Municipality of Crowsnest Pass

Wastewater Collection System Master Plan

Final Report

February 2008

Executive Summary

Stantec Consulting Ltd. was retained by the Municipality of Crowsnest Pass to complete a comprehensive Master Plan for the wastewater collection system. The objectives of this Master Plan include assessing the performance of the existing system, identifying system deficiencies, and developing a long-term system growth strategy as well as a 20-year Capital Improvement Program (CIP) for the sustainable growth and development of the Municipality of Crowsnest Pass.

A hydraulic model was developed to analyze the performance of the existing collection system network. The model was developed using existing GIS databases, as-built drawings, data extracted from an older spreadsheet model (by others), and numerous field measurements. Although the model does not represent the exact physical characteristics of the wastewater collection system, it provides a conceptual representation the actual collection system that adequately meets the analysis needs of a master planning study. Subsequent detailed analysis of the wastewater collection system will require significant data collection on manhole and pipe invert and rim elevations. As such, it is recommended that a comprehensive survey of the wastewater collection system should be carried out to complete the database for the wastewater collection system. This effort will verify the connectivity of the collection system network and the associated pipe slopes and capacities. The collected data should be used to update the wastewater collection system model and databases. Costs to complete these surveys are unknown at this time.

The existing wastewater system was analyzed using the hydraulic model to measure the performance of the wastewater system under various conditions, including dry weather and wet weather conditions in order to develop a list of system deficiencies. System performance was also tested for the future system under dry weather and wet weather conditions with the additional sanitary loading from proposed future growth areas. The model was then used to evaluate improvement options for the various deficiencies and to develop wastewater servicing strategies for the future growth areas. Flow monitoring should be continued throughout the Municipality on an annual basis to confirm sewage generation rates and wet weather flow contributions in each community. Verified flow monitoring data should be used to update the wastewater collection system model in order to further refine proposed upgrades and improve operational performance of the wastewater system. Approximately $20,000 per year should be allocated to flow monitoring and data retrieval and analysis efforts.

The findings of the existing and future system assessments suggest several projects for inclusion within the capital improvement plan. The intent of these plans is to outline construction priorities based upon the present and future needs of the utility and the Municipality as a whole.

A specific list of prioritized capital projects including their cost and the triggers that will determine the timing of implementation are provided in Section 6. The short-term capital improvement plan to address existing system deficiencies include three projects as follows (listed in order of importance):

- Bellevue Inverted Siphon Upgrade — Estimated Capital Cost = $1,200,000
- Riverbottom Lift Station Upgrade — Estimated Capital Cost = $310,000
- Coleman Trunk Improvements — Estimated Capital Cost = $950,000

Total Estimated Capital Cost (Short-Term Capital Plan) = $2,460,000

The long-term capital plan to accommodate future development with existing infrastructure includes four trunk improvements in the existing system, required as future development is anticipated:

- Sentinel Trunk — Estimated Capital Cost = $10,790,000
- Blairmore-Coleman Interconnection — Estimated Capital Cost = $10,160,000
- Bellevue Trunk Upgrades — Estimated Capital Cost = $660,000
- Hillcrest Trunk Upgrades — Estimated Capital Cost = $770,000

Total Estimated Capital Cost (Growth Related Capital Improvement Plan) = $22,380,000

In addition to these improvements to the existing system, future development will also require significant infrastructure investment to support this growth. A conceptual growth servicing strategy is provided for future growth areas, noting the approximate costs to provide these integral services. Unit costs are calculated for each growth area in order to provide information in determining an approximate offsite funding requirement in each area. The total projected cost to construct infrastructure to support the development of the proposed 1,800 ha of developable area within the Municipality of Crowsnest Pass is $46,580,000. This equates to approximately $26,500 per hectare of developable land. However, the flows that result from the development of the proposed lands will exceed the capacity of the Existing Frank Wastewater Treatment Plant (WWTP). If the estimated cost to upgrade to the existing WWTP ($35,000,000) are included in the overall development costs, the cost per hectare of developable land increases to $46,000 per hectare.

The individual area offsite costs (on a per hectare basis) are summarized as follows:

Area Description	Area (ha)	Cost per hectare (not incl WWTP upgrade)	Cost per hectare (incl WWTP upgrade - $35,000,000)
Sentinel Growth Area	854	$36,000 / ha	$67,000 / ha
Coleman-Blairmore Growth Area	757	$16,000 / ha	$28,000 / ha
Bellevue Growth Area	100	$18,000 / ha	$18,000 / ha
Hillcrest Growth Area	50	$32,000 / ha	$32,000 / ha
Total	**1,761**	**$26,500 / ha**	**$46,000 / ha**

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1.0 Introduction

1.1 STUDY BACKGROUND

Stantec Consulting Ltd. was retained by the Municipality of Crowsnest Pass to complete a comprehensive Master Plan for the wastewater collection system. The objectives of this master plan include assessing the performance of the existing system, identify system deficiencies, and develop a long-term system growth strategy and 20-year Capital Improvement Program (CIP) for the sustainable growth and development of the Municipality of Crowsnest Pass.

The Wastewater Master Plan includes an assessment of the wastewater collection and pumping systems for the communities of Coleman, Blairmore, Belleview, Hillcrest, Frank and Sentinel. The scope of this study does not include an assessment or identify any existing deficiencies at the Frank Main Wastewater Treatment Plant or the Belleview Sewage Treatment Lagoons. An assessment of these facilities has been completed as a separate activity.

1.2 METHODOLOGY

The Wastewater Master Plan for the Municipality of Crowsnest Pass consisted of 5 tasks, and are documented as sections within this report.

1.2.1 Data Collection and Review

The following data was collected and assembled into a Geographic Information System (GIS) where applicable during the data collection task:

- Collection and Review of reports and studies
- SCADA flow / pressure data for all facilities and water supply sources as were available
- Recent Census Data and Population Projection Data
- Base mapping and topographic elevation data
- GIS files and databases including – recent utility system layers, land use zoning layers, legal parcel mapping, census tract boundaries, digital aerials / orthophotos, future land use mapping, etc.
- New infrastructure as-built drawings
- Flow Monitoring Data (collected as part of this study)
- Surcharge depth data (collected as part of this study)

Geographical Information System (GIS) databases and base mapping were prepared for use throughout the study to graphically display hydraulic model results and other data requiring visual presentation.

1.2.2 Model Development

A hydraulic model was developed to analyze the performance of the existing collection system network. The model was developed using existing GIS databases, as-built drawings (where available), data extracted from the UMA spreadsheet model, and numerous field measurements. Although the model does not represent the exact physical characteristics of the wastewater collection system, it provides a conceptual representation the actual collection system that adequately meets the analysis needs of a master planning study. Subsequent detailed analysis of the wastewater collection system will require significant data collection on manhole and pipe invert and rim elevations.

1.2.3 Existing System Evaluation

The existing system was analyzed using the hydraulic model to measure the performance of the wastewater system under various conditions. The existing system performance was tested under dry weather and wet weather conditions.

1.2.4 Future System Evaluation

The existing system was analyzed using the hydraulic model to measure the performance of the wastewater system under future conditions. System performance was tested under dry weather and wet weather conditions with the additional sanitary loading from proposed future growth areas.

The model was then used to evaluate improvement options and wastewater servicing strategies for the study areas.

1.2.5 Capital Improvement Plan Development

The findings of the existing and future system assessments will suggest projects for inclusion within the Municipality's capital improvement plans. The intent of these plans is to outline construction priorities based upon the present and future needs of the utility and the Municipality as a whole.

A specific list of prioritized capital projects including their cost and the triggers that will determine the timing of implementation are provided.

