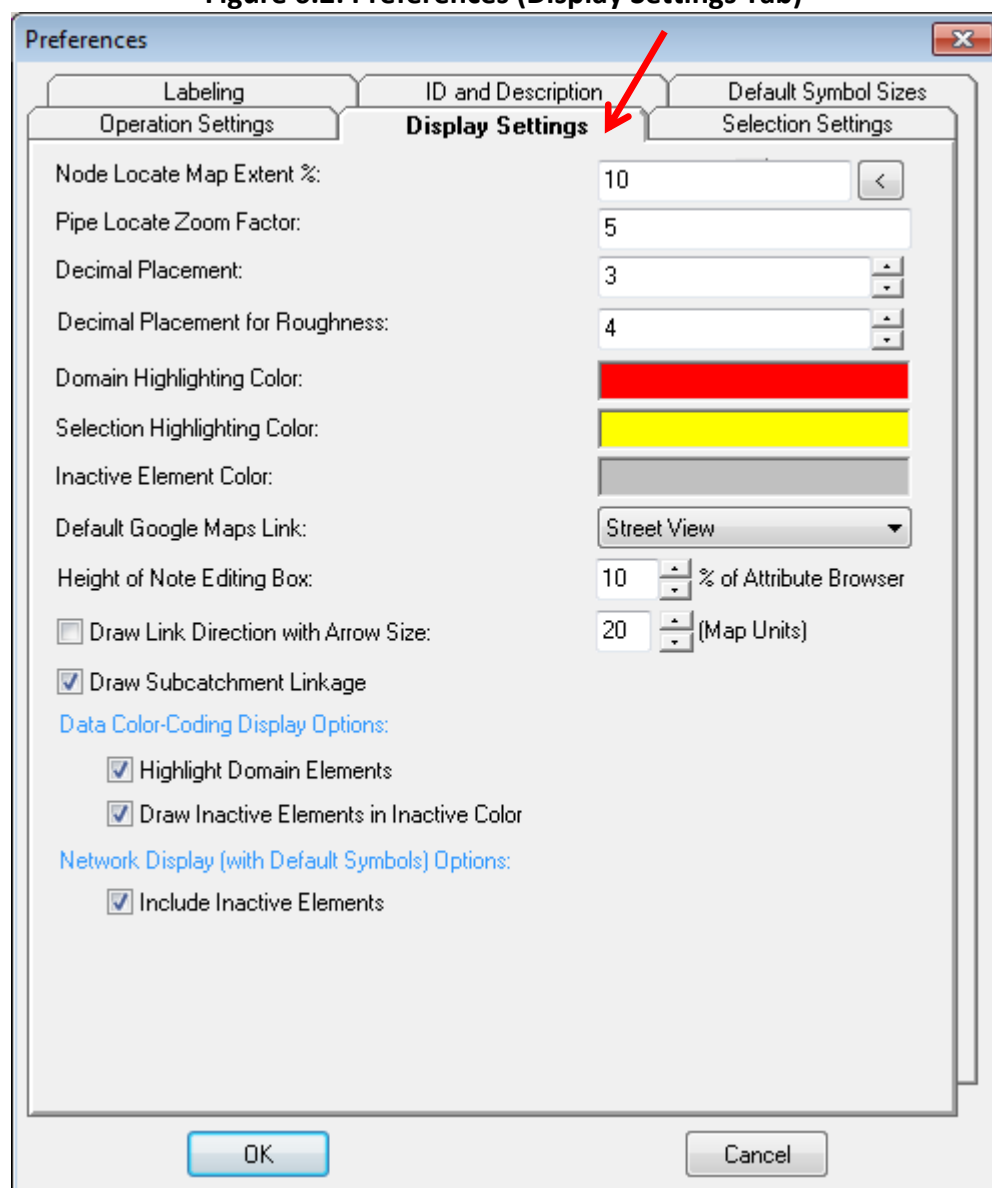
**Table 6.4: Recommended Project Preferences - Display Settings**

Setting	Value
Node Locate Map Extent %	10
Pipe Locate Zoom Factor	5
Decimal Placement*	3
Decimal Placement for Roughness	4
Domain Highlighting Color	RED
Selection Highlighting Color	YELLOW
Inactive Element Color	GRAY
Default Google Maps Link	Street View
Height of Note Editing Box	10%
Draw Link Direction with Arrow Size	Unchecked
Draw Subcatchment Linkage	Checked
Highlight Domain Elements	Checked
Draw Inactive Elements in Inactive Color	Checked
Include Inactive Element	Checked

\*Decimal Placement may need to be increased when performing data statistics to increase the precision of the sum.

**(Geo)Advice 47 - Check the “Draw Inactive Elements in Inactive Color” option in Project Preferences - Display Setting tab to display inactive elements on the map.**

**Figure 6.2: Preferences (Display Settings Tab)**



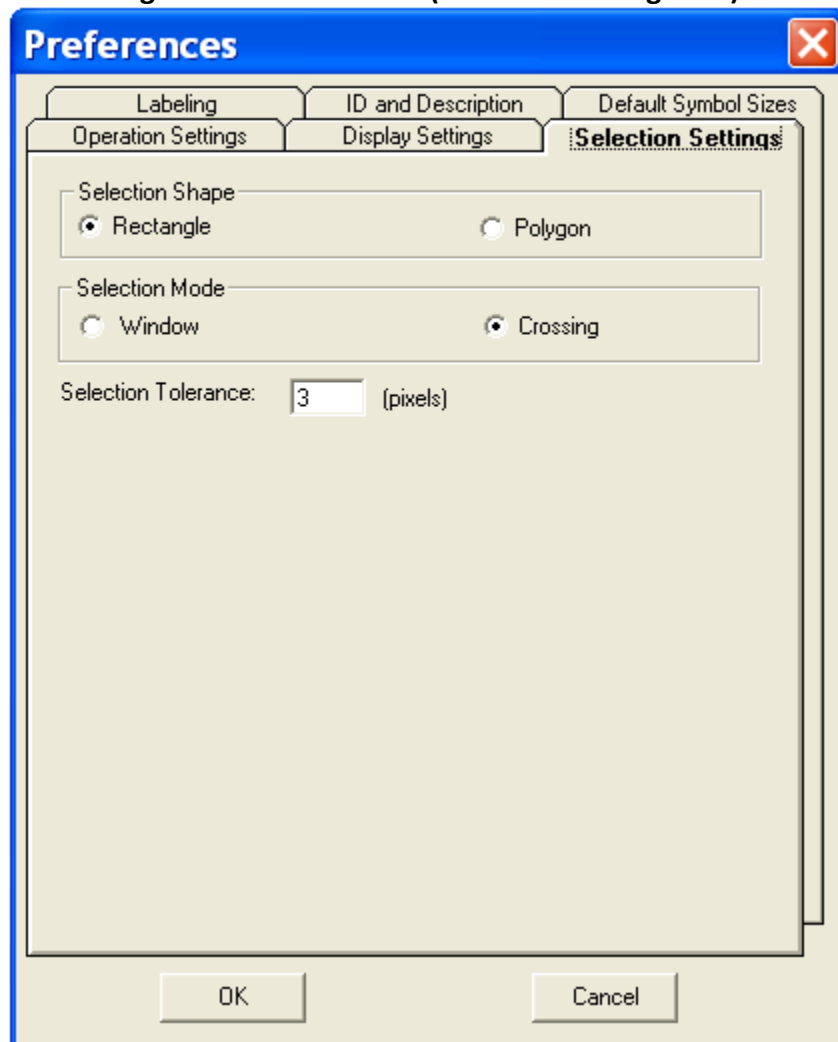


**Table 6.5** lists the recommended Project Preferences - Selection Settings (under **Tools** → **Preferences** → **Selection Settings** tab).

**Table 6.5: Recommended Project Preferences - Selection Settings**

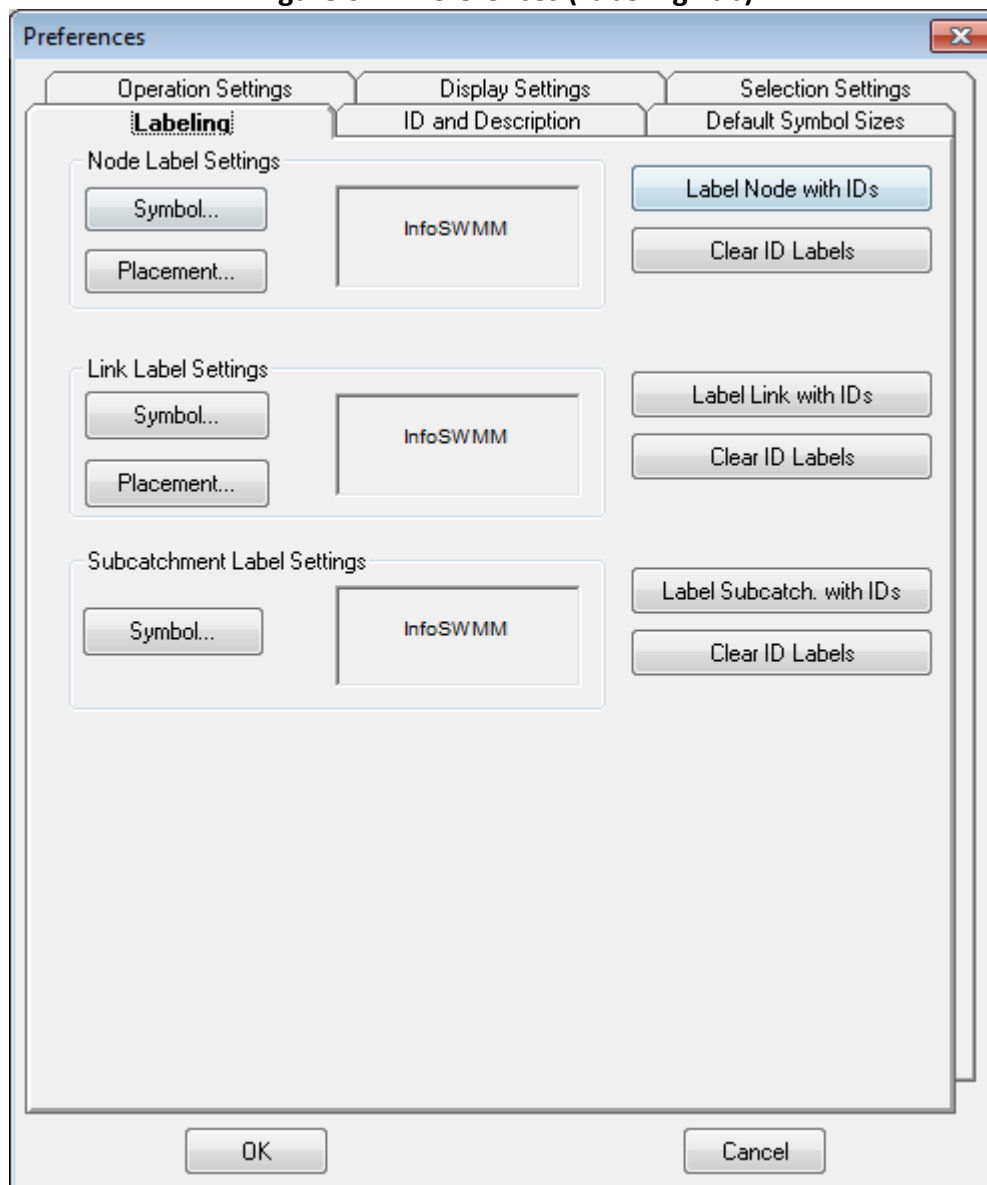
Setting	Value
Selection Shape	Rectangle
Selection Mode	Crossing
Selection Tolerance	3

**Figure 6.3: Preferences (Selection Settings Tab)**



**Figure 6.4, Figure 6.5** and **Figure 6.6** illustrates the recommended Project Preferences for the other tabs (Labeling Tab, ID and Description Tab, Default Symbol Size Tab).

**Figure 6.4: Preferences (Labeling Tab)**





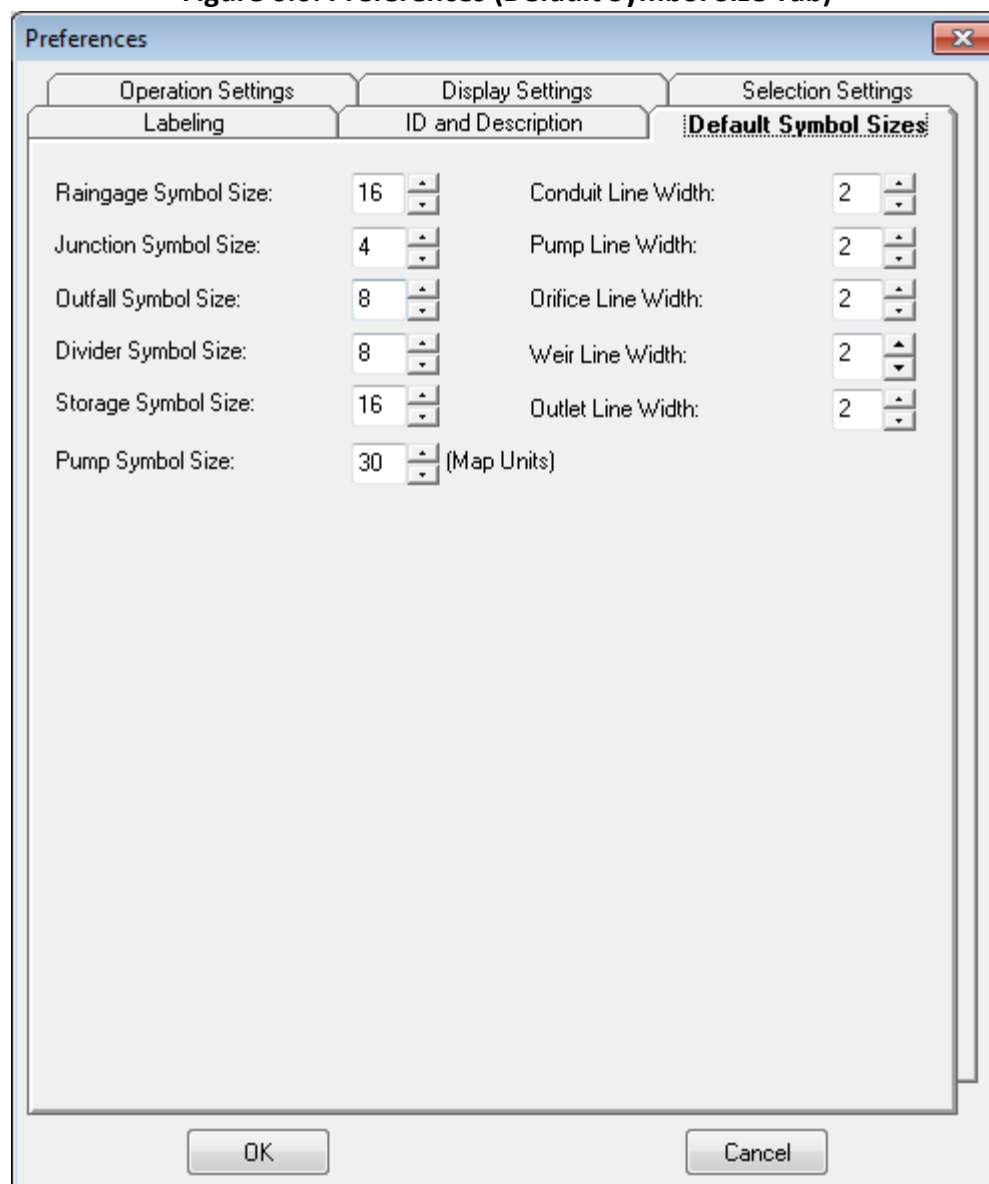
**Figure 6.5: Preferences (ID and Description Tab)**

The screenshot shows the 'Preferences' dialog box with the 'ID and Description' tab selected. The 'ID Suggestion' checkbox is checked. A table lists various object types with their corresponding ID prefixes, next values, and increments. The 'Junction Set' row is highlighted.

	ID Prefix	Next	Increment	Description
Junction Set	JCT-	1	1	
Divider Set	DIV-	1	1	
Outfall Set	OUT-	1	1	
Storage Set	STU-	1	1	
Subcatch. Set	SUB-	1	1	
Conduit Set	CDT-	1	1	
Pump Set	PMP-	1	1	
Orifice Set	ORI-	1	1	
Weir Set	WEI-	1	1	
Outlet Set	OUL-	1	1	
Rainage Set	RAG-	1	1	
Treatment Set	TRE-	1	1	
Inflow Set	INF-	1	1	
DWF Set	DWF-	1	1	
RDII Set	RDII-	1	1	
WQ Set	WQ-	1	1	
Initial Buildup Set	WQL-	1	1	
Ground Water Set	GWA-	1	1	
Coverage Set	COV-	1	1	
Infiltration Set	INF-	1	1	
Status Set	STA-	1	1	
Control Set	CTR-	1	1	
Soil Set	SOL-	1	1	
Aquifer Set	AQF-	1	1	
Snow Pack Set	SNO-	1	1	
Landuse Set	LDU-	1	1	
Pollutant Set	POL-	1	1	

Buttons: OK, Cancel

**Figure 6.6: Preferences (Default Symbol Size Tab)**



## 6.5 Import Manager and Export Manager

**(Geo)Advice 48 - The Import Manager and Export Manager tools are the recommended methods of importing and exporting ESRI Shape files.**

Figure 6.7 and Figure 6.8 show the Import and Export manager (under **Tools** → **Exchange** → **Import/Export Manager**).



Two major data components can be imported and exported:

- Geometric Data - Network geometry such as shape, connectivity and location.
- Hydraulic Data - Model input data such as element hydraulic information.