2.0 Data Collection

A large amount of data was collected for use during the Municipality of Crowsnest Pass Wastewater Master Plan. While for the most part this data is discussed in the relevant sections of the report that follow, some items are more global in nature and should be described in advance.

2.1.1 Engineering Drawings

The configuration of the Municipality's underground infrastructure is detailed in existing municipal CAD and GIS mapping products. These mapping products lack detailed elevation data. Slope and connectivity information is present for much of the system but is somewhat incomplete. Detailed engineering drawings were not available for use in this study.

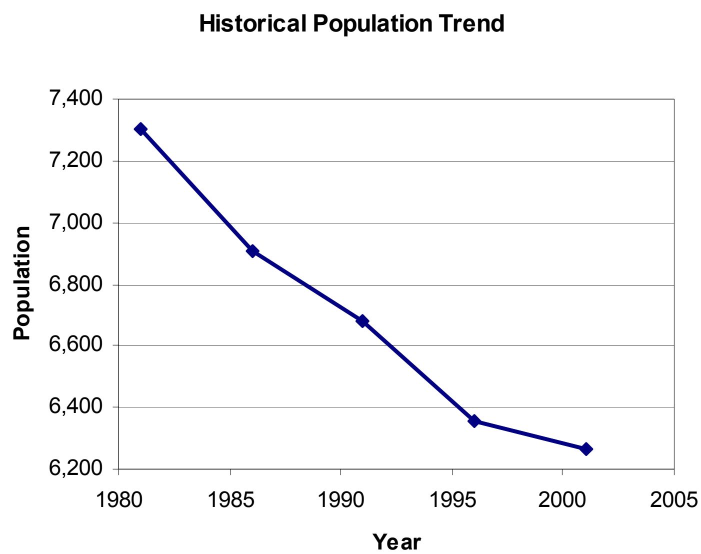
2.1.2 Population Statistics

There is limited detailed population data available for current population statistics in the Municipality of Crowsnest Pass. Total population in the Crowsnest pass has been declining since 1981, however it is important to note that there is a portion of the population that have dual residences and are not accounted for in the total population counts.

Detailed community by community population breakdowns were taken from the UMA report, "Municipality of Crowsnest Pass Infrastructure Evaluation Sanitary System", and tabulated in **Table 2-1**. Data from the 2006 Federal Census was not available for use during this study.

Table 2-1 Population Breakdown

	2001 Population
Coleman	2,565
Blairmore	2,411
Bellevue	1,009
Hillcrest	802
Total	6,787



2.2 SYSTEM PERFORMANCE DATA COLLECTION

Operational Data was collected to support the system performance evaluation and assess the impacts of future development on the sanitary sewer collection system. The programs included a flow monitoring program and a surcharge gauging program.

2.2.1 Flow Monitoring Program

Sewage generation rates for an area can be estimated based on land use using empirical relationships to predict flows. However, in order to fully assess a sanitary sewer collection system, actual sewage flows must be measured.

The key objectives of the flow monitoring program included the following:

- Quantification of existing system flows within the existing sanitary sewer collection system for the areas currently serviced by the Municipality of Crowsnest Pass infrastructure.
- Derive specific sewage generation rates for dry weather and wet weather flows within the existing sanitary sewer system.
- Collect data to be used for the creation of a computer hydraulic model. The data will be used for calibration and verification, ensuring the reliability and value of the model to the Municipality.

By meeting these objectives, the flow monitoring program will provide the background data required for the complete assessment of the sanitary system in the 2006 Wastewater Master Plan.

2.2.1.1 General Concepts

Dry weather flows occur during periods of no precipitation. Dry weather flows are normally composed of a base flow (BASE) from constant inputs to the system and a variable or diurnal flow (DWF) that results from day to day discharges to the system. Base flows generally consist of groundwater infiltration or continuous discharges that do not vary with time.

Wet weather flows (WWF) are the result of precipitation, specifically rainfall, affecting a system in two ways: inflow and infiltration. Inflow (a rapid response to rainfall) is flow created from rainfall directly entering the sanitary system through manhole covers and weeping tile connections. Infiltration (a slower and more extended response to rainfall) is flow created from rainfall entering the system through cracked manholes and pipes. The total response to a rain event is Rainfall Derived Inflow and Infiltration (RDII). RDII differs from groundwater infiltration as it is directly related to rainfall events.

Figure 2-1 illustrates these concepts. The graph demonstrates the base flow contribution (BASE, light green), regular dry weather flow (DWF, dark green), a sample rainfall event (dark blue bars) and the resulting rainfall derived inflow and infiltration (RDII, light blue).

2.2.1.2 Program Implementation

Prior to the implementation of the flow monitoring program, current system flow data was not available. While flow data is collected at the Frank Wastewater Treatment Plant on a daily basis, it does not provide the level of detail required for this study and was not included in the analysis.

Six flow monitor sites were selected based on the criteria that they provide useful data on unique sewersheds within the system, or that they provide data that can be used in quantifying RDII and its sources. **Table 2-2** shows the details of each selected flow monitor site.

Table 2-2 Flow Monitor Site Data

Site	Community	Location	Diameter of Pipe (mm)	Upstream Area/ Zone (ha)	2001 Population Upstream
1	Coleman	88th Street & 15th Avenue	600	190	2570
2	Blairmore	112th Street & 19th Avenue	600	200	2660
3	Blairmore	129th Street & 19th Avenue	600	270	3750
4	Blairmore	Highway 3 & 20th Avenue	600	340	4840
5	Frank	147th Street & 13th Avenue	600	360	4976
6	Bellevue	216th Street & 23rd Avenue	200	40	1090

Flow monitoring services were provided by GEOtivity Inc who provided the equipment, installation, removal, field services and data processing for the flow monitoring program. As part of the flow monitoring program, GEOtivity also installed one tipping bucket rain gauge on the roof of the Municipal Office, located at 8502 – 19th Avenue in Coleman.

Figure 2-2 shows the locations of the flow monitors and rain gauge and the representative areas for each monitor.

2.2.1.3 Data Collection

Data was collected at each site for a period starting at the end of June and running until the middle of September. **Table 2-3** provides recording durations for the rain gauge and flow monitors.

Table 2-3 Flow Monitor and Rain Gauge Recording Durations

Site	Monitor Type	Downloading Begins	Downloading Ends
1	Wireless Qtrek	July 22, 2006	Sept. 14, 2006
2	Wireless Qtrek	June 22, 2006	Sept. 14, 2006
3	Wireless Qtrek	June 21, 2006	Sept. 14, 2006
4	Wireless Qtrek	June 21, 2006	Sept. 14, 2006
5	Wireless Qtrek	June 23, 2006	Sept. 14, 2006
6	Wireless Qtrek	June 22, 2006	Sept. 14, 2006
Rain Gauge		June 23, 2006	July 9, 2006

2.2.1.4 Data Analysis

The raw flow monitor data was validated using logarithmic scatter plots of depth versus velocity. It is expected that "good" data will produce a linear logarithmic pattern in these plots with few outliers. Drifting in the scatter plots will aid in effectively identifying erroneous data sets.

There are many sources of erroneous data, which can include the following:

- Equipment malfunctions,
- Sensors clogged with debris,
- Monitor Calibration,
- Poor site specific hydraulic conditions.

Table 2-4 provides a summary of the flow monitoring data that was collected and comments on the quality and status of the data. The table also describes figures that show the flow monitoring data and logarithmic depth vs. velocity plots.

Table 2-4 - Flow Monitoring Data Figures

Site Number	Figure Number			
Site 1	**Figure 2-4**	Flow Hydrographs Logarithmic Scatter Plot	Average Flow Average Depth Average Velocity	5.21 l/s 64.6 mm 0.29 m/s
Notes:	Site 1 was located downstream of Coleman, on the 600mm trunk main. The depth of flow in the main and the average flow were low. In general the data appears reliable and suitable for use in characterizing dry weather flows for the upstream catchment.			
Site 2	**Figure 2-5**	Flow Hydrographs Logarithmic Scatter Plot	Average Flow Average Depth Average Velocity	6.88 l/s 84.8 mm 0.3 m/s
Notes:	Site 2 is located at the upstream end of Blairmore, on the 600mm trunk main. The data appears reliable and is suitable for use in characterizing dry weather flows for the upstream catchment.			
Site 3	**Figure 2-6**	Flow Hydrographs Logarithmic Scatter Plot	Average Flow Average Depth Average Velocity	17.44 l/s 120 mm 0.4 m/s
Notes:	Site 3 is located midway through Blairmore on the 600mm trunk main. There is significant drift in portions of the data. Site three data is not used in dry weather flow generation in this study. The data points and hydrograph shape are used in assessing dry weather flow calibration and wet weather verification.			
Site 4	**Figure 2-7**	Flow Hydrographs Logarithmic Scatter Plot	Average Flow Average Depth Average Velocity	10.32 l/s 102.4 mm 0.3 m/s
Notes:	Site 4 is located at the downstream end of Blairmore, on the 600mm trunk main. The data appears reliable and is suitable for use in characterizing dry weather flows for the upstream catchment.			
Site 5	**Figure 2-8**	Flow Hydrographs Logarithmic Scatter Plot	Average Flow Average Depth Average Velocity	18.97 l/s 172.5 mm 0.3 m/s
Notes:	Site 5 is located upstream of the Frank WWTP, on the 600mm trunk main. Due to the average depth of flow in the main over the monitoring period this site was chosen for use in developing the Dry Weather Flow pattern discussed later in this report.			
Site 6	**Figure 2-9**	Flow Hydrographs Logarithmic Scatter Plots	Average Flow Average Depth Average Velocity	8.12 l/s 73.8 mm 0.9 m/s
Notes:	Site 6 is located in North Bellevue on the 250mm main shown in the diagram. The site was a difficult location to get consistent data; a weir was set up to assist in producing a more consistent velocity / depth profile. The data was used for the construction of the model; however, the reliability of the data is suspect.			

2.2.1.5 Conclusions and Recommendations

The following points outline the conclusions and recommendations resulting from the Flow Monitoring Programs and data analysis.

- The data collection of the flow monitoring program was limited by the time period that data was collected. Typically, May and June are the wettest months in the Crowsnest Pass. No precipitation occurred in June, and little rain occurred July, August and September. Future flow monitoring programs should commence earlier in the spring to maximize the chance of capturing a large rain event.

- One small wet weather event was captured on September 13, 2006 that demonstrated a measurable RDII response. The Rainfall Event had an average intensity of 0.48 mm/hr over a period of 48 hours and a total rainfall volume for the period of 18.3 mm. This event was used for model verification.

- Generally the flow monitoring data was of good quality. Many of the sites where data was collected had hydraulic conditions that produced unreliable data during portions during the monitoring period.

2.2.2 Surcharge Gauging Program

While the flow monitoring efforts conducted in the sanitary trunk systems provided valuable information about the nature of flow generation for large areas, more detailed information was required to properly calibrate the gravity flow models and confirm the nature of known sewer surcharging problems.

Installation of numerous flow monitors and data loggers would be prohibitively expensive so a simple instrumentation concept previously developed by Stantec was deployed to collect data in the wastewater system. By measuring the depth of surcharge occurring as a result of a specific wet weather event in a large number of manholes with an inexpensive low-tech device, a more geographically representative distribution of maximum hydraulic grade lines can be determined.

The construction of the surcharge gauge for the Municipality of Crowsnest Pass was adapted from the Stantec design of a surcharge gauge for the City of Lethbridge, and the City of St. Albert. The gauge was constructed using twelve-foot sections of two-inch, black ABS pipe. The gauge cover consisted of an ABS cleanout plug and cap to prevent inflow from above. A small hole was drilled in the cap to allow the inside of the gauge to ventilate. At the bottom of the ABS pipe, three 90° PVC elbows were connected together by a small horizontal section of ABS pipe. **Figure 2-10** shows a schematic of the surcharge gauge used in the Municipality of Crowsnest Pass.

The measuring device used in the surcharge gauge consisted of a floating plastic ball encased in a thin plastic cage (**see Figure 2-11**). The ball and cage were designed to rise with the water level but to hold in the pipe when the water level dropped. Each gauge was attached to its respective manhole by a large karabiner linked to the highest ladder rung in the manhole (see **Figure 2-12**). The karabiner was linked to an eyelet bolt, which was threaded though a hole drilled through both sides of the ABS pipe at the top of the gauge. Plastic strapping was also used in conjunction with the eyelet bolt to secure the karabiner to the ABS pipe. **Figure 2-13** depicts a surcharge gauge being installed in the field, and **Figure 2-13** shows a surcharge gauge after installation in a manhole. **Figure 2-14** represents the surcharge gauge locations, and surcharge levels associated with each rain event included in the study.

The surcharge data collected during the five events between July 7, 2006 and September 13, 2006 resulted in detection of surcharging in a number of locations. The surcharging that was detected occurred during rainfall events that can be considered relatively small (3.3 mm to 5.1mm.) **Table 2-5** provides a summary of the surcharging program data.