Figure 6.7: Import Manager

The screenshot shows the 'Import Manager - Source & Options' dialog box. It has a blue title bar with a close button. The dialog is divided into three main sections: 'Import Element Type', 'Operation Options', and 'Import Options'. In the 'Import Element Type' section, 'Conveyance Node (point):' is selected with a radio button, and 'Junction' is chosen in the dropdown. 'Conveyance Link (line):' is unselected, and 'Conduit' is chosen in its dropdown. In the 'Operation Options' section, 'Disable Auto-Length Calculation' is checked, and there is a 'Pack Element Tables...' button. In the 'Import Options' section, 'Format' is set to 'Shapefile', 'Delimiter' is 'Comma', 'Create New Records' is unchecked, 'Update Existing Records' is checked, 'Skip Field Title (First) Row' is unchecked, and 'No Geometry Update' is unchecked. At the bottom, there is a 'Source File' text box with a browse button (...). Navigation buttons '< Back', 'Next >', and 'Close' are at the very bottom.

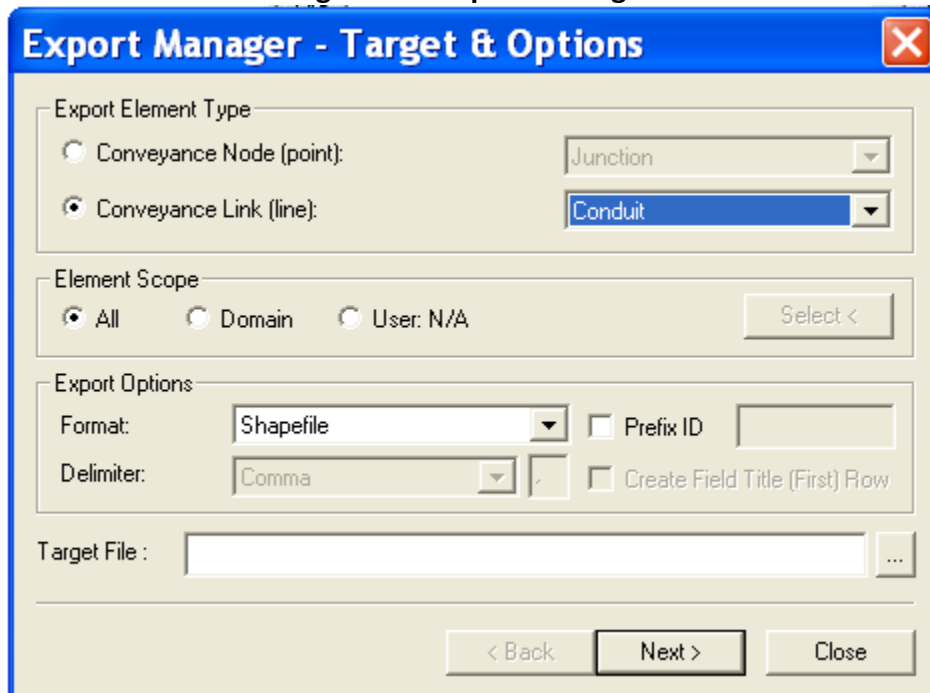
It is important to note the following before using the **Import Manager**.

- All GIS data should be checked for proper link and node connectivity before being imported.
- If “Auto-length calculation” (in **Project Preferences**) is turned on, all imported pipes will have their lengths recalculated.
- The network map display in InfoSWMM can be automatically updated with the imported data by selecting **Utilities → Update Map from DB**.
- **Create New Records** - Create new physical elements in the model (e.g. junction, storage unit, conduit or pump). Using this option is required when creating a new project.
- If the **Create New Records** option is checked in the **Import Manager**, wherever there is an imported ID that does not match any existing ID, a new element will be created.
- If the **Update Existing Records** option is checked in the **Import Manager**, wherever there is a match between an imported ID and an existing ID, the existing ID information will be updated.

Use the **Export Manager** to export model data into shape files (GIS data), delimited text files and Map Info files (MIF/MID). The following options allow the user to specify the type of export file to be created and its destination.

**(Geo)Advice 49 - Only one database table can be imported or exported at a time as each table requires a separate file.**

**Figure 6.8: Export Manager**

The image shows a software dialog box titled "Export Manager - Target & Options". It has a blue title bar with a close button (X) in the top right corner. The dialog is divided into several sections. The first section, "Export Element Type", contains two radio buttons: "Conveyance Node (point):" and "Conveyance Link (line):". The "Conveyance Link (line):" option is selected. To the right of these radio buttons are two dropdown menus; the first shows "Junction" and the second shows "Conduit". The second section, "Element Scope", contains three radio buttons: "All", "Domain", and "User: N/A". The "All" option is selected. To the right of these radio buttons is a "Select <" button. The third section, "Export Options", contains two rows of controls. The first row has a "Format:" label, a dropdown menu showing "Shapefile", a checkbox labeled "Prefix ID", and an empty text field. The second row has a "Delimiter:" label, a dropdown menu showing "Comma", a checkbox labeled "Create Field Title (First) Row", and an empty text field. Below these sections is a "Target File:" label followed by a large empty text field and a browse button (three dots). At the bottom of the dialog are three buttons: "< Back", "Next >", and "Close".

**(Geo)Advice 50 - Only currently active components of the model are exported through the Export Manager.**

## 6.6 Domain Manager

A Domain is a temporarily selected subset of network components, within which a user can perform group edits, mapping, reporting, graphing and contouring.

**(Geo)Advice 51 - Always click on the “Zoom to Domain” button  to validate the domain that has been added.**

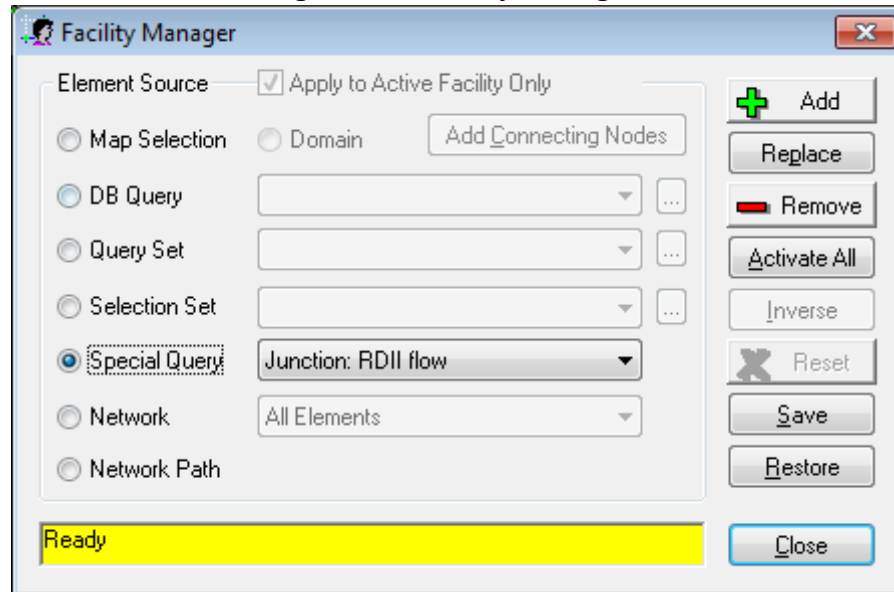
## 6.7 Facility Manager

The **Facility Manager** is used to create and maintain the active facility set. The active facility set defines the network components in a current scenario that will be considered during the next simulation run(s).



**(Geo)Advice 52 - The Facility Manager should not be used if possible. Instead, use the Scenario Explorer with Query Sets to create a new scenario with a customized facility set.**

**Figure 6.9: Facility Manager**



## 6.8 GIS Gateway

**GIS Gateway** provides a means of quickly exchanging data between InfoSWMM and other GIS formats. To run **GIS Gateway**, click on the **GIS Gateway** icon on your **InfoSWMM Control Center** → **Map Legend** toolbar. The GIS Gateway allows the user to define a data exchange in three steps:

- Select a GeoDatabase and the relevant feature class or table that is to be imported.
- Select the appropriate table in InfoSWMM that the data is flowing into.
- Select the GIS ID mapping field in the underlying GeoDatabase.

**(Geo)Advice 53 - The GIS Gateway tool is the recommended method of importing and exporting ESRI Geo-Databases.**

## 6.9 Change ID

The **Change ID** dialog box allows the user to change the ID for any selected data element.

**(Geo)Advice 54 - The Change ID tool should not be used unless the ID change is required by the City staff.**

To perform a mass edit:

- In the **DB Editor** open the database where the subject IDs are stored. Highlight and copy the IDs to the Windows clipboard and paste the values into a third-party software like Microsoft Excel. Next to each ID, enter the new value for the ID using Excel functions such as “mid” and “concatenate” to help you with the mass edit.
- Once you have the old and new IDs, determine how many rows are being used in Excel.
- Highlight all old and new IDs in Excel and use Ctrl+C to copy the highlighted area.
- Go back to InfoSWMM and use the **Set Rows** command to make the rows the same as those in the Windows clipboard. Once this is done, highlight the first cell in the Change ID dialog box and use the Ctrl+V function to paste the values from the clipboard.
- You have now greatly reduced your time from having to edit each ID individually.
- Click **Apply** to change the IDs and then **Close** to close the dialog box.

### 6.10 Connectivity and Network Review/Fix Tools

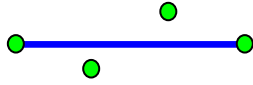
The **Connectivity and Network Review/Fix** tools are a comprehensive network drawing examination and correction applications in InfoSWMM. The tools offer users complete functionality to quickly identify and automatically correct any network topology problems (e.g. disconnected nodes) and data flaws (e.g. duplicated pipes or nodes) that may arise from digitizing a model or building it using pre-existing GIS datasets.

(Geo)Advice 55 - When correcting the connectivity of imported GIS data, always add the results to the Domain and review yourself. Correct the issues only after the City has reviewed them.



The following is a list of recommended network topology and connectivity checks to perform on GIS data being imported into the model.

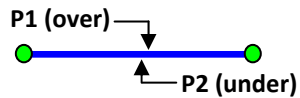
- Check 1: Orphan nodes



- Check 2: Orphan links

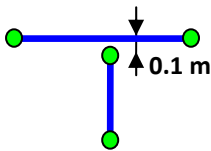


- Check 3: Locate Parallel Conduits

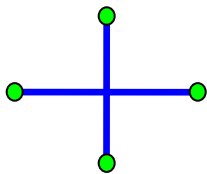


- Check 4: Locate/Fix Conduit-Split Candidates

**(Geo)Advice 56 - The tolerance for locating conduit split candidates should be 0.1 m.**

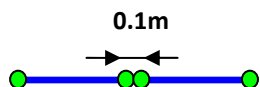


- Check 5: Locate/Fix Crossing/Intersecting Conduits



- Check 6: Locate/Fix Nodes in Close Proximity

**(Geo)Advice 57 - The tolerance for locating nodes in close proximity should be 0.1 m.**



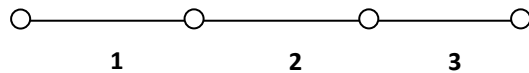
## 6.11 Data Inference

(Geo)Advice 58 - In many cases, model data may not be complete. However, it may be inferred to satisfy data requirements for hydraulic modeling. Inferred data should be appropriately reported to the City.

The following is a list of recommended data inference rules.

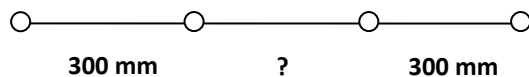
### Missing Pipe Diameter

- **Rule 1:** Identical upstream and downstream pipe diameter then use same diameter;



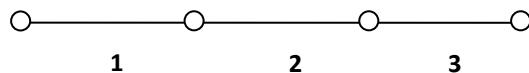
Diameter:  $1 = 3$ , 2 unknown, then  $1 = 2 = 3$

Ex)



The missing pipe diameter would be inferred as 300 mm.

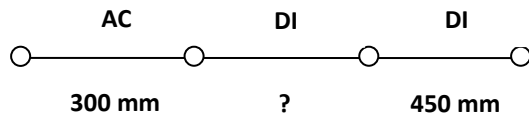
- **Rule 2:** Different diameter but same upstream and/or downstream material then use the same diameter as the pipe matching material;



Material:  $2 = 1$ , or  $2 = 3$

Diameter:  $2 = 1$ , or  $2 = 3$  (Respectively)

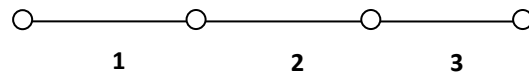
Ex)



The missing pipe diameter would be inferred as 450 mm.



- **Rule 3:** Different material and different diameter for upstream and downstream pipes then use diameter = 150 mm (default);

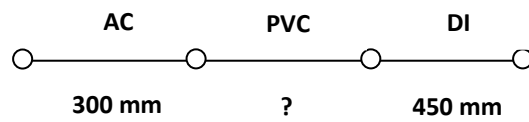


Material:  $2 \neq 1$ , and  $2 \neq 3$

Diameter:  $1 \neq 3$

Diameter:  $2 = 200$  mm (default)

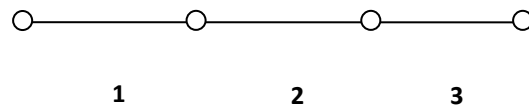
Ex)



The missing pipe diameter would be inferred as 150 mm by default.

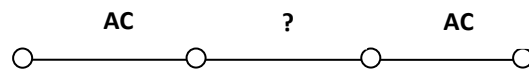
### Missing Pipe Material

- **Rule 1:** Identical upstream and downstream pipe material then use same material;



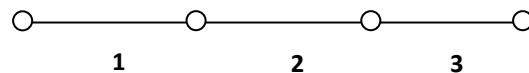
Material:  $1 = 3$ , 2 unknown, then  $1 = 2 = 3$

Ex)



The missing pipe material would be inferred as AC.

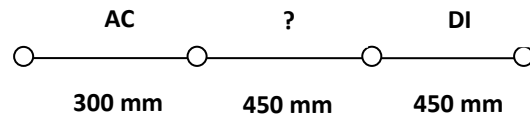
- **Rule 2:** Different material but same upstream and/or downstream diameter then use the same Material as the pipe matching diameter;



Diameter:  $2 = 1$ , or  $2 = 3$

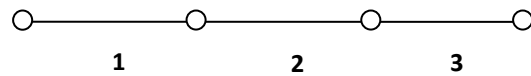
Material:  $2 = 1$ , or  $2 = 3$  (Respectively)

Ex)



The missing pipe material would be inferred as DI.

- **Rule 3:** Different diameter and different material for upstream and downstream pipes then use material = VC (default);

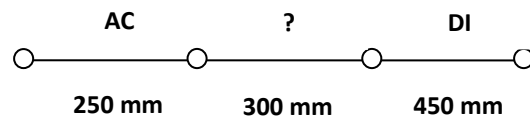


Diameter:  $2 \neq 1$ , and  $2 \neq 3$

Material:  $1 \neq 3$

Material:  $2 = \text{VC (default)}$

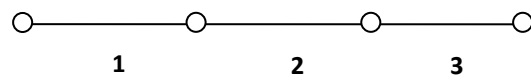
Ex)



The missing pipe material would be inferred as VC by default.

### Missing Pipe Year of Installation

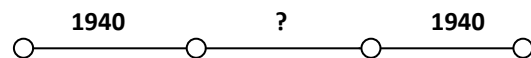
- **Rule 1:** Identical upstream and downstream pipe year of installation then use same year of installation;



Year of Installation:  $1 = 3$ , 2 unknown,

Then:  $1 = 2 = 3$

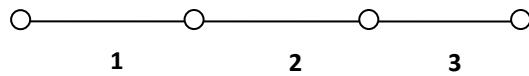
Ex)



The missing pipe year of installation would be inferred as 1940.



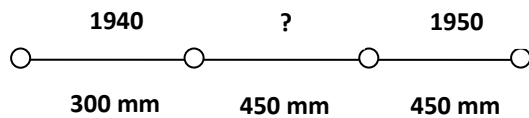
- **Rule 2:** Different year of installation but same upstream and/or downstream diameter then use the same year of installation as the pipe matching diameter;



Diameter:  $2 = 1$ , or  $2 = 3$

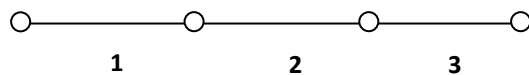
Year of Installation:  $2 = 1$ , or  $2 = 3$  (Respectively)

**Ex)**



The missing pipe year of installation would be inferred as 1950.

- **Rule 3:** Different diameter and different year of installation for upstream and downstream pipes then use year of installation = 9999 (default).

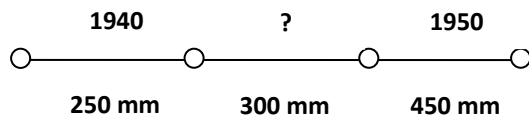


Diameter:  $2 \neq 1$ , and  $2 \neq 3$

Year of Installation:  $1 \neq 3$

Year of Installation:  $2 = 9999$  (default)

**Ex)**

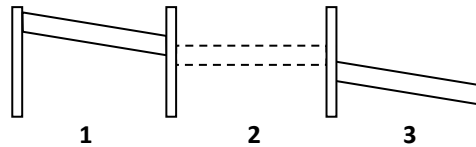


The missing pipe diameter would be inferred as 9999 by default.

## Missing Pipe Inverts

Inverts are highly critical to network hydraulic behavior, as the slope and therefore pipe capacity is directly proportionate to them. Missing invert information are corrected using the following set of rules:

- **Rule 1:** When invert information is missing from one pipe, the corresponding invert of the connecting pipe is used;



To Invert of Pipe 1 is known, From Invert of Pipe 2 unknown

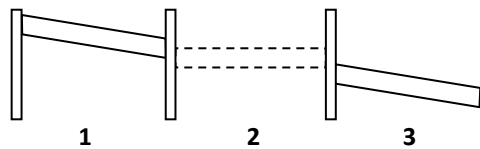
Then From Invert of Pipe 2 = To Invert of Pipe 1

OR

To Invert of Pipe 2 unknown, From Invert of Pipe 3 is known

Then To Invert of Pipe 2 = From Invert of Pipe 3

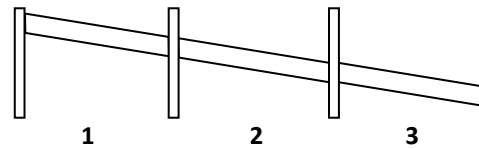
Ex)



To Inv: 20 m

From Inv: ?  
To Inv: ?

From Inv: 10 m



To Inv: 20 m

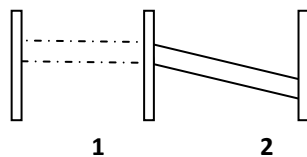
From Inv: 20 m  
To Inv: 10 m

From Inv: 10 m

The missing From Invert for Pipe 2 would be 20 m.

The missing To Invert for Pipe 2 would be 10 m.

- **Rule 2:** When invert information is missing from an upstream dead end pipe, the slope of the downstream pipe is assumed to be the same for the dead end pipe and inverts interpolated accordingly. No drop is assumed in the manhole.



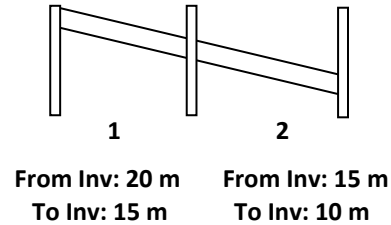
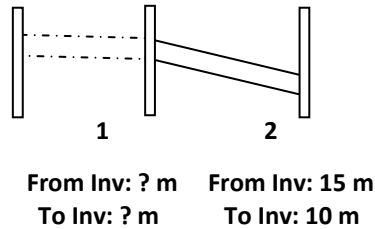
From Invert of Pipe 1 unknown, To Invert of Pipe 1 is unknown

From Invert of Pipe 2 is known, To Invert of Pipe 2 is known

Then, the To Invert for Pipe 1 equals the From Invert of Pipe 2 and the slope of the two pipes is assumed to be the same and inverts interpolated accordingly.



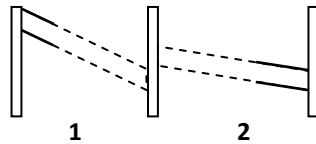
Ex)



The missing To Invert for Pipe 1 would be 15 m.

The missing From Invert for Pipe 1 would be 20 m.

- **Rule 3:** When invert information is missing from both pipes at a manhole, the slope of the two pipes is assumed to be the same and inverts interpolated accordingly. No drops are assumed in the manhole.

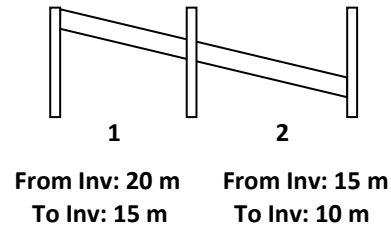
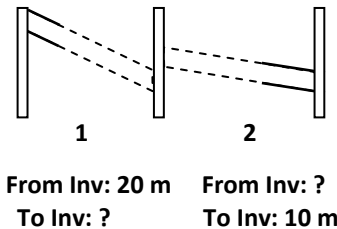


From Invert of Pipe 1 known, To Invert of Pipe 1 is unknown

From Invert of Pipe 2 is unknown, To Invert of Pipe 2 is known

Then, the slope of the two pipes is assumed to be the same and inverts interpolated accordingly.

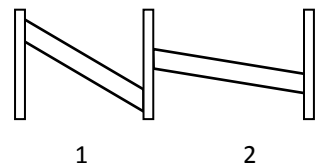
Ex)



The missing To Invert for Pipe 1 would be 15 m.

The missing From Invert for Pipe 2 would be 15 m.

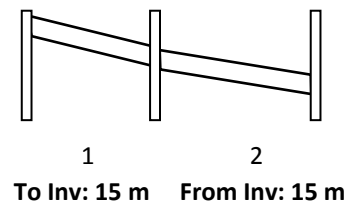
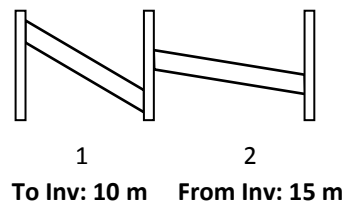
- **Rule 4:** Large drops that clearly are the result of an invert error are adjusted so that inverts at the manhole match.



To Invert of Pipe 1 << From Invert of Pipe 2

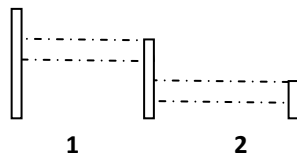
Then To Invert of Pipe 1 = From Invert of Pipe 2

Ex)



The To Invert for Pipe 1 would be adjusted from 10 m to 15 m to match the From Invert of Pipe 2.

- **Rule 5:** For all other missing inverts, it is assumed that they are located 2 m below the manhole's rim elevation.



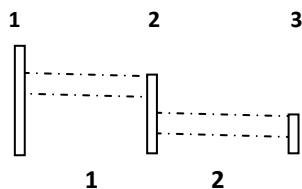
From Invert of Pipe 1 unknown, To Invert of Pipe 1 is unknown

From Invert of Pipe 2 is unknown, To Invert of Pipe 2 is unknown

Manhole rim elevation of manhole 1 is known, Manhole rim elevation of manhole 2 is known, Manhole rim elevation of manhole 3 is known

Then, the From Invert for Pipe 1 becomes 2 m below its manhole rim, the To Invert of Pipe 1 and the From Invert of Pipe 2 become 2m below their manhole rim and the To Invert of Pipe 2 becomes 2 m below its manhole rim.

Ex)



**From Inv: ? m    From Inv: ? m**

**To Inv: ? m    To Inv: ? m**

**Manhole 1: 20 m**

**Manhole 2: 15 m**

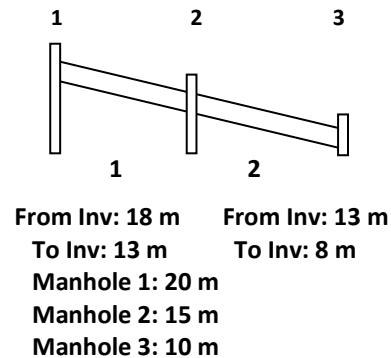
**Manhole 3: 10 m**

The missing From Invert for Pipe 1 would be 18 m.

The missing To Invert for Pipe 1 would be 13 m.

The missing From Invert for Pipe 2 would be 13 m.

The missing To Invert for Pipe 2 would be 8 m.





## 6.12 Database


**(Geo)Advice 59 - The “Clean” command should be followed by the “Pack” command in InfoSWMM. Do not use the other commands under the Database menu.**

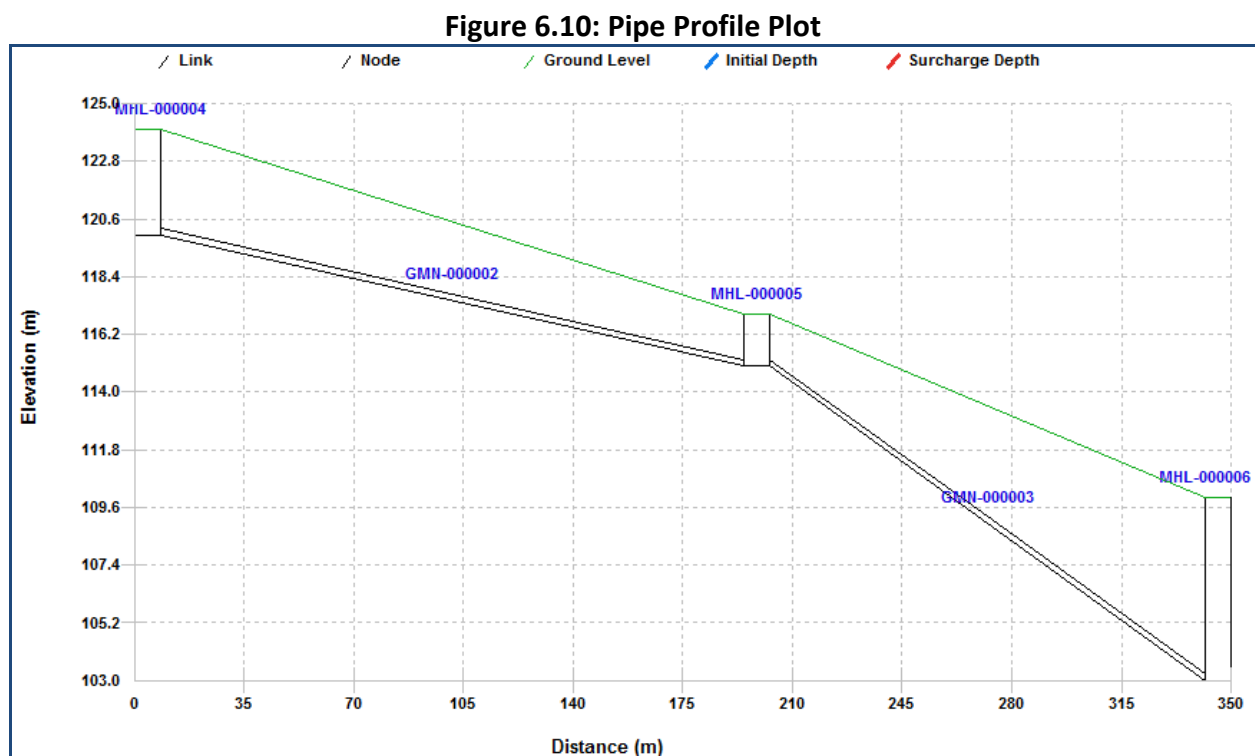
## 6.13 Recall

The Recall command is used to restore/or undelete network components that have been deleted. This command will not work if the user has enabled **Auto Database Packing** option (**Project Preferences**). Recall is found under **Utilities → Recall**.


Recalled components will be redrawn with their graphical properties (node size, pipe connectivity and shape) at the time of deletion. All database values assigned to those components will be restored.

## 6.14 Pipe Profile for Input

Pipe profiles can be viewed using the ‘Create Profile Plot’ tool  to visualize hydraulic grade lines. **Figure 6.10** illustrates an example of this.



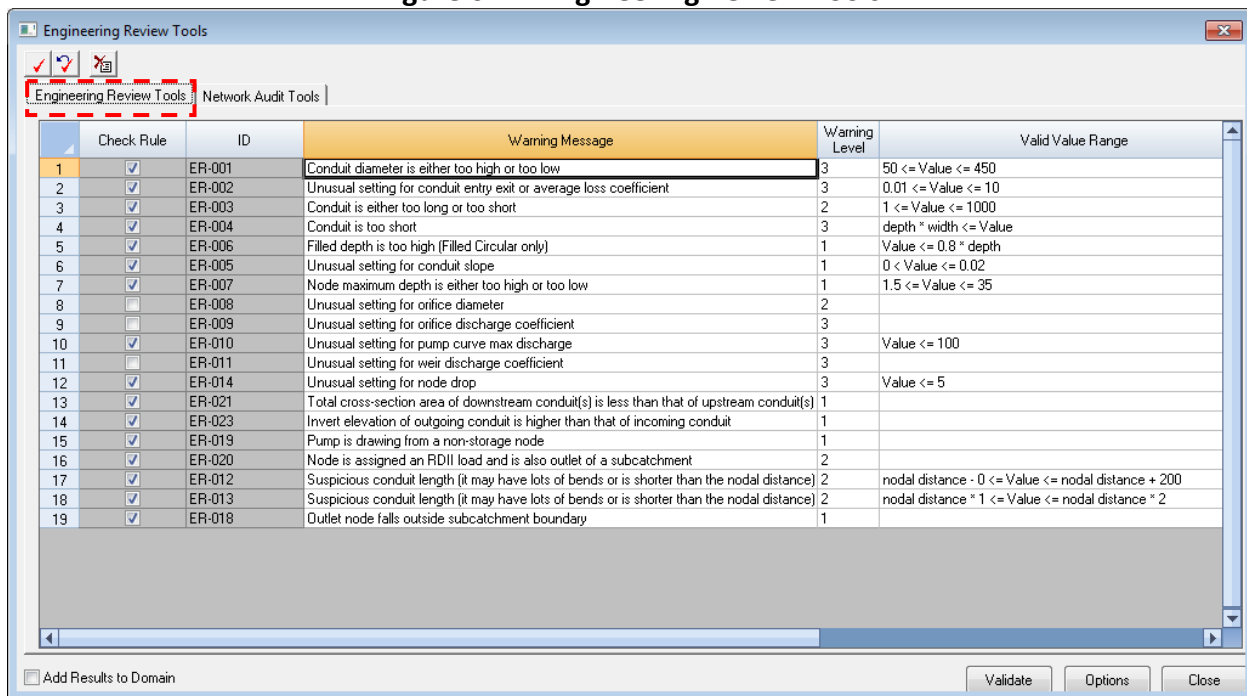
## 6.15 Pipe Profile for Output

After simulations are run, Hydraulic Gradient Line (HGL) profiles of selected pipes can be displayed using the Output Report/Graph module in Report Manager . This tool is particularly useful when studying locations where water level rise above the manhole ground elevations and allows the user to visualize how the HGL varies within the simulation time frame.

## 6.16 Engineering Review Tools

InfoSWMM's Engineering Review tools provide an efficient way to review input data for missing values and connectivity issues (**Tools → Engineering Review Tools**). InfoSWMM is capable of checking up to nineteen (19) Engineering Review rules and thirty three (33) Network Audit rules. **Figure 6.11** and **Figure 6.12** illustrate all of these rules. The desire range to be checked can be altered under the 'Valid Value Range' column. **Table 6.6** and **Table 6.7** tabulate the recommended valid range for the rules that apply to the City's model.

**Figure 6.11: Engineering Review Tools**



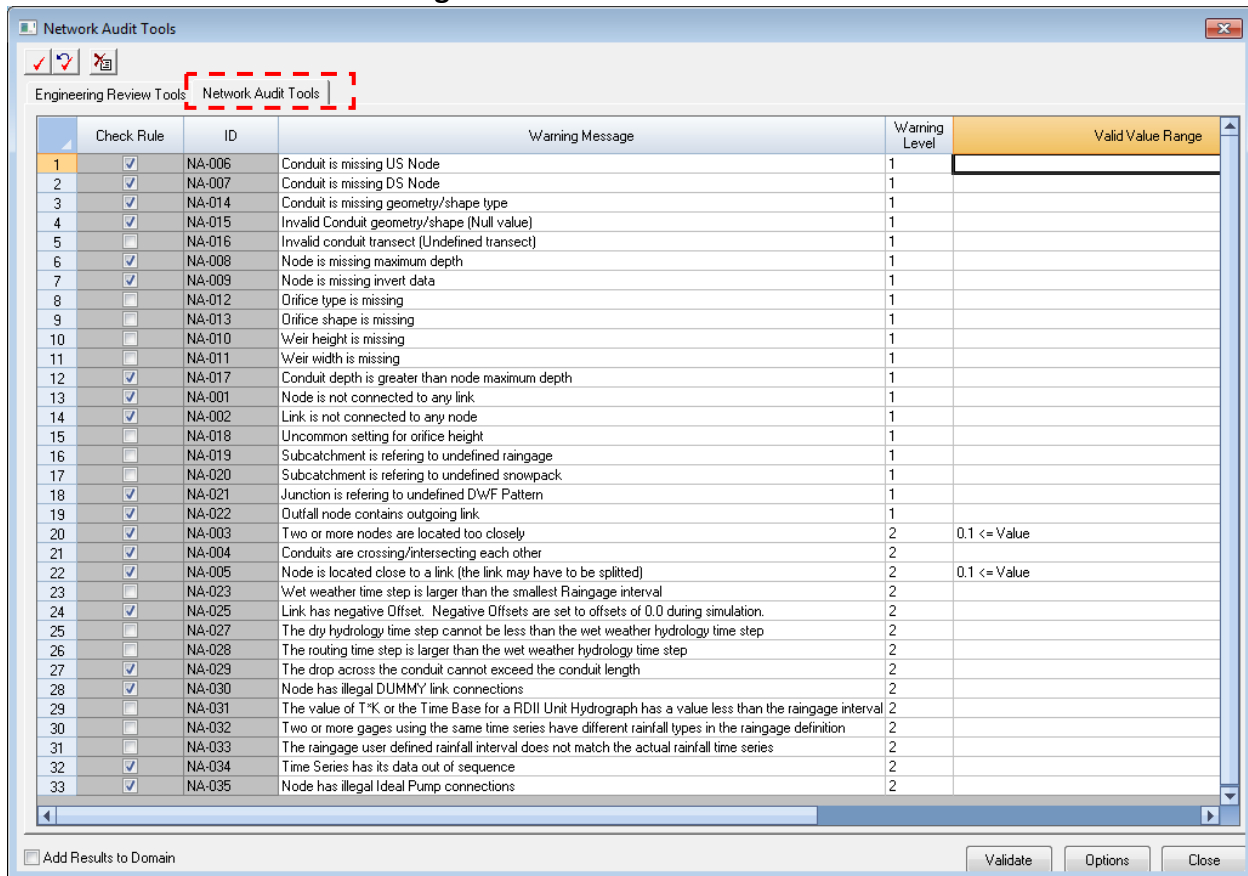
Check Rule	ID	Warning Message	Warning Level	Valid Value Range
<input checked="" type="checkbox"/>	ER-001	Conduit diameter is either too high or too low	3	50 <= Value <= 450
<input checked="" type="checkbox"/>	ER-002	Unusual setting for conduit entry exit or average loss coefficient	3	0.01 <= Value <= 10
<input checked="" type="checkbox"/>	ER-003	Conduit is either too long or too short	2	1 <= Value <= 1000
<input checked="" type="checkbox"/>	ER-004	Conduit is too short	3	depth * width <= Value
<input checked="" type="checkbox"/>	ER-006	Filled depth is too high (Filled Circular only)	1	Value <= 0.8 * depth
<input checked="" type="checkbox"/>	ER-005	Unusual setting for conduit slope	1	0 < Value <= 0.02
<input checked="" type="checkbox"/>	ER-007	Node maximum depth is either too high or too low	1	1.5 <= Value <= 35
<input type="checkbox"/>	ER-008	Unusual setting for orifice diameter	2	
<input type="checkbox"/>	ER-009	Unusual setting for orifice discharge coefficient	3	
<input checked="" type="checkbox"/>	ER-010	Unusual setting for pump curve max discharge	3	Value <= 100
<input type="checkbox"/>	ER-011	Unusual setting for weir discharge coefficient	3	
<input checked="" type="checkbox"/>	ER-014	Unusual setting for node drop	3	Value <= 5
<input checked="" type="checkbox"/>	ER-021	Total cross-section area of downstream conduit(s) is less than that of upstream conduit(s)	1	
<input checked="" type="checkbox"/>	ER-023	Invert elevation of outgoing conduit is higher than that of incoming conduit	1	
<input checked="" type="checkbox"/>	ER-019	Pump is drawing from a non-storage node	1	
<input checked="" type="checkbox"/>	ER-020	Node is assigned an RDII load and is also outlet of a subcatchment	2	
<input checked="" type="checkbox"/>	ER-012	Suspicious conduit length (it may have lots of bends or is shorter than the nodal distance)	2	nodal distance - 0 <= Value <= nodal distance + 200
<input checked="" type="checkbox"/>	ER-013	Suspicious conduit length (it may have lots of bends or is shorter than the nodal distance)	2	nodal distance * 1 <= Value <= nodal distance * 2
<input checked="" type="checkbox"/>	ER-018	Outlet node falls outside subcatchment boundary	1	