Table 2-5 Surcharge Gauge Data Summary

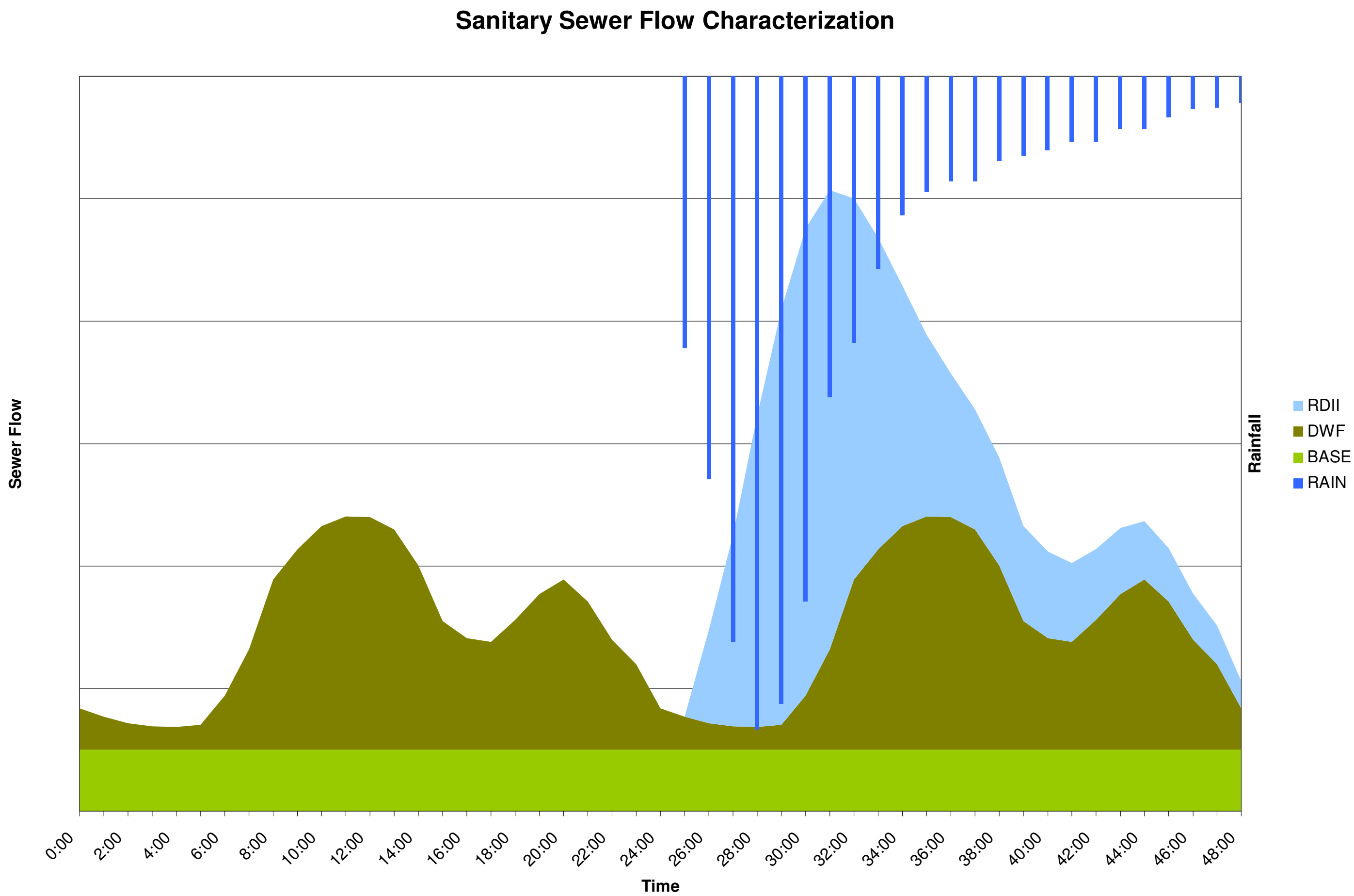
Manhole	Location	Manhole Depth (m)	Surcharge Depth from Manhole Bottom (m) and Surcharging Severity				
C91	17 Ave. & 69 St. Coleman	3.72	-	-	-	**0.213** 🔵	-
C312	17 Ave. & 75 St. Coleman	4.20	**0.542** 🔴	**0.288** 🔵	-	-	-
C305	16 Ave. & 81 St. Coleman	3.08	**0.414** 🔵	**0.364** 🔵	-	-	-
C540	15 Ave. & 85 St. Coleman	2.80	**0.416** 🔴	**0.213** 🔵	-	-	-
BL57	12513 21 Ave. Blairmore	3.68	-	-	-	-	-
SANMH1	22 Ave. & 133 St. Blairmore	3.50	-	-	-	**0.326** 🔵	-
BL109	13234 19 Ave. Blairmore	3.41	**0.568** 🔴	**0.264** 🔵	**0.314** 🔵	-	-
BL119	18 Ave. & 135 St. Blairmore	3.07	-	-	-	**0.276** 🔵	-
BL240	19 Ave. & 124 St. Blairmore	3.15	-	-	**0.327** 🔵	**0.352** 🔵	**0.302** 🔵
BL230	19 Ave. & 121 St. Blairmore	3.51	**0.467** 🔴	**0.314** 🔵	**0.314** 🔵	-	-
BL219	11609 19 Ave. Blairmore	2.93	-	-	-	-	-
FR274	HWY#3 Frank	3.42	**0.554** 🔵	**0.427** 🔵	**0.452** 🔵	**0.427** 🔵	-
H47	11 Ave. & 230 St. Hillcrest	3.57	-	-	**0.264** 🔵	-	**0.289** 🔵
BE78	21725 28 Ave. Bellevue	5.04	**0.711**[2] 🔴	**N/A**	-	-	**0.213** 🔵
SANMH3	2314 23 Ave. Bellevue	4.00	**2.169** ⚫	-	-	**0.238** 🔵	**0.822** 🔴
SANMH4	2766 12 Ave. Bellevue	3.06	-	-	-	-	-
SANMH5	11 Ave. & 217 St. Bellevue	2.79	-	**0.302** 🔵	-	-	-
NEWMH5	HWY#3 Bellevue	2.69	**0.556** 🔴	**N/A**	-	-	**0.352** 🔵

Manhole Surcharging Severity
- No Surcharging
- Minor Surcharging 🔵
- Moderate Surcharging 🔴
- Severe Surcharging ⚫

RAIN EVENT	1	2	3	4[1]	5
DATE	07/06/06	07/24/06	08/16/06	08/30/06	09/13/06
TOTAL ACCUMULATION (mm)	5.1	3.6	3.3	N/A	16.8
MAX INTENSITY (mm/hr)	30.5	30.5	30.5	N/A	15.2

[1] *Discrepancy between Geotivity and Environment Canada rain gauge data for August 30*
[2] *Ball& cage did not rise, but measurement is to visible wastewater residue level on outside of gauge.*
[3] *For definitions of Manhole Surcharging Severity see Table 4.1*

2.3 LIST OF FIGURES FOR SECTION 2.0



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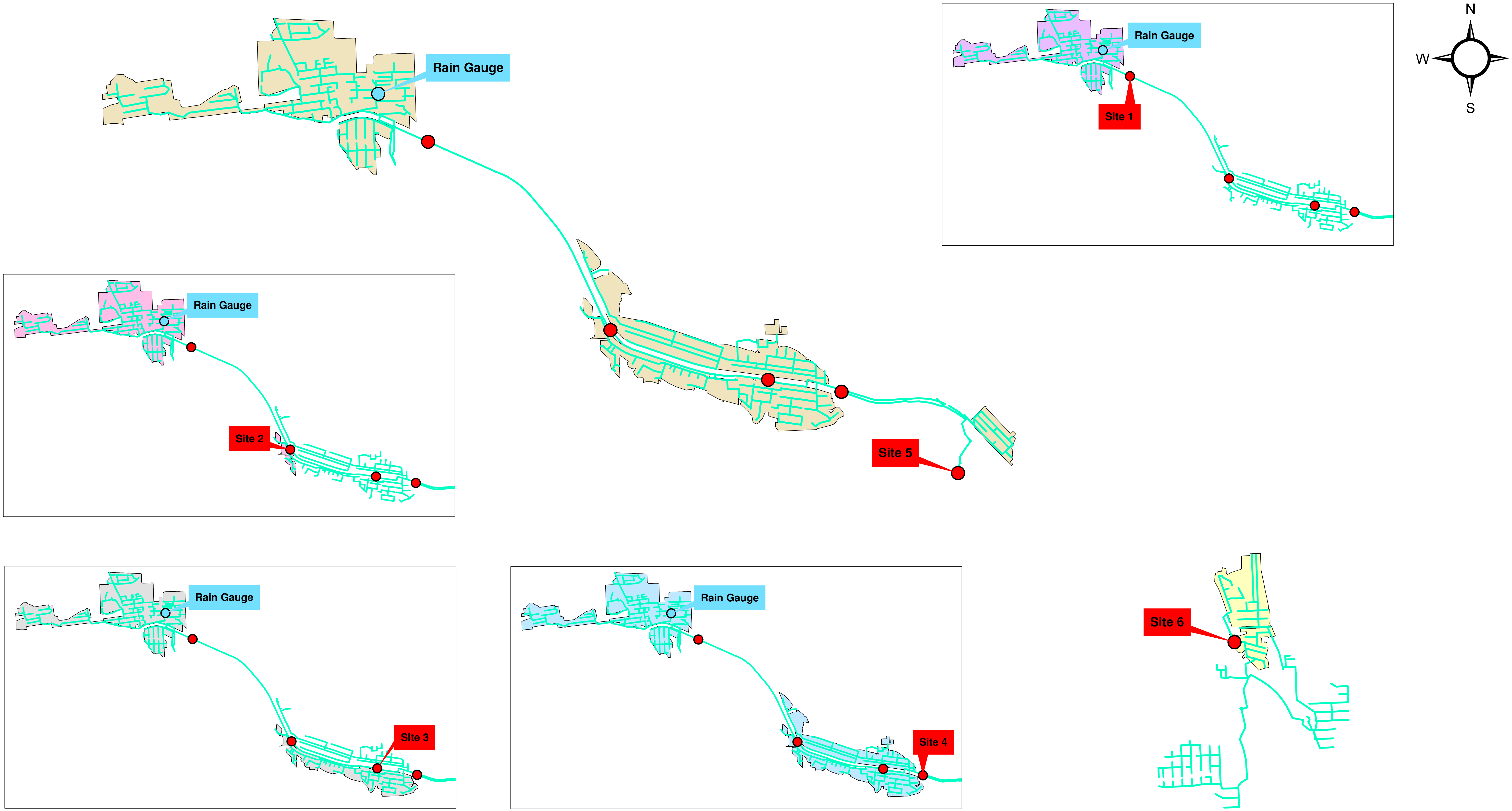
Wastewater Master Plan

Figure No.