**Table 6.6: Engineering Review Tools (Recommended setup)**

ID	Warning Message	Warning Level	Valid Value Range
ER-001	Conduit diameter is either too high or too low	3	50mm <= Value <= 450mm
ER-002	Unusual setting for conduit entry exit or average loss coefficient	3	0.01 <= Value <= 10
ER-003	Conduit is either too long or too short	2	1m <= Value <= 1000m
ER-004	Conduit is too short	3	depth * width <= Value
ER-005	Unusual setting for conduit slope	1	0 < Value <= 0.02
ER-006	Filled depth is too high (Filled Circular only)	1	Value <= 0.8 * depth
ER-007	Node maximum depth is either too high or too low	1	1.5m <= Value <= 35m
ER-010	Unusual setting for pump curve max discharge	3	Value <= 100 L/s
ER-012	Suspicious conduit length (it may have lots of bends or is shorter than the nodal distance)	2	nodal distance - 0 <= Value <= nodal distance + 200
ER-013	Suspicious conduit length (it may have lots of bends or is shorter than the nodal distance)	2	nodal distance * 1 <= Value <= nodal distance * 2
ER-014	Unusual setting for node drop	3	Value <= 0.2m
ER-018	Outlet node falls outside subcatchment boundary	1	n/a
ER-019	Pump is drawing from a non-storage node	1	n/a
ER-020	Node is assigned an RDII load and is also outlet of a subcatchment	2	n/a
ER-021	Total cross-section area of downstream conduit(s) is less than that of upstream conduit(s)	1	n/a
ER-023	Invert elevation of outgoing conduit is higher than that of incoming conduit	1	n/a

Figure 6.12: Network Audit Tools





**Table 6.7: Network Audit Tools (Recommended setup)**

ID	Warning Message	Warning Level	Valid Value Range
NA-001	Node is not connected to any link	1	n/a
NA-002	Link is not connected to any node	1	n/a
NA-003	Two or more nodes are located too closely	2	0.1m <= Value
NA-004	Conduits are crossing/intersecting each other	2	n/a
NA-005	Node is located close to a link (the link may have to be split)	2	0.1m <= Value
NA-006	Conduit is missing US Node	1	n/a
NA-007	Conduit is missing DS Node	1	n/a
NA-008	Node is missing maximum depth	1	n/a
NA-009	Node is missing invert data	1	n/a
NA-014	Conduit is missing geometry/shape type	1	n/a
NA-015	Invalid Conduit geometry/shape (Null value)	1	n/a
NA-017	Conduit depth is greater than node maximum depth	1	n/a
NA-021	Junction is referring to undefined DWF Pattern	1	n/a
NA-022	Outfall node contains outgoing link	1	n/a
NA-025	Link has negative Offset. Negative Offsets are set to offsets of 0.0 during simulation.	2	n/a
NA-029	The drop across the conduit cannot exceed the conduit length	2	n/a
NA-030	Node has illegal DUMMY link connections	2	n/a
NA-034	Time Series has its data out of sequence	2	n/a
NA-035	Node has illegal Ideal Pump connections	2	n/a

## 7 PROJECT MANAGEMENT

### 7.1 Track Modeling Changes

(Geo)Rule 9 - To ensure adequate model data control, as well as aid future model users, it is required that the model changes are appropriately logged within an external document.

(Geo)Advice 60 - The number of logs should be kept to a minimum and any redundant information removed from the tracking system.

(Geo)Advice 61 - Any data that is changed from the original data import should be appropriately tracked to represent the source and confidence of the data.

(Geo)Advice 62 - All notes input by the modeler should be prefixed with the modeler's or company's initials. (e.g. "GA -" for all notes input by GeoAdvice).

### 7.2 Local Save versus Global Save

When working in InfoSWMM, changes to the model can be saved either locally or globally. A local save stores all changes in the temporary model file. The local save button is located in both the **Attribute Browser** and the **DB Editor**. A global save updates the original model file with all changes made to the temporary model file. The global save command is located under the **File** menu. Only changes saved globally will be kept after closing the model.

### 7.3 Backup Strategy

Having a good backup strategy in place will help to minimize the loss of information while editing the model. As InfoSWMM does not have an 'Undo' function, when undertaking large network amendments it is very difficult to correct the changes should an error be identified.

(Geo)Rule 10 - A backup copy of the model must be made before every editing session so that old data may be recovered if necessary.

As InfoSWMM does not have an 'Undo' function, when undertaking large network amendments it is very difficult to correct the changes should an error be identified.

A "Backup" folder should be created in the project folder. During each backup, the current model (the ModelName.MXD file as well as the ModelName.ISDB folder) should be copied into a sub folder named using the format **YYYY-MM-DD** with the date being the date of the backup. Additional information pertaining to the update may be included as well.


**Ex)** If a major GIS update was made on October 30, 2011, the backup model would look like:

...\Project1\Backup\2011-10-30 (Before Major GIS Update)\ModelName.MXD



...\Project1\Backup\2011-10-30 (Before Major GIS Update)\ModelName.ISDB

The following two screenshots are examples of how the project model directory should be configured.



Name	Type
Backup	File Folder
Merritt.ISDB	File Folder
Merritt.OUT	File Folder
Merritt.mxd	ESRI ArcMap Document

Name	Type
2011-10-21	File Folder
2011-10-20	File Folder
2011-10-30 (Before Major GIS Update)	File Folder

Name	Type
Merritt.ISDB	File Folder
Merritt.mxd	ESRI ArcMap Document

Further information on the update should have been recorded in the model tracking log containing all model changes.

## 8 LOAD CALCULATION AND ALLOCATION

**(Geo)Rule 11 - The City geocoded metered billing data must be used in the model to represent the Base Sanitary Flow (BSF).**

### 8.1 Load Data Types

Different load types are assigned based on the land use. **Table 8.1** lists the recommended load types along with proposed naming convention for the patterns.

**Table 8.1: Recommended Load Types Based on Land Use**

Load Field #	Load Type	Scenario	Pattern ID
1	Single Family	Existing	LDG-1-SFRES
2	Multi Family	Existing	LDG-2-MFRES
3	Commercial	Existing	LDG-3-COM
4	Industrial	Existing	LDG-4-IND
5	Institutional	Existing	LDG-5-INST
6	Agricultural	Existing	LDG-6-AGR
7	Parks & Irrigation	Existing	LDG-7-PARKS
1	Single Family Growth	Future	LDG-1-SFRES-FUT
2	Multi Family Growth	Future	LDG-2-MFRES-FUT
3	Commercial Growth	Future	LDG-3-COM-FUT
4	Industrial Growth	Future	LDG-4-IND-FUT
5	Institutional Growth	Future	LDG-5-INST-FUT
6	Agricultural Growth	Future	LDG-6-AGR-FUT
7	Parks & Irrigation Growth	Future	LDG-7-PARKS-FUT

**(Geo)Advice 63 - The average of pattern multipliers to be applied to the base load should equal to one (only applies for load pattern).**

### 8.2 Load Scenarios

Different load scenarios should be modeled in InfoSWMM as shown in **Table 8.2**.



**Table 8.2: Modeling Scenarios**

Scenario	Description
Existing-BSF	Existing Base Sanitary Flow
Existing-ADWF	Existing Average Dry Weather Flow
Existing-PDWF	Existing Peak Dry Weather Flow
Future-ADWF	Future Average Dry Weather Flow
Future-PWWF-II5	Future 5-Year Peak Wet Weather Flow
Future-PWWF-II25	Future 25-Year Peak Wet Weather Flow

### 8.3 Spatial Load Allocation

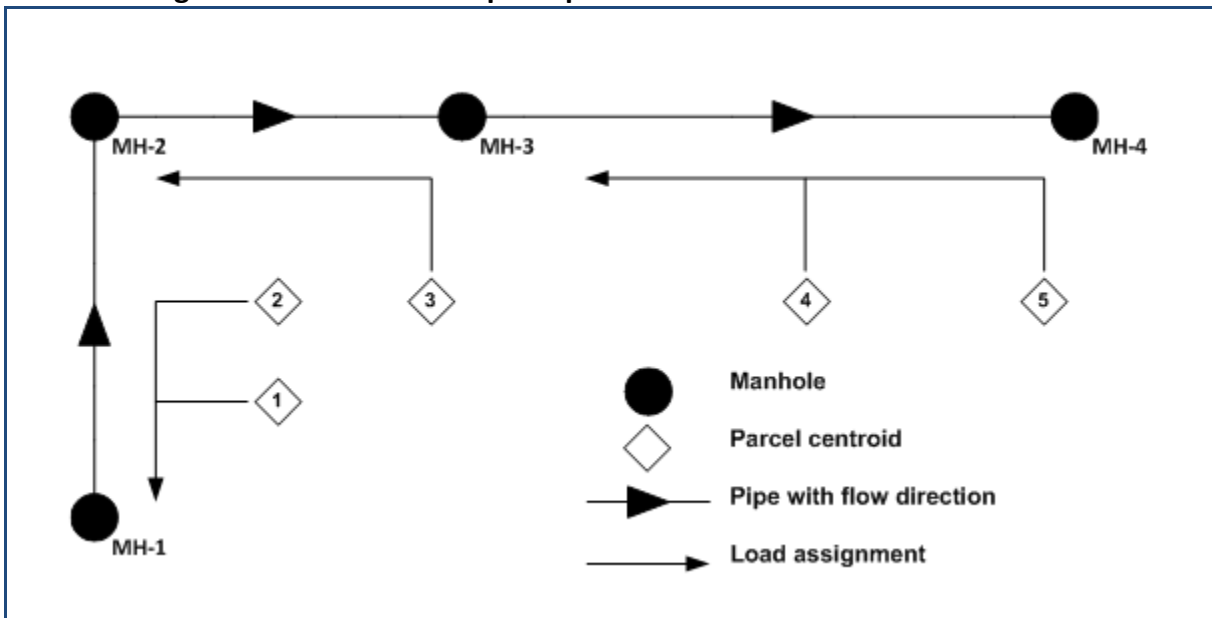
Spatial allocation of existing loadings may contain metered users or non-metered users. The recommended steps for allocating existing loads are:

#### 8.3.1 Allocation of Metered Users (ICI)

Water meter billing data should be allocated to the manholes in the model as follows:

- First, non-loading nodes are excluded from the allocation process (e.g. nodes connected to pumps and wet wells). Manhole nodes located on the trunk system (diameter > 350 mm) are also excluded from the allocation process.
- Each meter is then assigned to a manhole ID, which represents the upstream manhole of the connected pipe as shown in **Figure 8.1** below. This pipe is usually the closest pipe to the meter.
- For each of the manholes, all contributing meters are summed up to represent the total load imposed on that node.
- Finally, all the loads are scaled down by a factor of 0.9 as it is assumed that 90 % of water consumption is converted to sanitary flows. Conversion rate to be validated during calibration.

**Figure 8.1: “Connected Pipe - Upstream Manhole” Allocation Method**



(Geo)Advice 64 - Non-loading nodes are excluded from the allocation process.

(Geo)Advice 65 - The meter loads should be allocated to the upstream manhole of the selected pipe.

(Geo)Advice 66 - It will be initially assumed that 90 % of water consumption is converted to sanitary flows (Conversion rate to be validated during calibration).

(Geo)Advice 67 - If needed, the top 20 meter loads (annual volume) should be validated manually to ensure that the loads are allocated to the correct manhole.

### 8.3.2 Allocation of Non-Metered Users (Residential)

The following assumptions are made to estimate and allocate the loading data for non-metered users:

- Sewer loadings are estimated on per capita basis. The average number of person per unit is to be provided in **Table 8.3**.
- Sewer loadings are then estimated by multiplying the total capita by the per capita flow (PCF) rate of 230 L/d/Cap (To be validated during calibration based on flow monitoring data).
- Calculated loads are then allocated to the Closest Pipe - Upstream manhole.



**Table 8.3: Recommended Population Density per Landuse**

Landuse	Population Density*
Single Family Dwellings	2.8 ppu
Low Density Multiple Family Dwellings	1.7 ppu
High Density Multiple Family Dwellings	1.7 ppu
Industrial	36 pph
Commercial	90 pph (incl. parking)
Institutional	50 pph (incl. parking, but not green space)

\*ppu = persons per unit, pph = persons per hectare

There may also be private parcels (e.g. strata development) that are not connected directly to the City sewer collection system. Although the private pipes should not be modeled, the corresponding loads should be considered and allocated manually to the first downstream City owned manhole. The City should provide a list of those “unallocated-unconnected” loads in geospatial format.

#### **8.4 Future Loadings**

**(Geo)Advice 68 - Load allocation for future scenarios should be calculated using the future BSF rate of 365 L/d/Cap.**

**(Geo)Advice 69 - Future population should be estimated with population density values found in Table 8.3 and/or growth projections from past City population numbers.**

## 9 SCENARIOS

### 9.1 Scenario Explorer

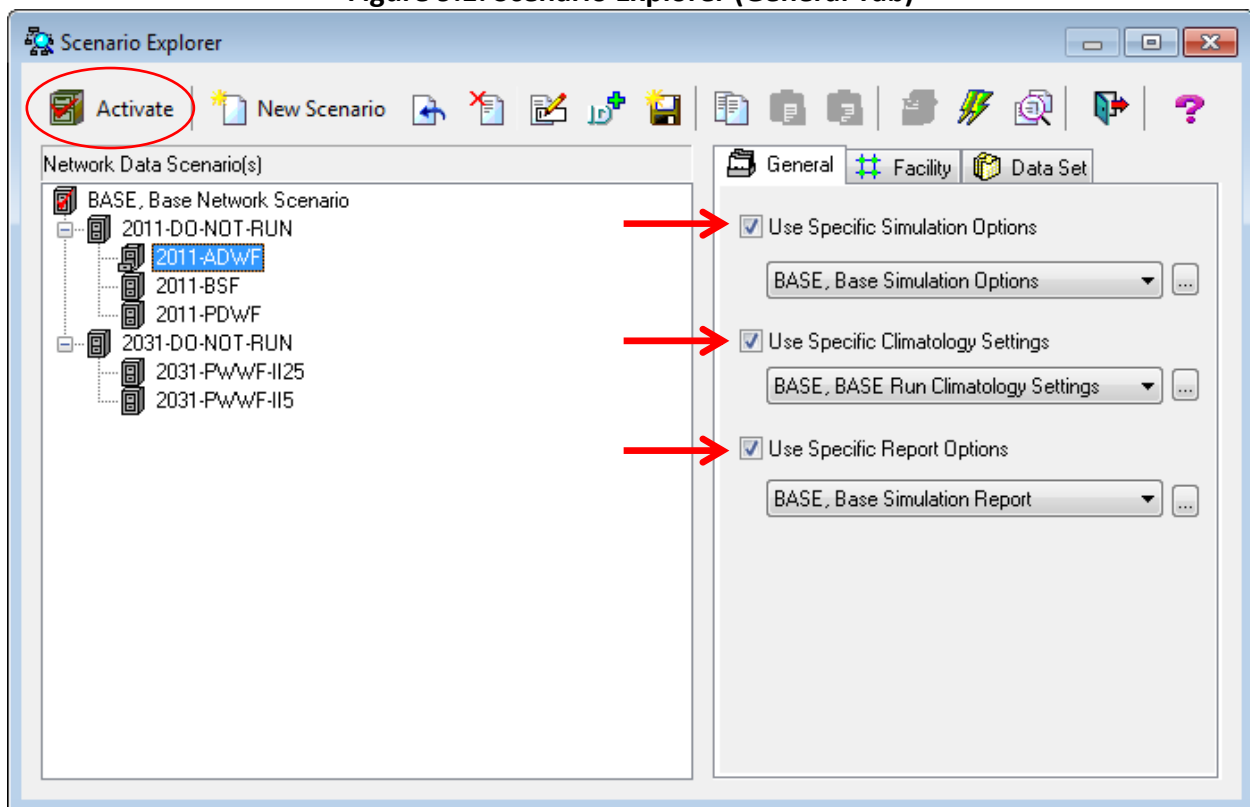
The **Scenario Explorer** is where InfoSWMM allows the user to create, delete and modify Scenarios. The **Scenario Explorer** is what allows the user to create "what if" situations throughout a sewer collection system.

If you do not create any custom scenarios, you are working in the "BASE" scenario by default, which contains all modeled elements.

**(Geo)Advice 70 - Scenarios should be activated from the Scenario Explorer dialog box (see Figure 9.1), and not from the dropdown box located on the Standard toolbar.**

When a new scenario is activated, all unsaved changes to the active data sets are saved. The facility set for the new scenario is then evaluated and applied to all elements meeting the facility set criteria. Finally, active modeling data is replaced with data from the new scenario's data sets.

**Figure 9.1: Scenario Explorer (General Tab)**



**(Geo)Advice 71 - For each Scenario, the "Use Specific Simulation Option" should be checked with the correct Simulation Option Set.**



**(Geo)Advice 72 - For each Scenario, the “Base Run Climatology Settings” should be used.**

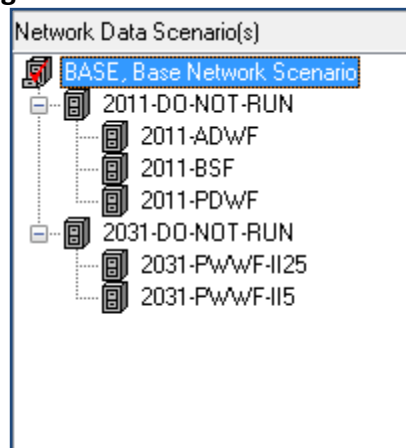
**(Geo)Advice 73 - For each Scenario, the “Use Specific Report Setting” should be checked with the correct Report Set.**

## 9.2 Parent and Child Scenario Conventions

Scenarios are helpful in alternative planning or master planning by developing variations of the same system. As there may be many scenarios in a single model, a proper naming convention must be used to avoid confusion.

Parent scenarios should be named with the simulated year followed by “Title Only, DO-NOT-RUN”. These scenarios should not be run, and are to be used solely for the purpose of creating a group of child scenarios with the same inherited properties. Child scenarios should be named with the simulated year of their parent scenario followed by any additional defining features separated by hyphens (-). **Figure 9.2** shows an example of proper scenario naming conventions.

**Figure 9.2: Parent-Child Scenarios**



Child scenarios will inherit one or more properties from a parent scenario. Typically for one parent scenario there will be multiple child scenarios. This convention is used when multiple scenarios have similar properties. The relationship between child and parent scenarios is dynamic, meaning that a shared property that is changed in the parent scenario will also be changed in the child scenario. If the property is changed in the child scenario instead, the “inheritance” link will be broken.

### 9.3 Facility Selection

When a new scenario is created, there is an option to define how the network components are to be included in the scenario. There are four separate and unique options available for associating a facility set with a scenario. They are as follows:

- **Active Network** - When this option is chosen, InfoSWMM will include the current facility set (what the user has currently created and activated via the **Facility Manager**) in a scenario. All currently activated components (i.e., those in the active facility set - and visible on the map display) at the time the scenario is activated will be included in the scenario.

#### (Geo)Rule 12 - Do not use the Active Network option in InfoSWMM.

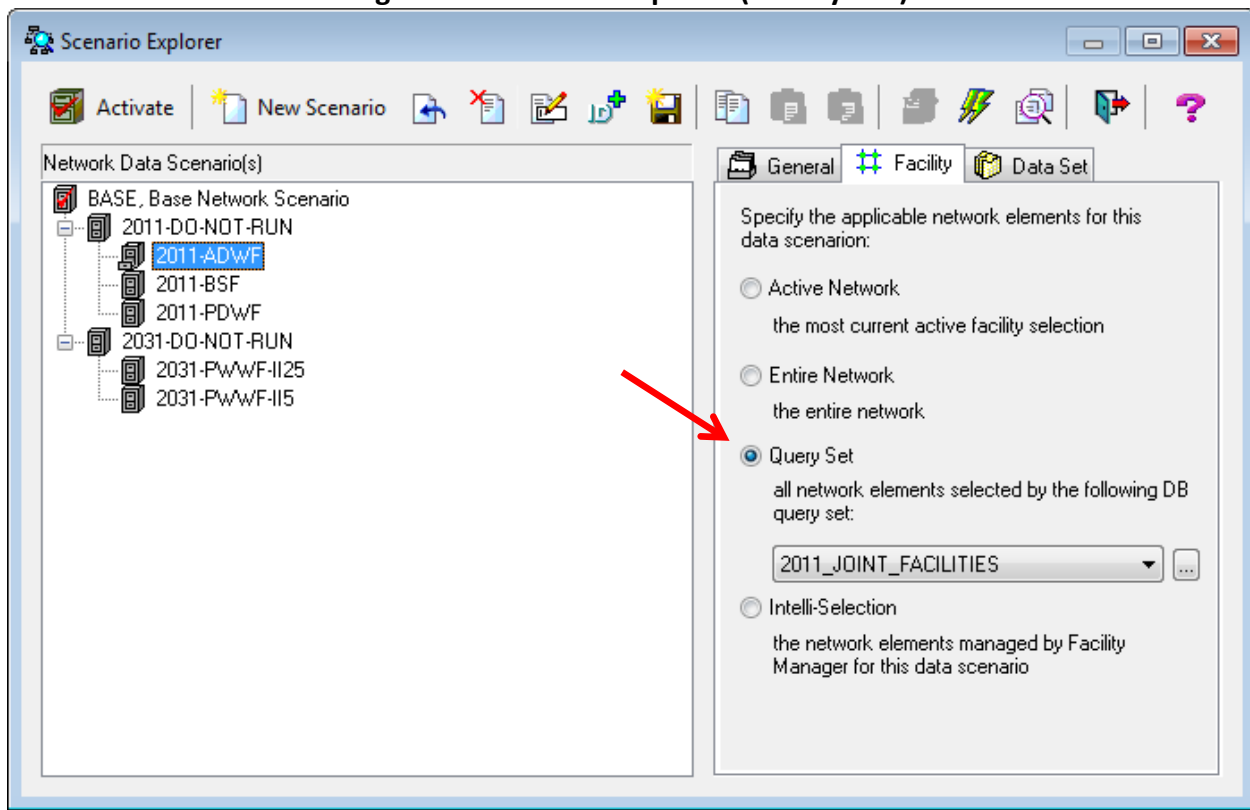
- **Entire Network** - When this option is chosen, InfoSWMM will include the entire network in a given scenario. Therefore, no matter what facilities are active (in the current facility set from the **Facility Manager**) at the time you load the scenario, that facility set will be replaced with a new facility set representing the entire suite of network components in the open InfoSWMM project.
- **Query Set** - When this option is chosen, InfoSWMM will evaluate one or more database statements and all network components meeting those criteria at the time the scenario is activated will be included in the scenario's facility set. Those facilities will be displayed and all facilities not meeting the entered criteria will be disregarded from the simulation and will be removed from the map display.

#### (Geo)Advice 74 - The Query Set option is the recommended method of selecting elements in an active scenario.

- **Intelli-Selection** - This option is like the "Active Network" option, but differs in that the Intelli-Selection remembers the active facility set from the **Facility Manager** and will reinstate that facility set every time the scenario is activated.



**Figure 9.3: Scenario Explorer (Facility Tab)**



**(Geo)Rule 13 - Do not use Intelli-Selection option in InfoSWMM.**

#### 9.4 Dataset Manager

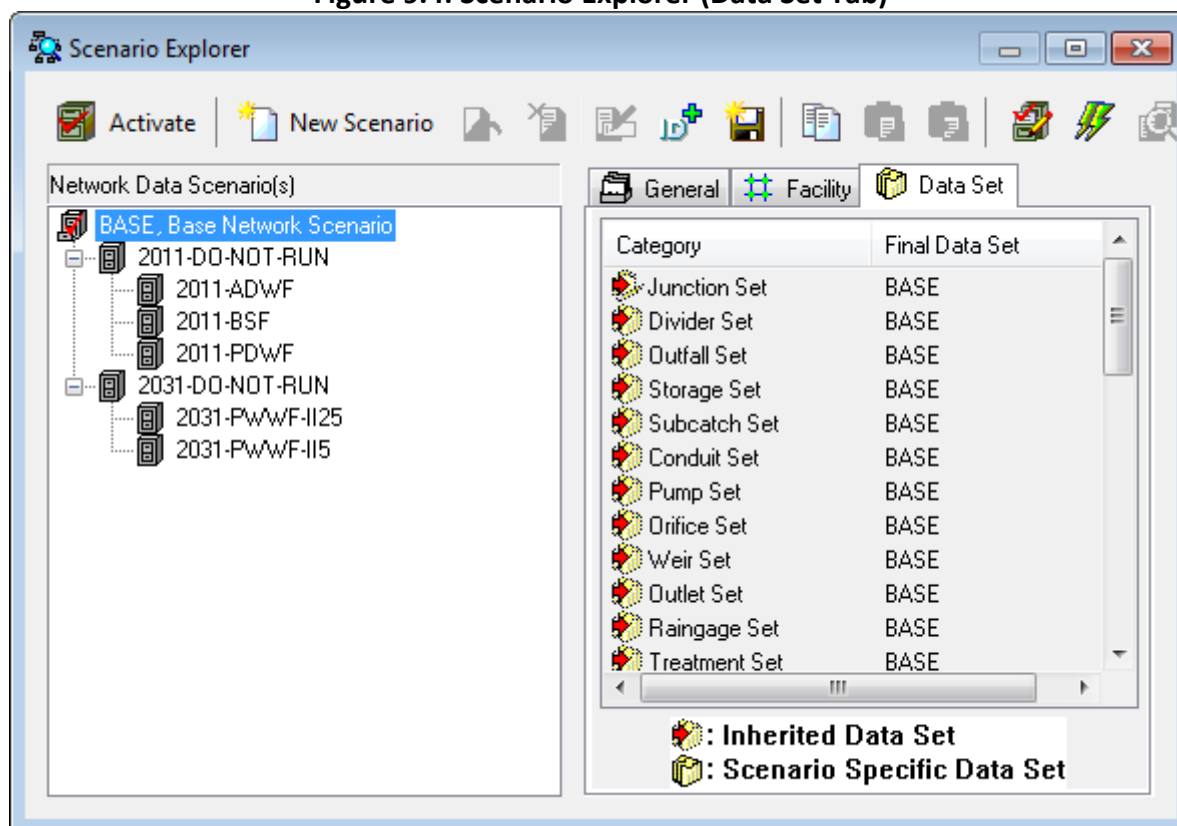
Data sets in InfoSWMM may be used for the following:

- Data sets store all the modeling information relating to the different scenarios in InfoSWMM. For instance, the Junction Set contains all the load information and so on.
- Different scenarios may have different data sets associated with them. For instance Scenario 1 may contain Junction Set 1 and Scenario 2 may contain Junction Set 2 implying that two scenarios may contain completely different loading values for modeling different situations.

**Table 9.1** lists some of the relevant data sets in the City of Merritt’s InfoSWMM model. The data set tab in the **Scenario Explorer** as shown in **Figure 9.4** allows the user to select whether to inherit data set or to create a scenario specific data set for the active scenario. **Figure 9.5** shows the **Dataset Manager** where all the datasets are uniquely described and managed.

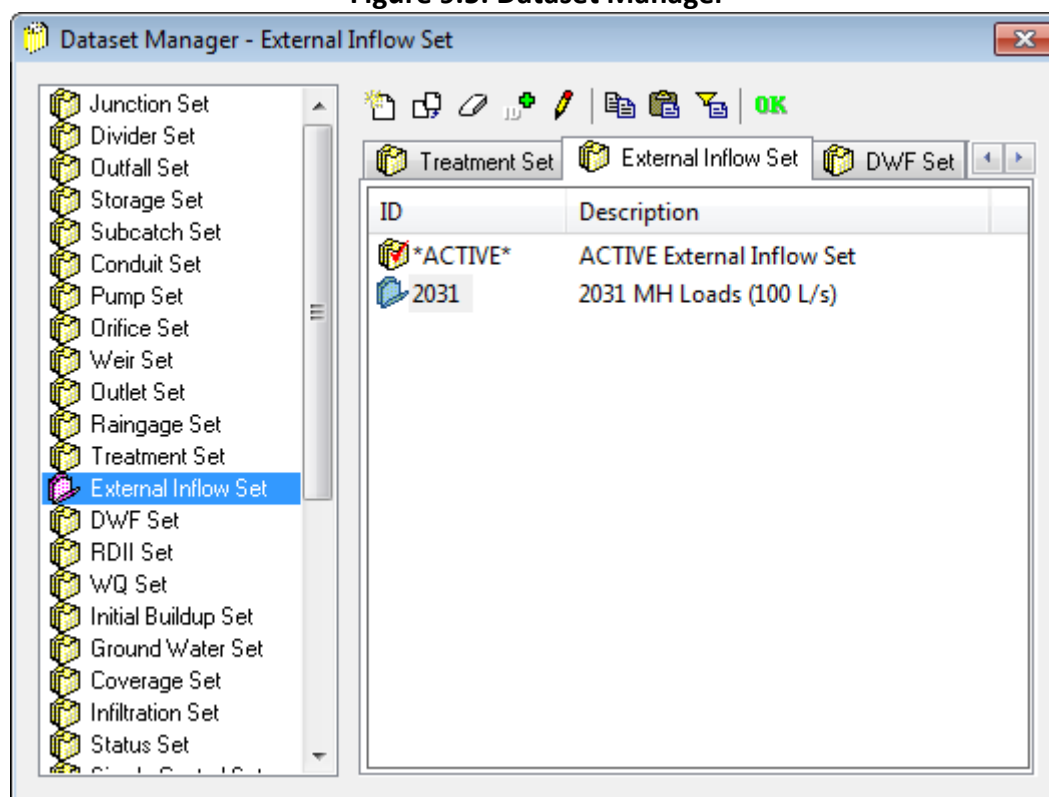
**Table 9.1: Dataset Descriptions Used With Sewer Collection System Models**

Dataset Name	Description
Junction Set	Junction Hydraulic Data
Storage Set	Storage Hydraulic Data
Conduit Set	Conduit Hydraulic Data
Pump Set	Pump Hydraulic Data
Simple Control Set	Initial Status and Control Data
External Inflow Set	Loading Data
RDII Set	RDII Data
Infiltration Set	Infiltration Rate Data
Outfall Set	Outfall Data
Divider Set	Divider Data
Time Series Set	Time Series Data
Curve Set	Curve Data
Pattern Set	Loading Pattern Data

**Figure 9.4: Scenario Explorer (Data Set Tab)**



**Figure 9.5: Dataset Manager**



(Geo)Advice 75 - New data sets should always be cloned from existing data sets. After the new data set is created, use the Copy and Replace commands as well.

(Geo)Advice 76 - External Inflow Sets should include the total load in the description as shown in Figure 9.5.

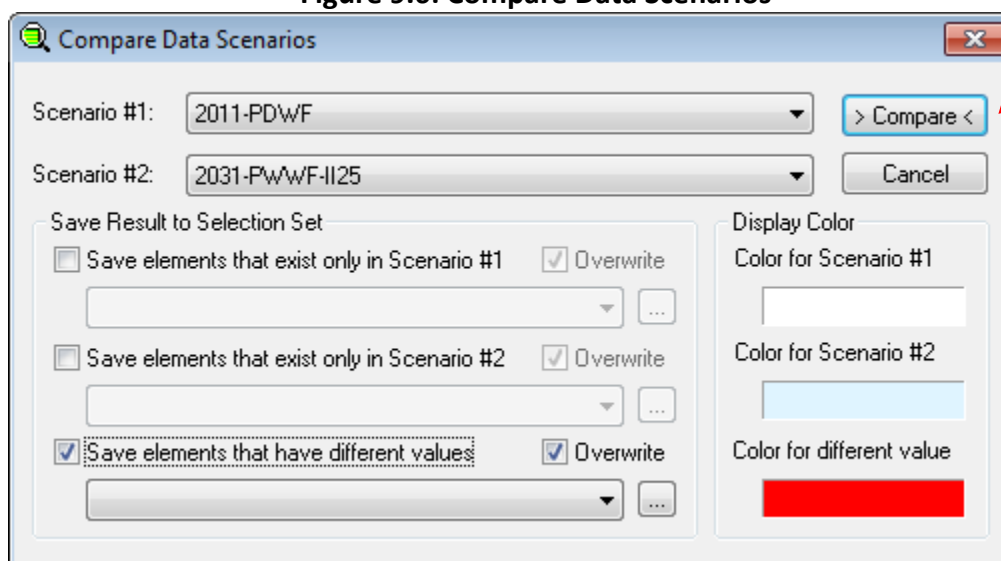
## 9.5 Compare Data Scenarios

InfoSWMM's **Compare Date Scenarios** command allows the user to compare the differences between any two scenarios in a model.

(Geo)Advice 77 - You should not run the “Compare Data Scenarios” tool on an active scenario in InfoSWMM.

If you are currently editing an active scenario, the **Compare Data Scenarios** tool will not record the changes made to your current scenario. Simply activate another scenario so that the changes made to your active scenario are recorded before to run the **Compare Data Scenarios** tool.

**Figure 9.6: Compare Data Scenarios**



(Geo)Advice 78 - Run the “Compare Data Scenarios” tool after adding a new scenario to validate the scenario data sets and facility set.



## 10 HYDRAULIC MODEL PERFORMANCE CRITERIA

### 10.1 Pipe Design Criteria

The modeled analysis should use 5-year 24-hour I&I for determining capacity deficiencies and 25-year 24-hour I&I for designing new facilities.

**Table 10.1: Recommended Design Criteria (Loadings)**

Criteria	Parameter Value
Base Sanitary Flow (BSF)	200 L/d/Cap (Existing) 365 L/d/Cap (Future)
Inflow & Infiltration (I&I)	Assume initially constant I&I rates: <ul style="list-style-type: none"> <li>10,520 L/d/ha (Existing Infrastructure)</li> <li>14,150 L/d/ha (Future Infrastructure)</li> </ul>

**Table 10.2: Design Criteria (New Gravity Mains\*)**

Criteria	Parameter Value
Maximum d/D ratio	$d/D < 0.50$
Hydraulic Grade Line	HGL < Ground elevation
Desired Minimum Velocity	$v > 0.75 \text{ m/s}$
Material	PVC
Roughness Coefficient <ul style="list-style-type: none"> <li>Gravity Main</li> <li>Forcemain</li> </ul>	Manning $n = 0.013$ Hazen William $C = 120$
Minimum Diameter	$d = 200 \text{ mm}$
Maximum Drop Between Pipe Inverts	200 mm
Minimum Depth Of Bury From Finished Ground Elevation To The Top Of The Pipe	1.8 m

\* Assume same slope as existing pipe

**Table 10.3: Minimum Grade (New Gravity Mains)**

Pipe Size (mm)	Minimum Grade (%)
200	0.40
250	0.28
300	0.22
350	0.17
375	0.15
400	0.14
450	0.12
525	0.10
600	0.08

Gravity mains of varying sizes and locations within the system have different requirements for pipe flow capacity. For example, the laterals and collectors at the upstream end of the system are generally designed to flow half-full because service connections cannot back up causing basements to flood. Larger diameter trunks and interceptors generally do not have service connections and surcharging may be allowable or even necessary in order to delay costly system upgrades. For these reasons the 'Hydraulic Level of Service' (HLoS) rating described below should be used.