Figure 2-1

Title

Sanitary Sewer Flow Characterization



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Legend

Existing Wastewater System	Site 1 Contributing Area
Flow Monitor Site	Site 2 Contributing Area
Rain Gauge Site	Site 3 Contributing Area
	Site 4 Contributing Area
	Site 5 Contributing Area
	Site 6 Contributing Area

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Figure No.
2-2

Title
Sanitary Sewer Flow
Monitor Locations

Site 1

Site 2

Site 3

Site 4

Site 5

Site 6

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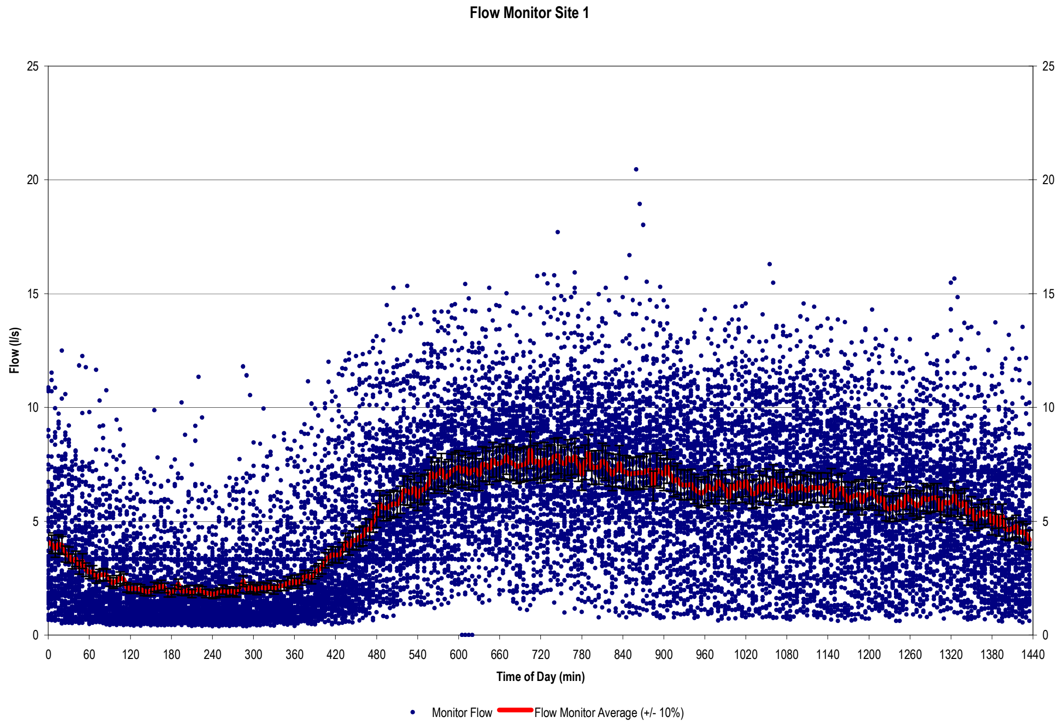
Figure No.
Figure 2-3

Title

Flow Monitor Site Photographs



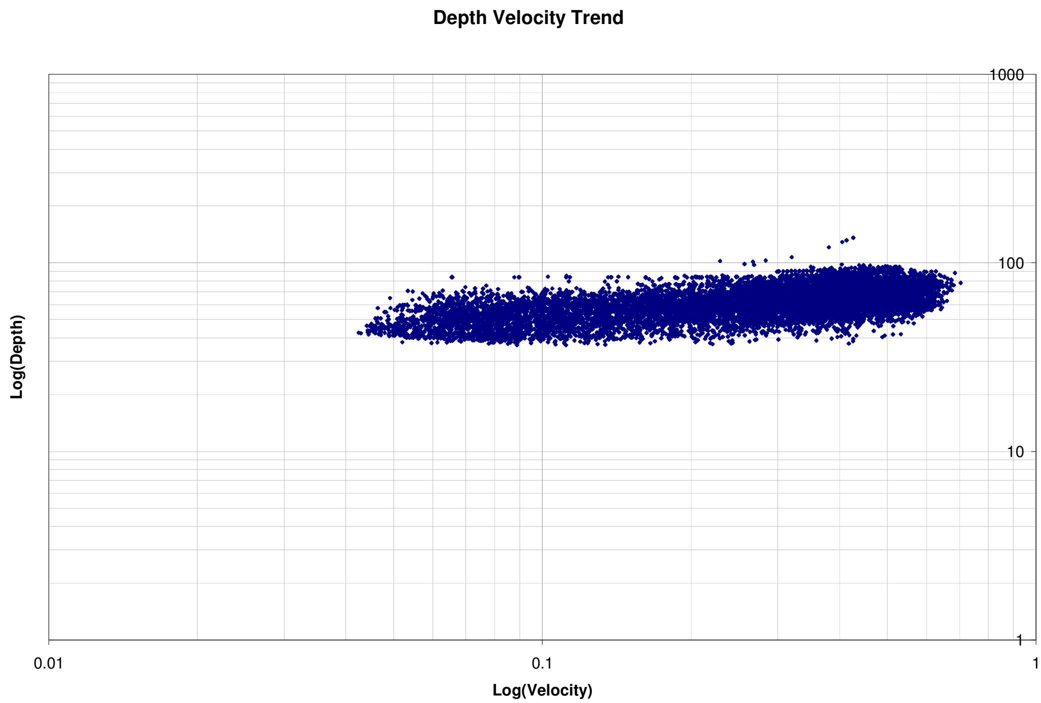


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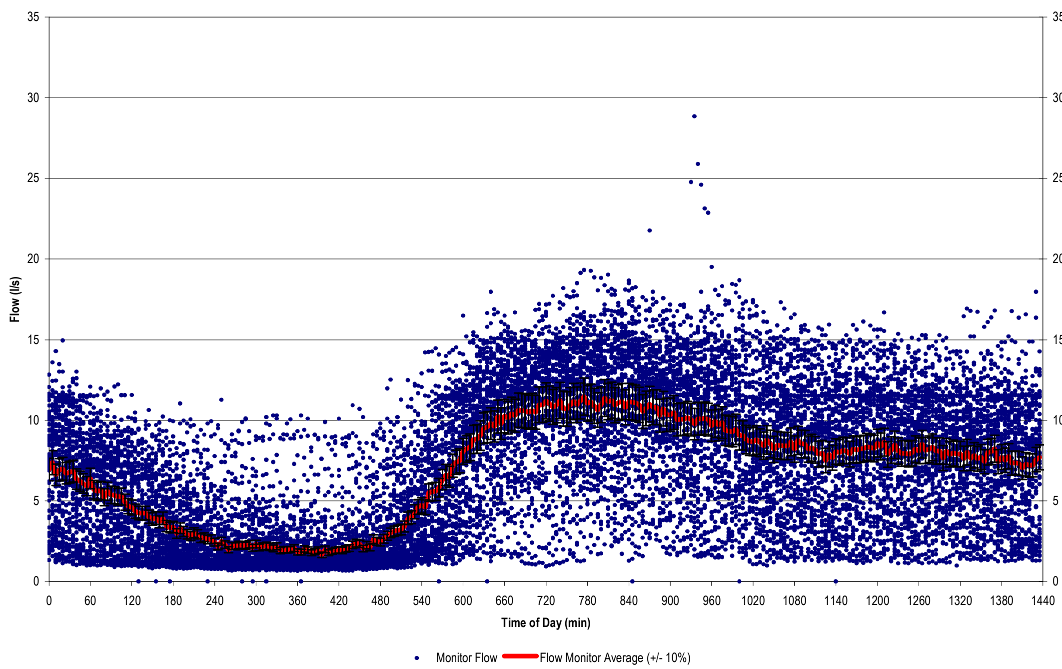
Figure No.
Figure 2-4

Title

Site 1 Analysis

Flow Monitor Site 2



Depth Velocity Trend

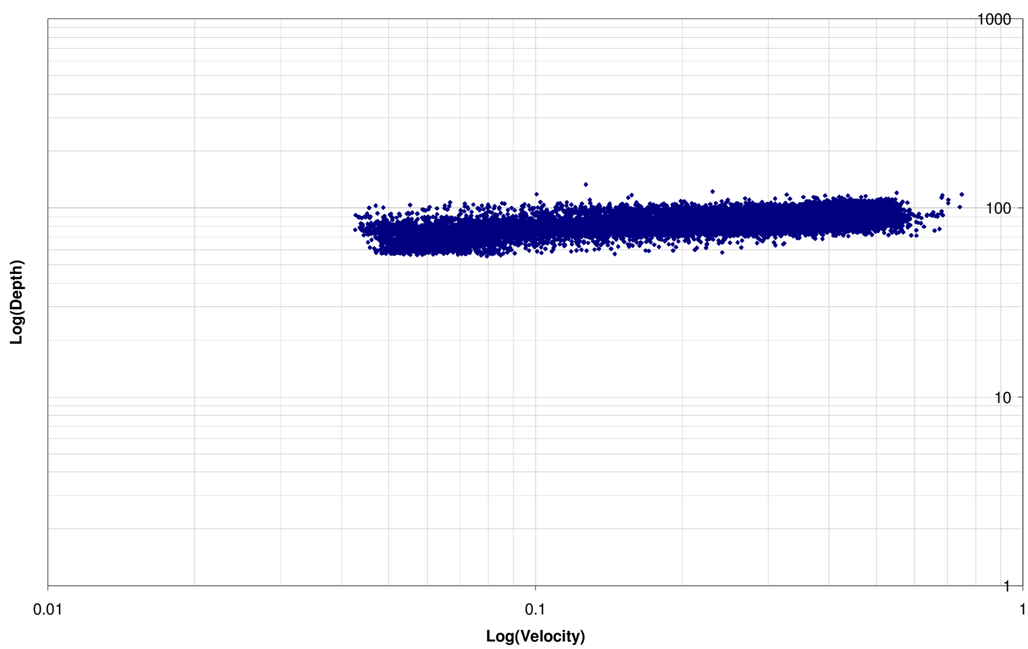


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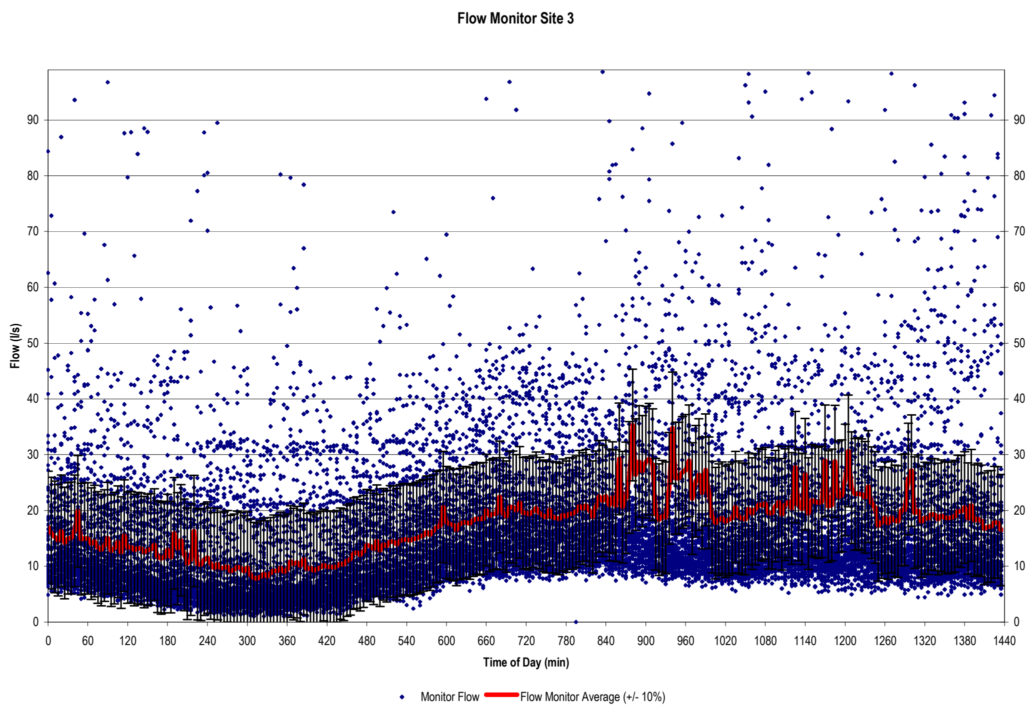
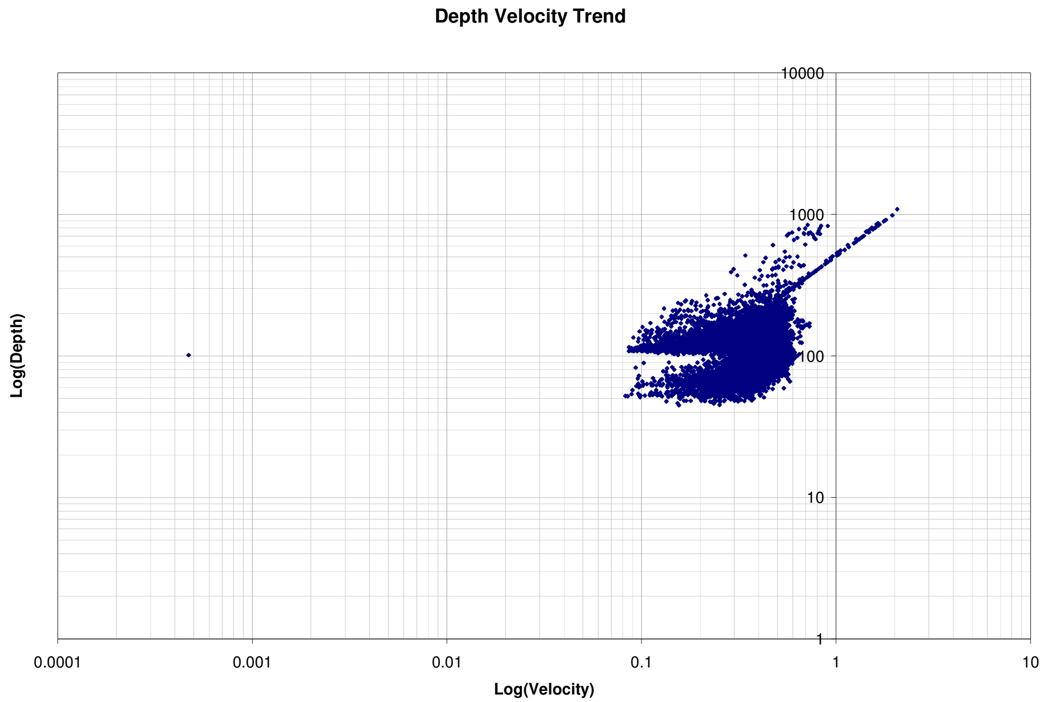
Figure No.
Figure 2-5