The HLoS system assigns a rating to each pipe based on three criteria categories:

- Hydraulic Capacity - d/D ratio and/or friction slope in surcharged pipes
- Hydraulic Grade Line - height of HGL with respect to pipe crown and ground elevation
- Velocity - whether minimum scouring velocity is achieved at peak flow

Pipes have been classified in three categories with different requirements for HLoS criteria:

- Laterals/Collectors - 250 mm diameter and smaller
- Trunks - 300-675 mm diameter
- Interceptors - 750 mm diameter and larger

Pipes can then be classified in three categories stated above with different requirements for HLoS criteria. Based on the pipe classification, hydraulic capacity, HGL, and velocity a letter-grade indicating the HLoS rating can be applied.

**Table 10.4: Hydraulic Level of Service Criteria Scoring**

Rating	Lateral/Collector ≤ 250 mm	Trunk 300-675 mm	Interceptor ≥ 750 mm
<b>Hydraulic Capacity</b>			
d/D ≤ 0.7	1	1	1
d/D ≤ 1.0	2	2	2
d/D = 1.0	3	3	2
Friction Slope > Pipe Slope + 0.5 %	-	-	3
<b>HGL</b>			
HGL < Crown	1	1	1
HGL ≤ 0.3 m above Crown	2	1	1
HGL ≤ Ground Elevation	3	2	1
HGL > Ground Elevation	3	3	2
<b>Velocity</b>			
v < 0.75 m/s	Pass	Fail	Fail
v ≥ 0.75 m/s	Pass	Pass	Pass

A letter-grade indicating the HLoS rating is assigned based on the above criteria scores.



The letter grades are described in the following table.

**Table 10.5: Hydraulic Level of Service Ratings**

Grade	Capacity	HGL	Velocity	Description
A	1	1	Pass	Pipe performing as designed
B	1	1	Fail	Adequate capacity, low velocity may indicate potential sedimentation
C	1	2 or 3	N/A	Adequate capacity, downstream condition causing backwater
D	2	N/A	N/A	Marginal capacity
E	3	2	N/A	Capacity exceeded
F	3	3	N/A	Capacity exceeded and overflow likely

In general, ratings A, B, C, and D will not trigger an immediate upgrade as there is capacity in the gravity main to convey flows. A gravity main receiving an E rating requires an upgrade as the gravity main is flowing full. A rating of F indicates a critical downstream condition causing poor performance upstream, increasing the priority of the upgrade at the critical point.

A map of the entire system for each development scenario with associated HLoS ratings should be produced to allow for a better understanding of the type of work that will have to be conducted to ensure the reliability of the system.

Triggers for constructing new projects and prioritizing projects will be based on the following criteria. Projects are assigned a value between 1 (lowest priority) and 4 (highest priority).

**Table 10.6: Project Prioritization Criteria**

Criteria	Priority Score	Action
HLoS = A - D	0	No Action
HLoS = D, E or F in proceeding scenario	1	Low priority for construction, can be delayed with least risk
HLoS = E	2	Project requires upgrading in five-year increment preceding scenario with deficiency
HLoS = E, adjacent pipes with HLoS = D	3	Project requires upgrade, adjacent projects likely require upgrade in next scenario
HLoS = E, upstream pipes with HLoS = C, F	4	Project is causing bottleneck in system and raising risk of overflow
HLoS = F	4	Upgrade required immediately to prevent overflow

## 11 MODEL CALIBRATION

### 11.1 Dry Weather Model Calibration

#### 11.1.1 Calibration Tolerances

Model calibration is done by comparing monitored average flow and peak flows. The sewer model should be calibrated under DWF conditions to the levels specified in **Table 11.1**.

**Table 11.1: Recommended DWF Calibration Accuracy**

Parameter	Recommended Accuracy
Volume of Flow	± 15 %
Peak flow	± 10 %
Peak Timing	± 1 hour
Shape	Representative of observed flow or depth pattern

**(Geo)Advice 79 - As a minimum, DWF calibration should be done to at least one weekday.**

#### 11.1.2 Acquiring Field Data for Calibration

A significant amount of effort during calibration is devoted to correcting modeling errors or missing values in the input or field data. Field data is generally collected using SCADA systems, chart recorders or other types of data loggers. Types of data collected include the following:

- Pump on/off status and flows
- Pump discharge pressures
- Wet well levels
- Pump test data
- Pump control operating procedures

SCADA data is often missing or may be unreliable and should be verified by a second source. Any data abnormalities found during calibration should be brought to the attention of City staff and investigated.

**(Geo)Advice 80 - Flow monitoring stations should be installed at critical locations such as pump stations, flow splits, and high flow areas.**



### 11.1.3 Model Calibration

Modeling input data can be categorized as “hard” and “soft” parameters. Hard parameters are based on physical attributes and generally are not changed during calibration except to correct errors. Soft parameters will have an initial value prior to starting calibration, but are adjusted throughout the calibration process. **Table 11.2** lists recommended hard and soft calibration parameters.

**Table 11.2: Recommended Hard and Soft Calibration Parameters**

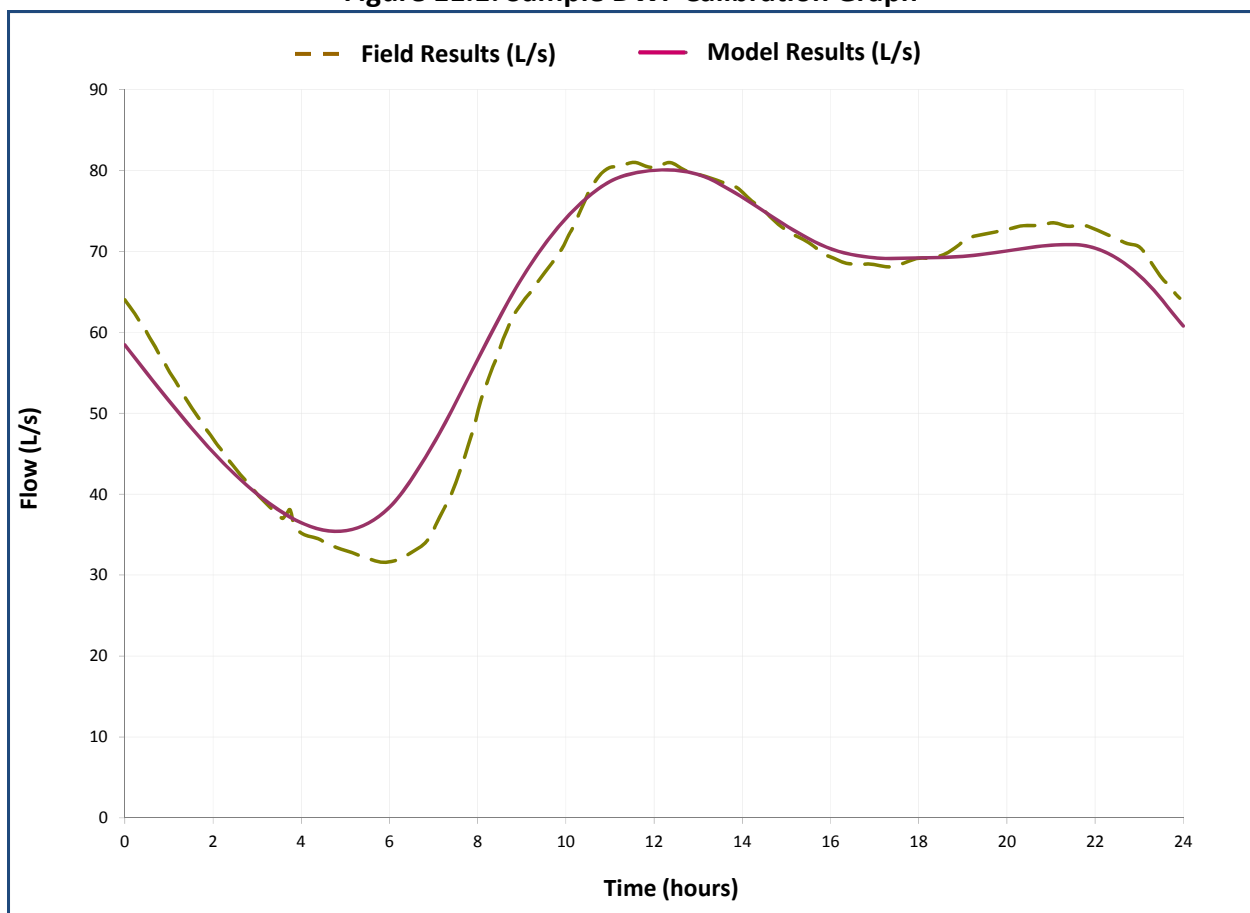
Hard Calibration Parameters	Soft Calibration Parameters
Pipe diameter and connectivity	Roughness coefficient for pipes
Manhole elevation	Sewer load unit rate (L/d/Cap)
Base load	Water to sewer conversion rate
Valve size and type	Load patterns
Wet well volume curves	Operational controls for pumps
Pump curves	Estimated pump curves
	Estimated minor loss factors

The selection of appropriate DWF calibration data is imperative to ensuring the accuracy of the model. DWF days must meet the following criteria:

- No previous rainfall for a duration of at least 1 week - no slow response flows
- Clear diurnal pattern - observed and representative of typical profiles throughout the survey
- Consistent base flow
- All or a majority of critical monitors in operation and providing reliable data.

**Figure 11.1** shows a sample DWF calibration graph.

**Figure 11.1: Sample DWF Calibration Graph**





## 11.2 Wet Weather Model Calibration

### 11.2.1 Calibration Tolerances

The sewer model should be calibrated under WWF conditions to the levels specified in the table below.

**Table 11.3: Recommended WWF Calibration Accuracy**

Parameter	Recommended Accuracy
Volume of Flow	$\pm 20 \%$
Peak flow	$\pm 15 \%$
Peak Timing	$\pm 1$ hour
Shape	Representative of observed flow pattern

## 11.3 Model Validation

The importance of validation should not be underestimated. Calibration is the detailed ‘tuning’ of the model to observed flow. Validation enables a check against different storm events, which in turn gives greater confidence in design storm runs, and different performance.

**Table 11.4: Recommended Validation Accuracy**

Type of Verification	Recommended Accuracy
Volume of Flow	$\pm 25 \%$
Peak flow	$\pm 20 \%$
Peak Timing	$\pm 2$ hour
Shape	Representative of observed flow pattern

## 12 GEOGRAPHIC INFORMATION SYSTEM (GIS) MODEL INTEGRATION

### 12.1 Model versus GIS

InfoSWMM is a sewer collection modeling software running as an add-on application within ArcGIS.

The model should represent a one-to-one match with the City GIS model complete with matching unique identification numbers for each element. Some additional entities will be added to the model in order to satisfy the software requirements for system operation and continuity.

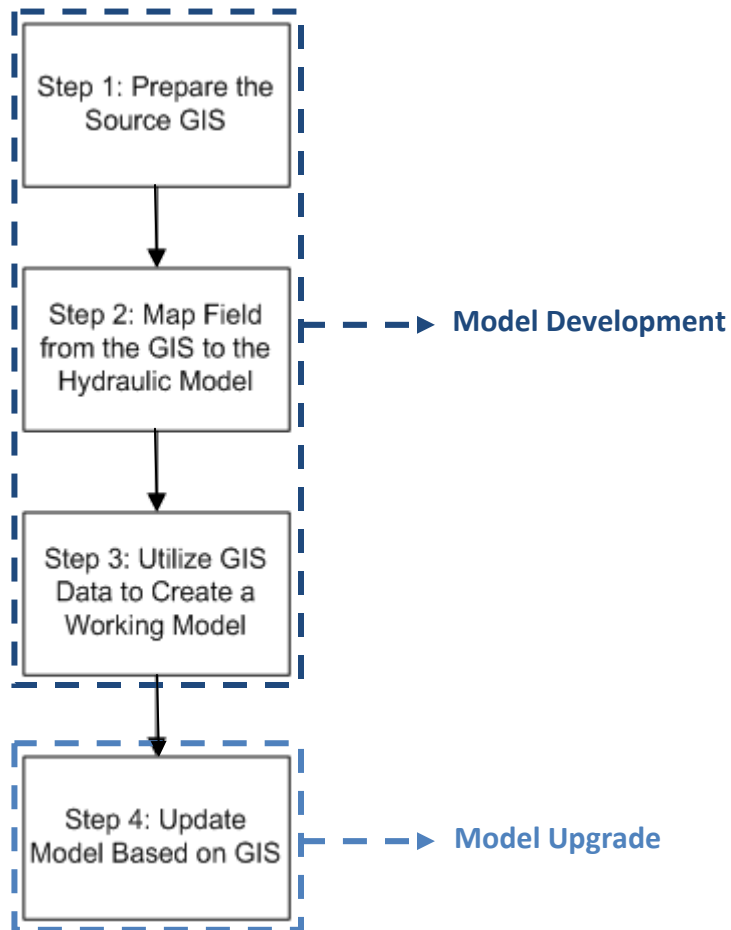
The GIS data should remain the data source of record for the sewer system elements. This allows for consistent tracking of physical changes and avoids the problems created when the model elements do not exactly match the real-world configuration. When errors are encountered in model data, they should be relayed to the GIS system for correction. Many utilities have adopted formal methods of requesting data verification or correction to the GIS but an informal export of model data in a spreadsheet format can also be used. Regardless of the method for data exchange between the model and GIS, it is important to have modelers and GIS experts cross-checking the validity of data and using both systems to troubleshoot problems.

### 12.1 Model Build and Update Using City GIS Data

The following figure illustrates the work flow process for integrating the GIS data with the sewer models. The purpose for GIS model integration is to build and update the models faster and more efficiently. The work flow process involves both the flow of data from the GIS to the hydraulic model and any updates needed for the hydraulic model that should first be made in the GIS.



**Figure 12.1: Work Flow Process Flow Chart**

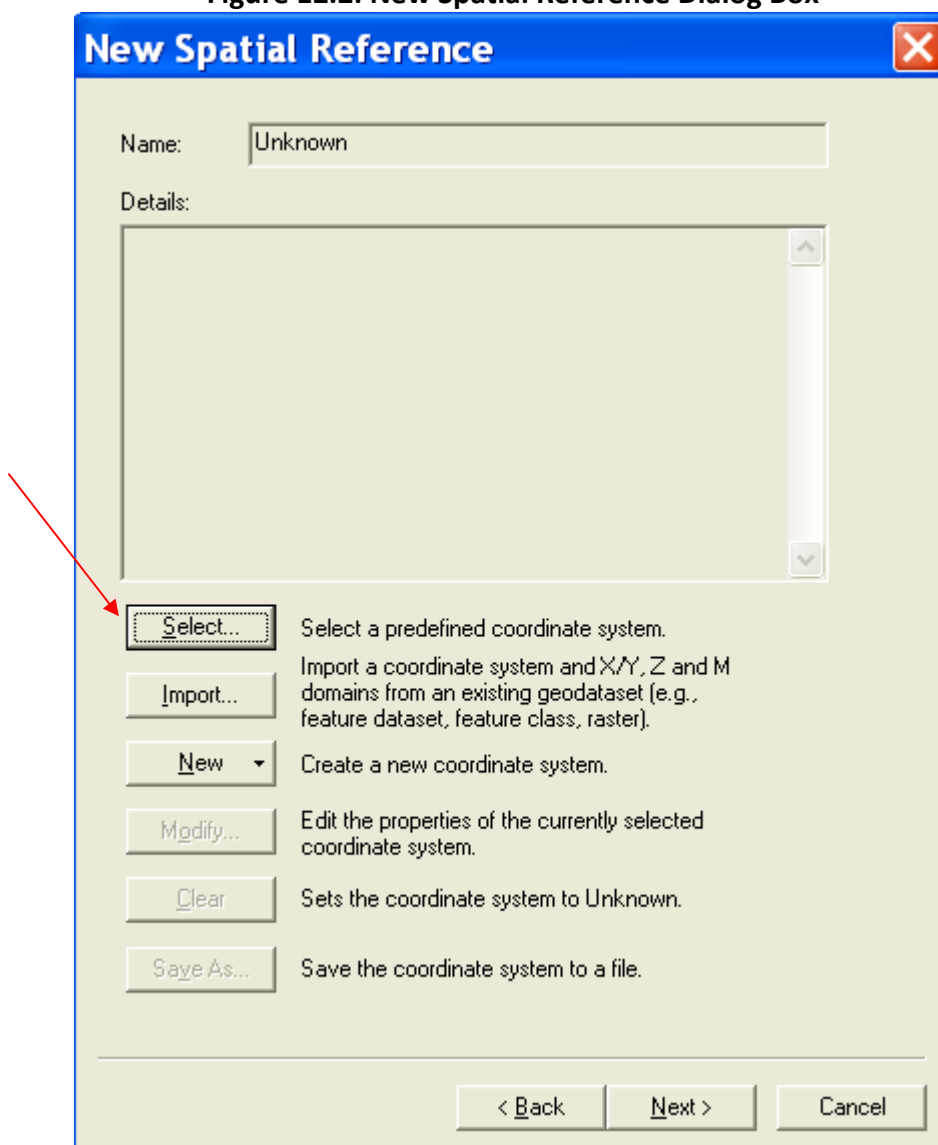


The overall process is composed of four steps. The first three steps describe how to move data from GIS to the hydraulic modeling application. Step 4 involves how the hydraulic model will be updated based on changes made to the GIS. Each of the four process steps is discussed below.

## 12.2 Coordinate System

When a new model/project is created, an option is available to choose the coordinate system of the model. A coordinate system can be user defined or selected from the ArcGIS library. It is very important to select the correct coordinate system, as for the City's model, the predefined "UTM NAD 83 Zone 10" coordinate system should be used.

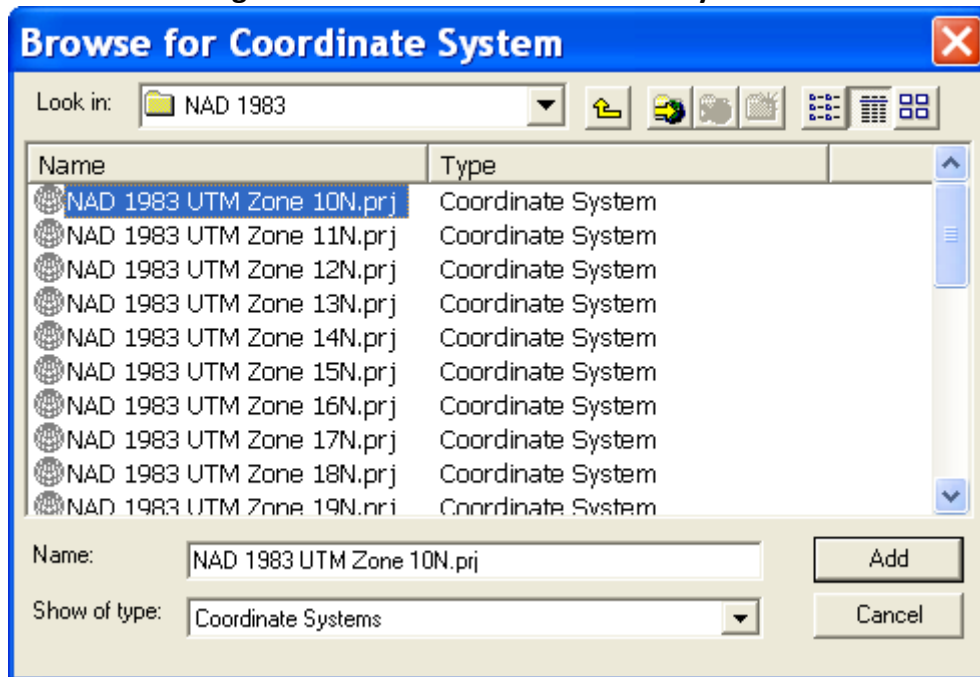
Figure 12.2: New Spatial Reference Dialog Box



It is recommended to select a predefined coordinate system, navigate '**Projected Coordinate System → UTM → NAD 1983 → NAD 1983 UTM Zone 10N.prj**' as shown in **Figure 12.3**.



Figure 12.3: Predefined Coordinate Systems



### Step 1: Prepare the Source GIS

The GIS ID may not be unique across all the feature classes. The first step in integration is to assign unique IDs to the GIS elements to be modeled. This unique ID will be referred to as the City Model ID used for ID Mapping when the model is being created/updated. In this case, all elements in the GIS that contain a City Model ID will be included in the hydraulic models.

The City Model ID must comply with the InfoSWMM ID conventions as follows:

- Up to 32 alphanumeric characters
- No “space” character allowed
- ID must be unique

The GIS contains many feature classes that are not relevant in creating the sewer models. **Appendix A** summarizes the selected feature classes to be used for model development and model integration. Some GIS feature classes may not directly translate to a model element type. In such cases, these feature classes need to be translated to its modeling equivalent.

Not all elements in the GIS will be in the InfoSWMM models. For example, private mains will not be included in the model.

## **Step 2: Map Field from the GIS to the Model**

It is important to identify the key fields needed for the sewer models. Data fields from the GIS are to be mapped to the fields in the InfoSWMM model. Importing elements into the model from the GIS creates a foundation for the model. The model will require additional input from the hydraulic modeler to create a working model such as patterns, curves and controls.

The Data Dictionary Found in **Appendix A** summarizes that data fields required for hydraulic modeling.

## **Step 3: Utilizes GIS Data to Create a Working Model**

There are two methods available in InfoSWMM to build a hydraulic model from the GIS data:

- GIS Gateway
- Import Manager

Refer to **Section 6.5** and **Section 6.8** and the InfoSWMM Users Guide for more information about the **Import Manager GIS** and **Gateway** tools.

### *GIS Network Data Review*

The sewer collection system GIS must be reviewed for discrepancies (e.g. data gaps and connectivity issues) before any data are to be imported to InfoSWMM.

Key items to verify in GIS:

- Ensure all pipes are split at “major” points
- Ensure pipes entering and exiting pumps follow the expected flow of water (pipe digitization direction)
- Address topology and/or connectivity issues
- Track and maintain TO\_NODE and FROM\_NODE for all pipes (optional)

How the sanitary sewer elements are connected together (i.e. their topology) is very important for the InfoSWMM models. The topology shows how sewer flows in the pipes and will affect system hydraulics. Many topological issues are not obvious in map applications and therefore can be easily overlooked in GIS. Connectivity checks should be performed prior to importing the GIS pipe data into the model as outlined in **Section 6.10**.



### *Hydraulic Model Building*

The hydraulic model is built by importing the node/pipe network. The node/pipe network provides a foundation for the model. Once the foundation is set, the facilities such as wet wells and pumps are imported into the model thereafter. Model facilities are high in maintenance and require special considerations. For example, the GIS represents an entire pump station with multiple pumps by a single point feature. Such cases require manual work to identify the suction and discharge nodes in the GIS.

#### **Step 4: Update Model Based on the GIS**

Updating a 1:1 model from the GIS can require significant effort. This can only be accomplished if the GIS has a way of tracking which elements have been modified. Different Utilities have proposed different methods of addressing this issue, but it may be as simple as tracking field called “date last modified” (MM/DD/YYYY) to check modified fields within the GIS or by using a comparison tool such as FME or GeoAdvice Model Comparator to identify changes between data sets. The steps to complete the GIS-to-Model update are summarized below:

1. Save an archive copy of latest model
2. Perform QA and topology checks on new GIS data (New Elements)
3. Import new GIS pipe data to model (New Elements)
4. Remove deleted pipes from model manually (Deleted Elements)
5. Update data for changed pipes in model (Updated Elements)
6. Create/update hydraulic facilities in model
7. Reassign model demands
8. Update scenario specific data
9. Validate model performance
10. Export model specific data back to the GIS

When the GIS data have been updated, the modeler may update the hydraulic model by re-importing the updated GIS data. The modeler may choose to update existing elements and/or create new elements. Step 4 may be subdivided into four scenarios:

### *New Elements*

As the City sewer collection system evolves, it is inevitable to add new pipes in the process of updating the GIS. In such case, the subset of elements added to the GIS will be imported to the hydraulic model.

### *Deleted Elements*

On the same token, pipes and junctions that are no longer in the system may be deleted from the GIS. The modeler would simply delete those elements manually from the model. This is often the safest method to use and is not model intensive because the GIS will not typically have many deleted elements to deal with.

### *Update Elements*

In this scenario, no new pipes are added nor removed from the system. However, minor changes to the pipes also require a change in the model data. A minor change to an element could be a diameter size update, year installation correction, roughness coefficient update, etc. The updated pipes and junctions may be re-imported to the model, updating the existing information but not creating new elements.

### *Create/Update Facilities*

Hydraulic facilities cannot be imported to the model using the importing methods mentioned above. They must be manually added to the model after the modeler has interpreted the modeling equivalence of the facility based on information gathered from the GIS and the field.

Maintaining a 1:1 model from the GIS will require periodic updates. A clear plan needs to be identified for how often updates will occur and how extensive the updates will be. However; it is important to realize that updating a model from the GIS is not simply importing new elements into the model that are in the GIS. Any time the model has been revised, the modeler may need to revisit model load values and load allocations, model operational controls, and may want to validate or recalibrate the model. In addition, the modeler must identify what model scenarios will be included within the updated model. This will require verification of model data sets and model operation to verify the updated model is operating as expected.



### 12.3 GIS Background Layer

**(Geo)Advice 81 - Table 12.1 lists all the recommended GIS background layers used in the model.**

**Table 12.1: Recommended GIS Background Layers**

GIS Background Layer
Cadastral
Contours
Catchments
Municipal Boundaries
Parks
Orthophotos

The GIS background layers can be updated by changing the data source of the GIS layer to the location containing the updated layer. This will preserve the current display settings of that layer within the model.

### 12.4 Bookmarks (ArcView Tool)

Bookmarks can be used to quickly locate a specific area within a hydraulic model. A Bookmark saves the user's current view of the model in the viewing pane and will instantly return the screen to that exact position when the Bookmark is selected.

**(Geo)Advice 82 - Bookmarks should be sorted alphabetically for easy reference.**

**(Geo)Advice 83 - A Bookmark should be created for each hydraulic facility (Pump and Wet Well).**

**(Geo)Advice 84 - A Bookmark should be created for each catchment and sub-catchment.**

**(Geo)Advice 85 - The Bookmark name of a hydraulic facility should correspond to the hydraulic facility location.**

## 13 MODEL MAINTENANCE

The dominant user of the sewer model will likely be the Engineering Department. However, proper documentation of the model is critical to ensure that all users (such as GIS, Infrastructure, Planning, Public Works, Water Quality, and Operations Departments) are aware of the model assumptions and limitations.

Ideally, the City sewer model should be updated every month for changes to the infrastructure, however this is dependent on the rate of growth of the system. Periodic tests to confirm the level of consistency between simulated and actual system performance will help to identify any changes to the collection system that have not been updated in the model. The sewer model should be re-calibrated every year.

If internal resources are not sufficient, the City should consider contracting all or part of the model activities to outside consultants. It is essential that the modeler be properly trained in hydraulic analysis and computer modeling. All users involved in model maintenance should be familiar with this set of standards and conventions.



## 14 CONCLUSIONS

As hydraulic models become more complex, the need for a set of model standards and conventions becomes increasingly important. Applying best practices, following conventions, tracking model changes, and updating model documentation are excellent ways to assure quality and accurate results, increase the user's level of confidence in the model, and better the user's understanding of the model. In the long run, well managed models will reduce the time and effort required for model maintenance, while acquiring more meaningful results.

## APPENDIX A DATA DICTIONARY

**Table A.1: InfoSWMM Junction Data**

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ID	Junction ID	Yes	Alphanumeric	
Description	Description of junction	Yes	Character	
X	X coordinate	Yes	Double	m
Y	Y coordinate	Yes	Double	m
Invert Elevation	Invert elevation	Yes	Double	m
Max Depth	Maximum depth of manhole (ground to invert)	Yes	Double	m
Initial Depth	Initial depth of manhole	Yes	Double	m
Surcharged Depth	Additional depth of water beyond the maximum depth that is allowed before the junction floods	Yes	Double	m
Ponded Area	Area of water allow to pond above manhole	Yes	Double	m <sup>2</sup>
HEADLOSS	Headloss Coefficient of Manhole	Yes	Double	K
LOAD	Load assigned to manhole	Yes	Double	L/s
PATTERN	Diurnal pattern	Yes	Alphanumeric	
Ground Elevation	Manhole ground elevation	No	Double	m
YR_INST	Year of installation	No	Integer	YYYY
YR_RETIRE	Year of retirement	No	Integer	YYYY
ZONE	Existing zoning	No	Alphanumeric	
PHASE	Phase number	No	Integer	
NOTES	Notes for modeling	No	Character	
LANDUSE	Landuse ID	No	Character	
IN_GIS	Does this manhole exist in GIS?	No	Boolean	Yes/No



**Table A.2: InfoSWMM Conduit Data**

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ID	Conduit ID	Yes	Alphanumeric	
Description	Description of conduit	No	Character	
Start Node	Upstream node ID	Yes	Alphanumeric	
End Node	Downstream node ID	Yes	Alphanumeric	
Length	Length of pipe	Yes	Double	m
Manning's	Manning's N coefficient	Yes	Double	
Upstream Offset	Offset of upstream invert elevation	Yes	Double	m
Downstream Offset	Offset of downstream invert elevation	Yes	Double	m
Entry Loss Coeff.	Entry Loss Coefficient	Yes	Double	k
Exit Loss Coeff.	Exit Loss Coefficient	Yes	Double	k
Diameter	Diameter of pipe	Yes	Double	mm
Number of Barrels	Number of identical parallel pipes	Yes	Double	
Shape	Shape type of conduit	Yes	List	
Force Main	Is the conduit a force main?	Yes	Boolean	
FM Roughness	Hazen Williams Coefficient	Yes	Double	
YR_INST	Year of installation	No	Integer	YYYY
YR_RETIRE	Year of retirement	No	Integer	YYYY
ZONE	Existing zoning	No	Character	
PHASE	Phase number	No	Integer	
MATERIAL	Material of conduit	No	Character	
COST_ID	Cost ID of conduit	No	Character	
NOTES	Notes for modeling	No	Character	
ADDRESS	Address of conduit	No	Character	
CATCHMENT	Name of catchment	No	Character	

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ASBUILT	Asbuilt drawing ID	No	Double	
IN_GIS	Does this pipe exist in GIS?	No	Boolean	Yes/No

**Table A.3: InfoSWMM Storage Unit Data**

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ID	Storage Unit ID	Yes	Alphanumeric	
Description	Description of storage unit	No	Character	
X	X coordinate	Yes	Double	m
Y	Y coordinate	Yes	Double	m
Invert Elevation	Invert elevation of the storage unit	Yes	Double	m
Maximum Depth	Maximum depth of storage unit (from ground surface to invert)	Yes	Double	m
Shape Type	Geometric shape of the storage unit	Yes	List	
Ponded Area	Area of ponded water atop the storage unit after flooding occurs	Yes	Double	m <sup>2</sup>
Infiltration	Model volume loss through the bottom of the storage	Yes	Boolean	
YR_INST	Year of Installation	No	Integer	YYYY
YR_RETIRE	Year of Retirement	No	Integer	YYYY
ZONE	Existing Zoning	No	Character	
PHASE	Phase Number	No	Integer	
CATCHMENT	Name of Catchment	No	Character	
IN_GIS	Does this wet well exist in GIS?	No	Boolean	Yes/No



**Table A.4: InfoSWMM Pump Data**

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ID	Pump ID	Yes	Alphanumeric	
Description	Description of pump	No	Character	
Start Node	Upstream node ID	Yes	Alphanumeric	
End Node	Downstream node ID	Yes	Alphanumeric	
Pump Curve ID	ID of the pump curve	Yes	List	
Ideal Pump	Specify whether the pump is an "Ideal Pump".	Yes	Boolean	
Startup Depth	Depth of Storage at the inlet node when pump turns on.	Yes	Double	m
Shutoff Depth	Depth of storage at the inlet node when pump turns off.	Yes	Double	m
YR_INST	Year of installation	No	Integer	YYYY
YR_RETIRE	Year of retirement	No	Integer	YYYY
ZONE	Existing zoning	No	Character	
COST_ID	Cost_ID of pump	No	Character	
PHASE	Phase number	No	Double	
NOTES	Notes for modeling	No	Character	
CATCHMENT	Name of catchment	No	Character	
IN_GIS	Does this pump exist in GIS?	No	Boolean	Yes/No

**Table A.5: InfoSWMM Outfall Data**

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ID	Outfall ID	Yes	Alphanumeric	
Description	Description of outfall	No	Character	
X	X coordinate	Yes	Double	m
Y	Y coordinate	Yes	Double	m
Type	Type of outfall	Yes	List	
Invert Elevation	Invert elevation of outfall	Yes	Double	m
Fixed Stage	Water elevation for a fixed type of outfall	Yes	Double	m
Tide Gate	Presence of tide gate	Yes	Boolean	
YR_INST	Year of installation	No	Integer	YYYY
YR_RETIRE	Year of retirement	No	Integer	YYYY
ZONE	Existing zoning	No	Character	
ASBUILT	Asbuilt drawing ID	No	Double	
PHASE	Phase number	No	Double	
NOTES	Notes for modeling	No	Character	
CATCHMENT	Name of catchment	No	Character	
IN_GIS	Does this pump exist in GIS?	No	Boolean	Yes/No



**Table A.6: InfoSWMM Flow Divider Data**

InfoSWMM Field	Description	Hydraulic Data?	InfoSWMM Format	Unit
ID	Flow divider ID	Yes	Alphanumeric	
Description	Description of flow divider	No	Character	
X	X coordinate	Yes	Double	m
Y	Y coordinate	Yes	Double	m
Type	Type of flow divider	Yes	List	
Invert Elevation	Invert elevation of outfall	Yes	Double	m
Diverting Link	Name of main link receiving the diverted flow	Yes	Alphanumeric	
Max Depth	Ground to invert elevation (depend on Operation Settings)	Yes	Double	m
Surcharged Depth	Additional depth of water beyond the maximum depth that is allowed before the divider floods	Yes	Double	m
Ponded Area	Area of water allow to pond above manhole	Yes	Double	m <sup>2</sup>
YR_INST	Year of installation	No	Integer	YYYY
YR_RETIRE	Year of retirement	No	Integer	YYYY
ZONE	Existing zoning	No	Character	
ASBUILT	Asbuilt drawing ID	No	Double	
PHASE	Phase number	No	Double	
NOTES	Notes for modeling	No	Character	
CATCHMENT	Name of catchment	No	Character	
IN_GIS	Does this pump exist in GIS?	No	Boolean	Yes/No

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## APPENDIX E LIST OF ABBREVIATIONS

<b>ADWF</b>	Average Dry Weather Flow
<b>BSF</b>	Base Sanitary Flow
<b>DEM</b>	Digital Elevation Model
<b>DWF</b>	Dry Weather Flow
<b>EPS</b>	Extended Period Simulation
<b>GIS</b>	Geographic Information System
<b>GW</b>	Ground Water Infiltration
<b>I&amp;I</b>	Inflow & Infiltration
<b>MIF/MID</b>	Map Information File
<b>ODBC</b>	Open Database Connectivity
<b>PBSF</b>	Peak Base Sanitary Flow
<b>PWWF</b>	Peak Wet Weather Flow
<b>PWWF<sub>25</sub></b>	Peak Wet Weather with Flow 25-year I&I
<b>PWWF<sub>5</sub></b>	Peak Wet Weather with Flow 5-year I&I
<b>RDI&amp;I</b>	Rainfall Dependent Inflow & Infiltration
<b>SCADA</b>	Supervisory Control and Data Acquisition
<b>SS</b>	Steady State
<b>WWF</b>	Wet Weather Flow