Title

Site 2 Analysis





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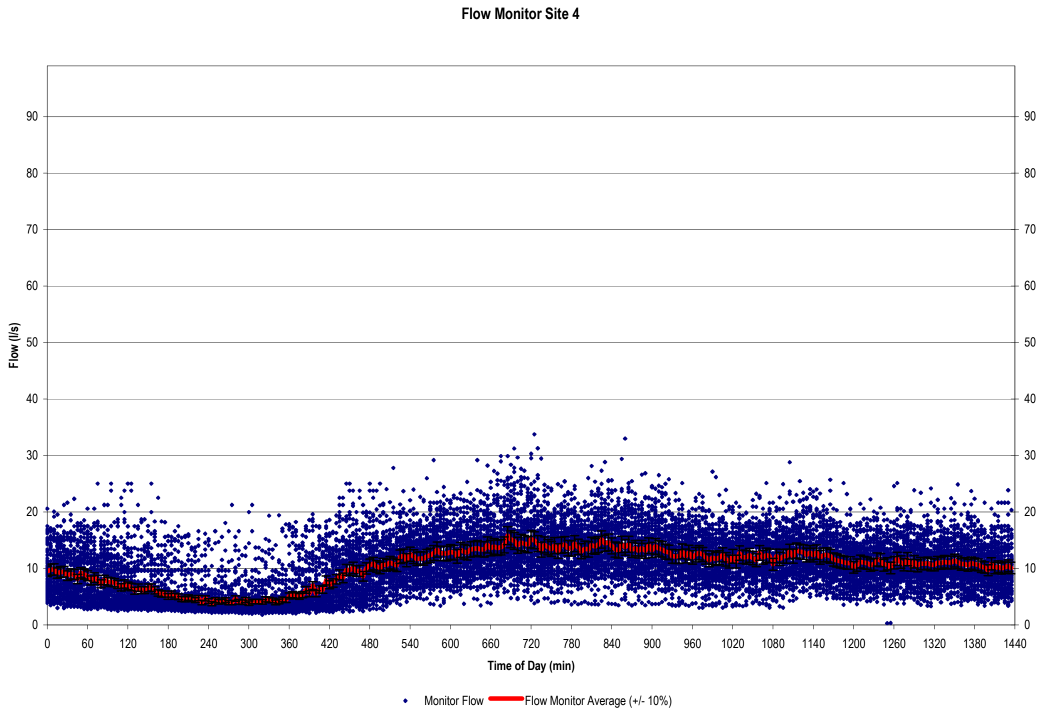
Wastewater Master Plan

Figure No.
Figure 2-6

Title

Site 3 Analysis



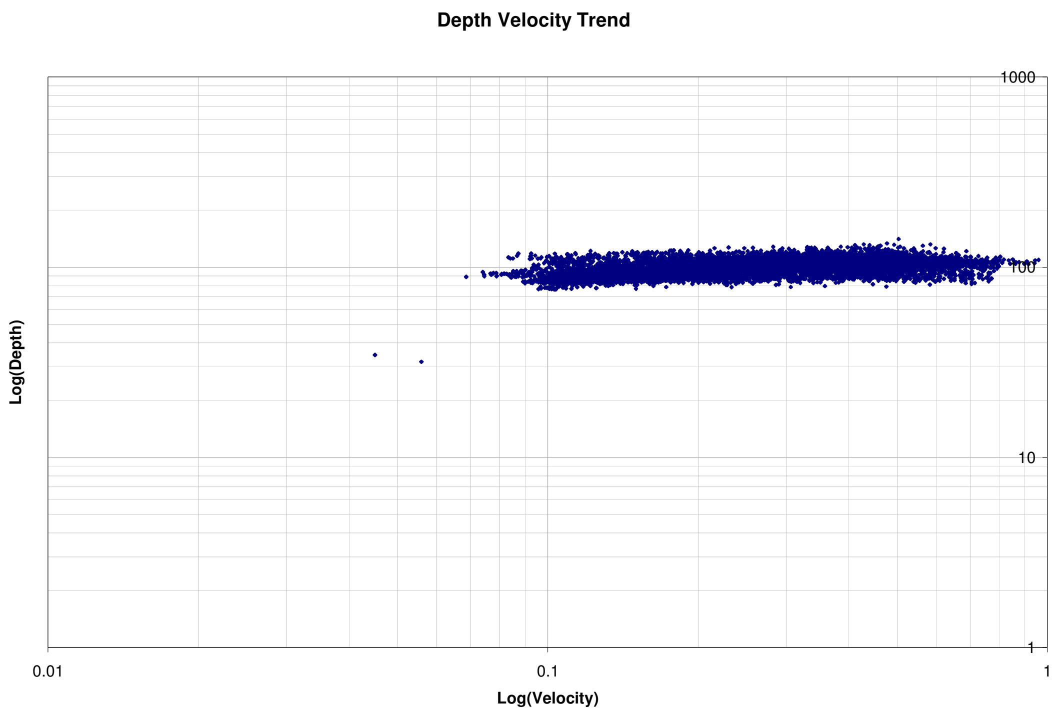


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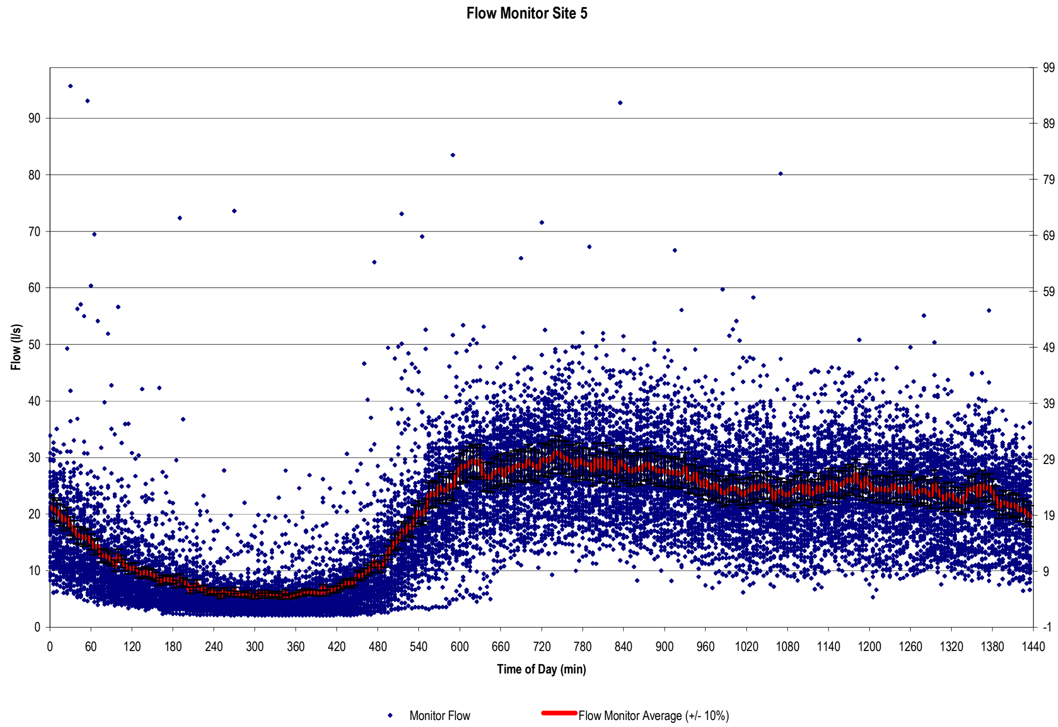
Figure No.
Figure 2-7