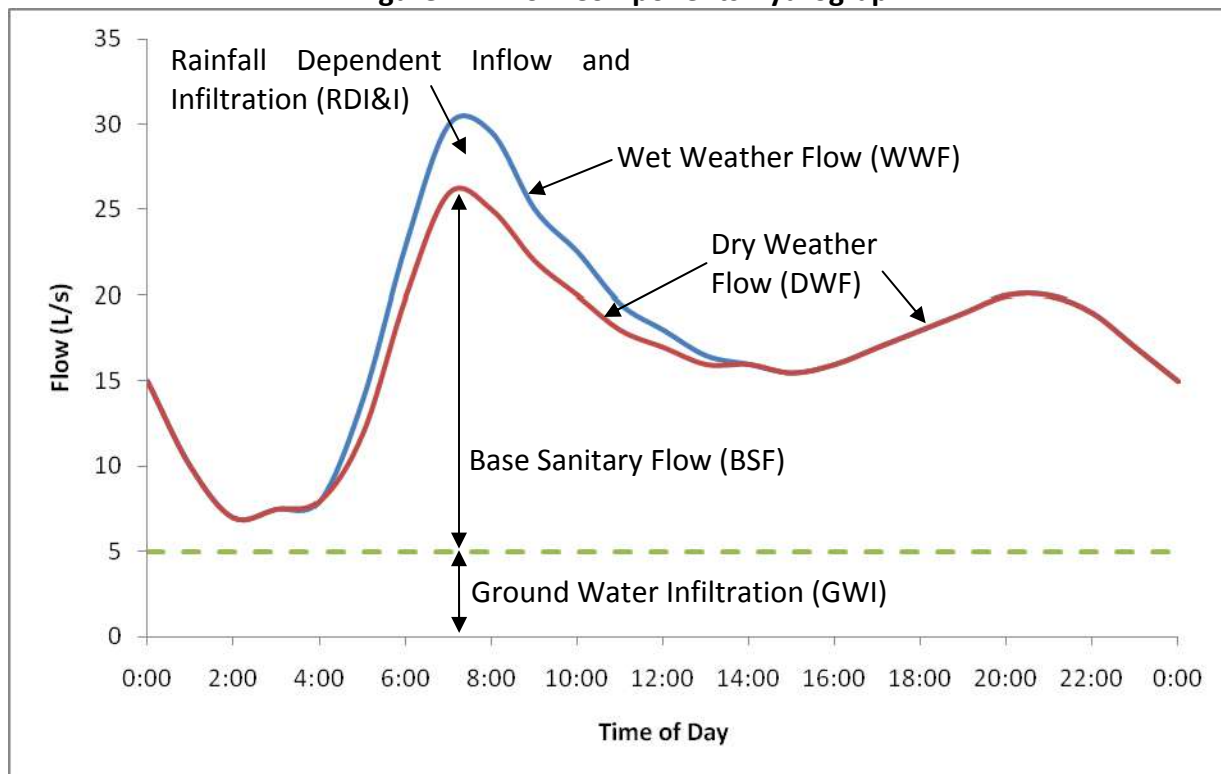
## APPENDIX F DEFINITIONS

Daily flow conveyed in a sanitary sewer system can be generally divided into 5 components:

- Ground Water Infiltration (GWI)
- Base Sanitary Flow (BSF)
- Dry Weather Flow (DWF)
- Rainfall Dependent Inflow and Infiltration (RDI&I)
- Wet Weather Flow (WWF)

Their relationship is shown in **Figure F.1**.

**Figure F.1: Flow Components Hydrograph**



The Metro Vancouver has provided definitions for those flow components. These definitions can be found in the *Inflow and Infiltration Reduction Program I/I Analysis Results: 1993 - 1994 Flow Monitoring Sites Volume I, January 1995* and are also listed below. These definitions are applied in this report.



### **Ground Water Infiltration (GWI)**

Ground water infiltration results from the movement of ground water in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table.

### **Base Sanitary Flow (BSF)**

All wastewater from residential, commercial, institutional, and industrial sources that the sanitary sewer system is intended to carry.

### **Dry Weather Flow (DWF)**

The portion of the total flow that is composed of BSF and GWI. Metro Vancouver defines dry weather flow week as the seven days including weekends with the lowest average flow.  $DWF = GWI + BSF$ .

### **Average Dry Weather Flow (ADWF)**

The daily average value of the diurnally varying Dry Weather Flow, averaged over a 24-hour period.

### **Rainfall Dependent I&I (RDI&I)**

Rainfall dependent inflow and infiltration equals rainfall-induced infiltration plus all sources of inflow.

### **Wet Weather Flow (WWF)**

All flow contributions carried by the sanitary sewer system during wet weather.  $WWF = GWI + BSF + RDI\&I$ .

### **Peak Wet Weather Flow (PWWF)**

All flow contributions carried by the sanitary sewer system during peak wet weather.

### **Peak Wet Weather Flow 5-year I&I (PWWF<sub>5</sub>)**

All flow contributions carried by the sanitary sewer system during a 5-year return storm event.

### **Peak Wet Weather Flow 25-year I&I (PWWF<sub>25</sub>)**

All flow contributions carried by the sanitary sewer system during a 25-year return storm event.

## APPENDIX G SUMMARY OF (GEO)RULES AND (GEO)ADVICES

### 1 Introduction

(Geo)Rules denote standards and conventions to be used with all City of Merritt InfoSWMM models, and are immutable unless first discussed with the City of Merritt.

(Geo)Advice highlights information useful to the modeler and techniques which are recommended, however not mandatory.

### 2 Rules for Using the City of Merritt InfoSWMM Models

(Geo)Rule 1 - The coordinate system used for the model is UTM NAD 83 Zone 10.

(Geo)Rule 2 - All elevations are measured using the geodetic datum.

(Geo)Rule 3 - The unit system used in the City's model must be SI Metric as in Table 2.1.

(Geo)Advice 1 - No modifications should be made to the existing elements unless the change is specified in the City GIS or by the City staff.

(Geo)Advice 2 - It is not recommended to insert nodes into an existing pipe.

(Geo)Advice 3 - The InfoSWMM element ID is limited to 32 characters in length (the space character is not allowed).

(Geo)Rule 4 - Existing element IDs are composed of an element type prefix and a location identifier for facilities (wet well, pump, etc.) or a unique numerical identifier for conduits and junctions separated by a dash.

(Geo)Rule 5 - The model ID for proposed elements is composed of an element type prefix, a prefix "P-" (Proposed) and a location identifier for facilities (wet well and pump) or a unique numerical identifier for conduits and junctions.

### 3 Physical Data

(Geo)Advice 4 - Known surcharge locations, pipe splits and diversions etc. should be reviewed in the field.

(Geo)Advice 5 - The actual diameter of the manhole should be supplied through the City GIS database and if not available use a default diameter of 1.05m which corresponds to a surface area of 0.866m<sup>2</sup> (refer to Section 5.1.3).

(Geo)Advice 6 - Manhole ground elevations should be supplied through the City GIS database and if not available by interpolating from ground elevation contours or DEM.

(Geo)Advice 7 - The use of dummy junctions should be avoided wherever possible.

(Geo)Advice 8 - The Manning equation is employed for gravity mains while the Hazen-Williams equation is used for force mains.

(Geo)Advice 9 - Nominal pipe diameters to be used for gravity and force mains.

(Geo)Advice 10 - In InfoSWMM, user can add identical parallel pipes by setting the number of barrels in the Attribute Browser as shown in Figure 3.2.

(Geo)Advice 11 - Connectivity around all facilities should be manually checked against GIS and available drawings.



(Geo)Rule 6 - If the City GIS supplies pipe material and/or roughness values these must be input into the model.

(Geo)Advice 12 - If only the pipe material is supplied then Table 3.1 should be used to generate appropriate roughness coefficients.


(Geo)Advice 13 - There will be areas where inverts will obviously be incorrect for whatever reason. These values should be 'cleaned up' and appropriately flagged to the City.

(Geo)Advice 14 - Minor losses should not be neglected at pump stations with higher velocities and many fittings and is modeled using the conduit entry and loss coefficients in InfoSWMM.

(Geo)Advice 15 - Centerline elevation of the pump should be used to define the pump elevation parameter.

(Geo)Advice 16 - Pumps should be tested after a certain period of time to indicate if its curve (flow vs. head) still agrees with the manufacturer's pump curve.

(Geo)Advice 17 - The pump station design documents and operation logs should be reviewed. Pump curve, wet well invert, volume, drawings, and start stop levels must be used in the model.

(Geo)Advice 18 - The default pump speed setting is one (pump speed ratio of 1). Select a pump and click the pump efficiency icon  to change the speed ratio.

(Geo)Advice 19 - There should be at least one outfall node in the model.

(Geo)Advice 20 - In the event of missing information, free discharge should be assumed at the outfalls.

(Geo)Advice 21 - Flow divider data should be manually field verified.

(Geo)Advice 22 - No more than two links can leave a flow divider in InfoSWMM.

(Geo)Advice 23 - The modeler should not 'force fit' the flow volumes within flow splits.

#### 4 Non-Physical Data

(Geo)Rule 7 - The base sanitary loading rate is assumed to be 200 L/d/cap.

(Geo)Advice 24 - For calculating the I&I unit rates in L/d/ha (GWI and RDI&I), use the catchment contributing area instead of the total catchment area. The contributing area should only consist of land that generates flow to the sewer collection system.

(Geo)Advice 25 - Future total catchment areas should be determined using elevation contours which show all lands that can drain into the sewer collection system.

(Geo)Advice 26 - If the manhole cover is completely sealed, set Surge Depth to a dummy value of 999m.

(Geo)Advice 27 - The default manhole Surge Depth should be set to "0" as most of the City's manholes are unlocked and not sealed.

(Geo)Advice 28 - RDI&I is combined with GWI to form a constant inflow and infiltration rate which is then assigned to the manholes in InfoSWMM.

(Geo)Advice 29 - The I&I rates are applied to the model based on the following City standards:

**(Geo)Advice 30** - The default startup and shutdown node depth can be set in the pump's attribute browser.

**(Geo)Advice 31** - It is important to set the Rule Priority for each rule so as to keep track of what rules are used during simulations.

**(Geo)Advice 32** - Pattern and curve descriptions should include the pattern/curve type as well as the units of the data.

**(Geo)Advice 33** - InfoSWMM only allows stepwise patterns.

**(Geo)Advice 34** - In Time Patterns, the X axis always represents the time.

**(Geo)Advice 35** - Table 4.2 lists the suggested Pattern prefix definitions.

**(Geo)Advice 36** - Use the following diurnal patterns (Figure 4.4 to Figure 4.8) if none is available.

**(Geo)Advice 37** - Table 4.4 lists the suggested Curve prefix definitions.

## **5 Simulation**

**(Geo)Rule 8** - Table 5.1 shows the Simulation Options that must be used with the City of Merritt sewer models.

**(Geo)Advice 38** - Set option to report all nodes and links.

**(Geo)Advice 39** - Always review modeling results to make sure that they are reasonable.

## **6 Advanced Modeling Data and Tools**

**(Geo)Advice 40** - Table 6.1 lists the recommended DB Query prefix definitions.

**(Geo)Advice 41** - DB Queries should always be validated by clicking the "Validate" button in the DB Query editing window.

**(Geo)Advice 42** - To validate a Selection Set, use the Domain Manager. In addition, Selection Sets should have descriptions.

**(Geo)Advice 43** - DB Queries should be used instead of Selection Sets.

**(Geo)Advice 44** - It is recommended that the "Store Absolute Conduit Invert" be checked. All link offsets will be stored as absolute elevations and not depth offsets.

**(Geo)Advice 45** - It is recommended that the "Store Absolute Junction Rim" be checked. The rim elevation of the manholes will be in absolute elevation and not maximum depth.

**(Geo)Advice 46** - It is recommended that the "Allow Project Database Editing Buffer (Virtual DB)" be checked. This option allows the creation of a backup of the Project Database.

**(Geo)Advice 47** - Check the "Draw Inactive Elements in Inactive Color" option in Project Preferences - Display Setting tab to display inactive elements on the map.

**(Geo)Advice 48** - The Import Manager and Export Manager tools are the recommended methods of importing and exporting ESRI Shape files.

**(Geo)Advice 49** - Only one database table can be imported or exported at a time as each table requires a separate file.



**(Geo)Advice 50** - Only currently active components of the model are exported through the Export Manager.

**(Geo)Advice 51** - Always click on the “Zoom to Domain” button  to validate the domain that has been added.

**(Geo)Advice 52** - The Facility Manager should not be used if possible. Instead, use the Scenario Explorer with Query Sets to create a new scenario with a customized facility set.

**(Geo)Advice 53** - The GIS Gateway tool is the recommended method of importing and exporting ESRI Geo-Databases.

**(Geo)Advice 54** - The Change ID tool should not be used unless the ID change is required by the City staff.

**(Geo)Advice 55** - When correcting the connectivity of imported GIS data, always add the results to the Domain and review yourself. Correct the issues only after the City has reviewed them.

**(Geo)Advice 56** - The tolerance for locating conduit split candidates should be 0.1 m.

**(Geo)Advice 57** - The tolerance for locating nodes in close proximity should be 0.1 m.

**(Geo)Advice 58** - In many cases, model data may not be complete. However, it may be inferred to satisfy data requirements for hydraulic modeling. Inferred data should be appropriately reported to the City.

**(Geo)Advice 59** - The “Clean” command should be followed by the “Pack” command in InfoSWMM. Do not use the other commands under the Database menu.

## **7 Project Management**

**(Geo)Rule 9** - To ensure adequate model data control, as well as aid future model users, it is required that the model changes are appropriately logged within an external document.

**(Geo)Advice 60** - The number of logs should be kept to a minimum and any redundant information removed from the tracking system.

**(Geo)Advice 61** - Any data that is changed from the original data import should be appropriately tracked to represent the source and confidence of the data.

**(Geo)Advice 62** - All notes input by the modeler should be prefixed with the modeler’s or company’s initials. (e.g. “GA -” for all notes input by GeoAdvice).

**(Geo)Rule 10** - A backup copy of the model must be made before every editing session so that old data may be recovered if necessary.

## **8 Load Calculation and Allocation**

**(Geo)Rule 11** - The City geocoded metered billing data must be used in the model to represent the Base Sanitary Flow (BSF).

**(Geo)Advice 63** - The average of pattern multipliers to be applied to the base load should equal to one (only applies for load pattern).

**(Geo)Advice 64** - Non-loading nodes are excluded from the allocation process.

**(Geo)Advice 65** - The meter loads should be allocated to the upstream manhole of the selected pipe.

**(Geo)Advice 66** - It will be initially assumed that 90 % of water consumption is converted to sanitary flows (Conversion rate to be validated during calibration).

**(Geo)Advice 67** - If needed, the top 20 meter loads (annual volume) should be validated manually to ensure that the loads are allocated to the correct manhole.

**(Geo)Advice 68** - Load allocation for future scenarios should be calculated using the future BSF rate of 365 L/d/Cap.

**(Geo)Advice 69** - Future population should be estimated with population density values found in Table 8.3 and/or growth projections from past City population numbers.

## **9 Scenarios**

**(Geo)Advice 70** - Scenarios should be activated from the Scenario Explorer dialog box (see Figure 9.1), and not from the dropdown box located on the Standard toolbar.

**(Geo)Advice 71** - For each Scenario, the “Use Specific Simulation Option” should be checked with the correct Simulation Option Set.

**(Geo)Advice 72** - For each Scenario, the “Base Run Climatology Settings” should be used.

**(Geo)Advice 73** - For each Scenario, the “Use Specific Report Setting” should be checked with the correct Report Set.

**(Geo)Rule 12** - Do not use the Active Network option in InfoSWMM.

**(Geo)Advice 74** - The Query Set option is the recommended method of selecting elements in an active scenario.

**(Geo)Rule 13** - Do not use Intelli-Selection option in InfoSWMM.

**(Geo)Advice 75** - New data sets should always be cloned from existing data sets. After the new data set is created, use the Copy and Replace commands as well.

**(Geo)Advice 76** - External Inflow Sets should include the total load in the description as shown in Figure 9.5.

**(Geo)Advice 77** - You should not run the “Compare Data Scenarios” tool on an active scenario in InfoSWMM.

**(Geo)Advice 78** - Run the “Compare Data Scenarios” tool after adding a new scenario to validate the scenario data sets and facility set.

## **10 Hydraulic Model Performance Criteria**

### **11 Model Calibration**

**(Geo)Advice 79** - As a minimum, DWF calibration should be done to at least one weekday.

**(Geo)Advice 80** - Flow monitoring stations should be installed at critical locations such as pump stations, flow splits, and high flow areas.

### **12 Geographic Information System (GIS) Model Integration**



**(Geo)Advice 81 - Table 12.1 lists all the recommended GIS background layers used in the model.**

**(Geo)Advice 82 - Bookmarks should be sorted alphabetically for easy reference.**

**(Geo)Advice 83 - A Bookmark should be created for each hydraulic facility (Pump and Wet Well).**

**(Geo)Advice 84 - A Bookmark should be created for each catchment and sub-catchment.**

**(Geo)Advice 85 - The Bookmark name of a hydraulic facility should correspond to the hydraulic facility location.**

## **13 Model Maintenance**

## **14 Conclusions**

### **APPENDIX A Data Dictionary**

### **APPENDIX B References**

### **APPENDIX C List of Tables**

### **APPENDIX D List of Figures**

### **APPENDIX E List of Abbreviations**

### **APPENDIX F Definitions**

### **APPENDIX G Summary of (Geo)Rules and (Geo)Advices**