Title

Site 4 Analysis



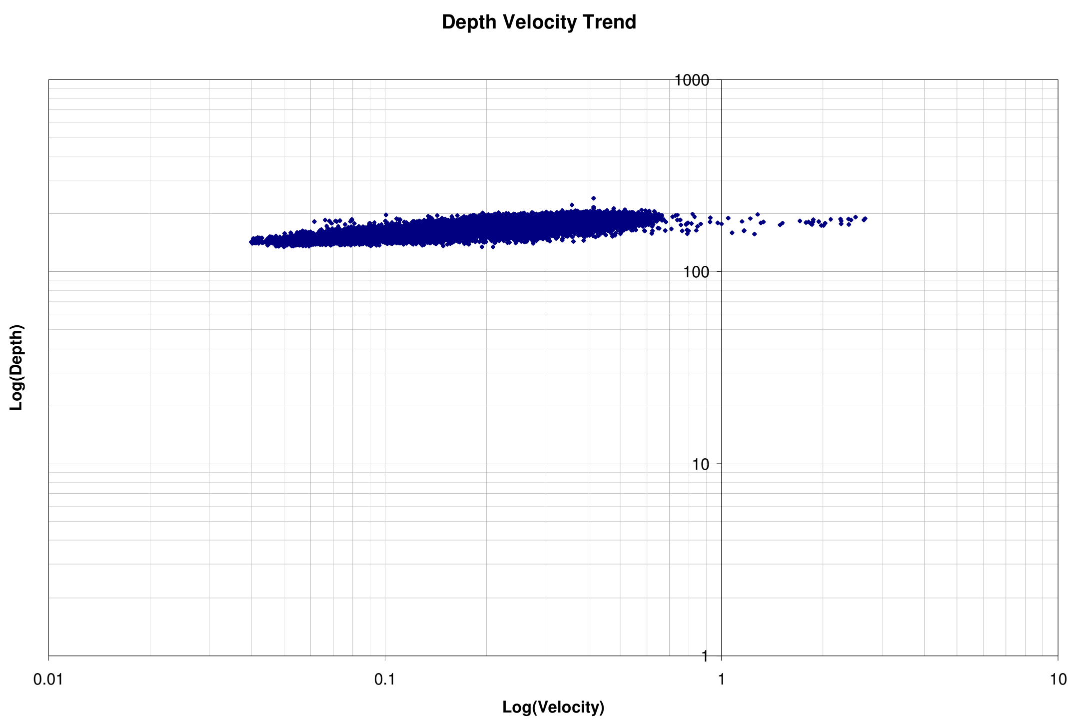


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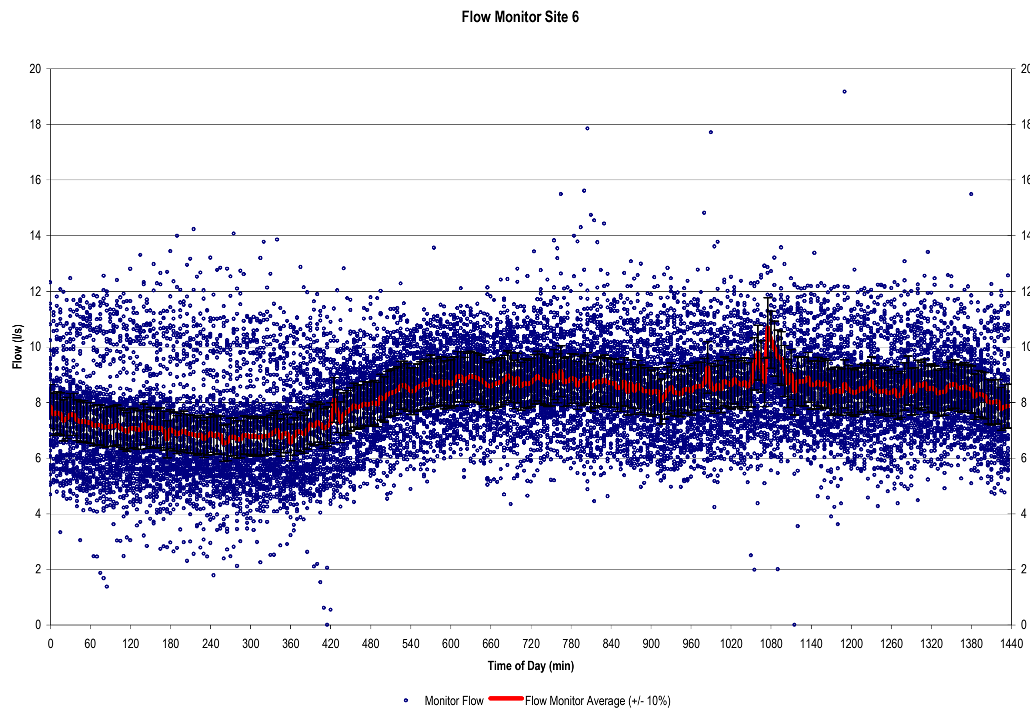
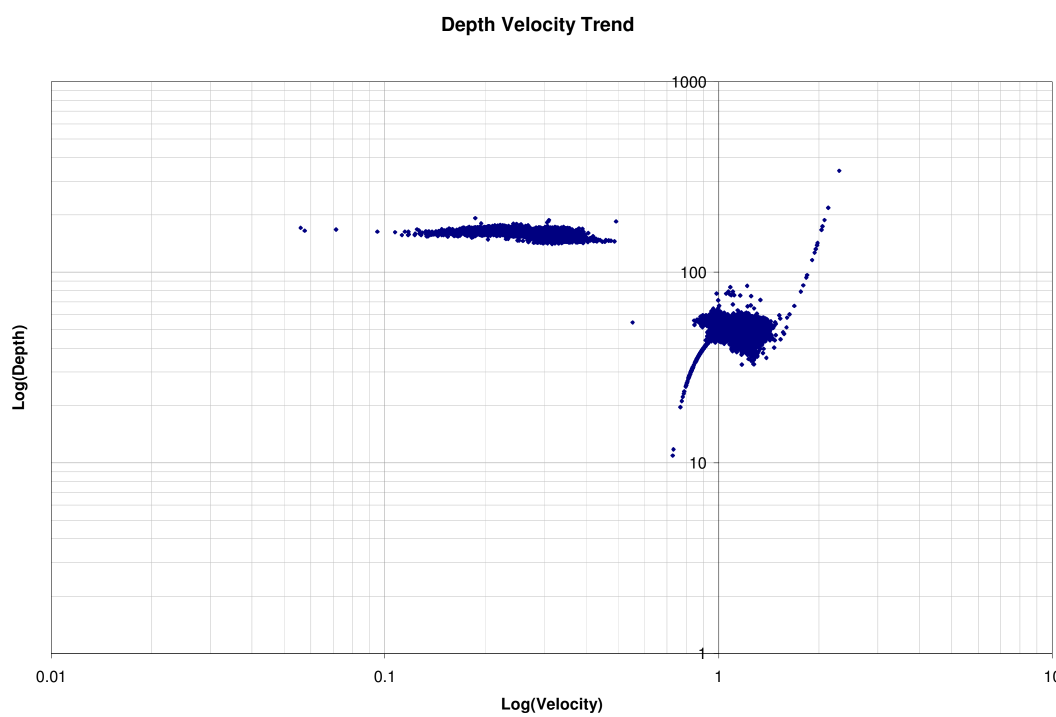
Figure No.
Figure 2-8

Title

Site 5 Analysis





Legend

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Figure No.

Figure 2-9

Title

Site 6 Analysis

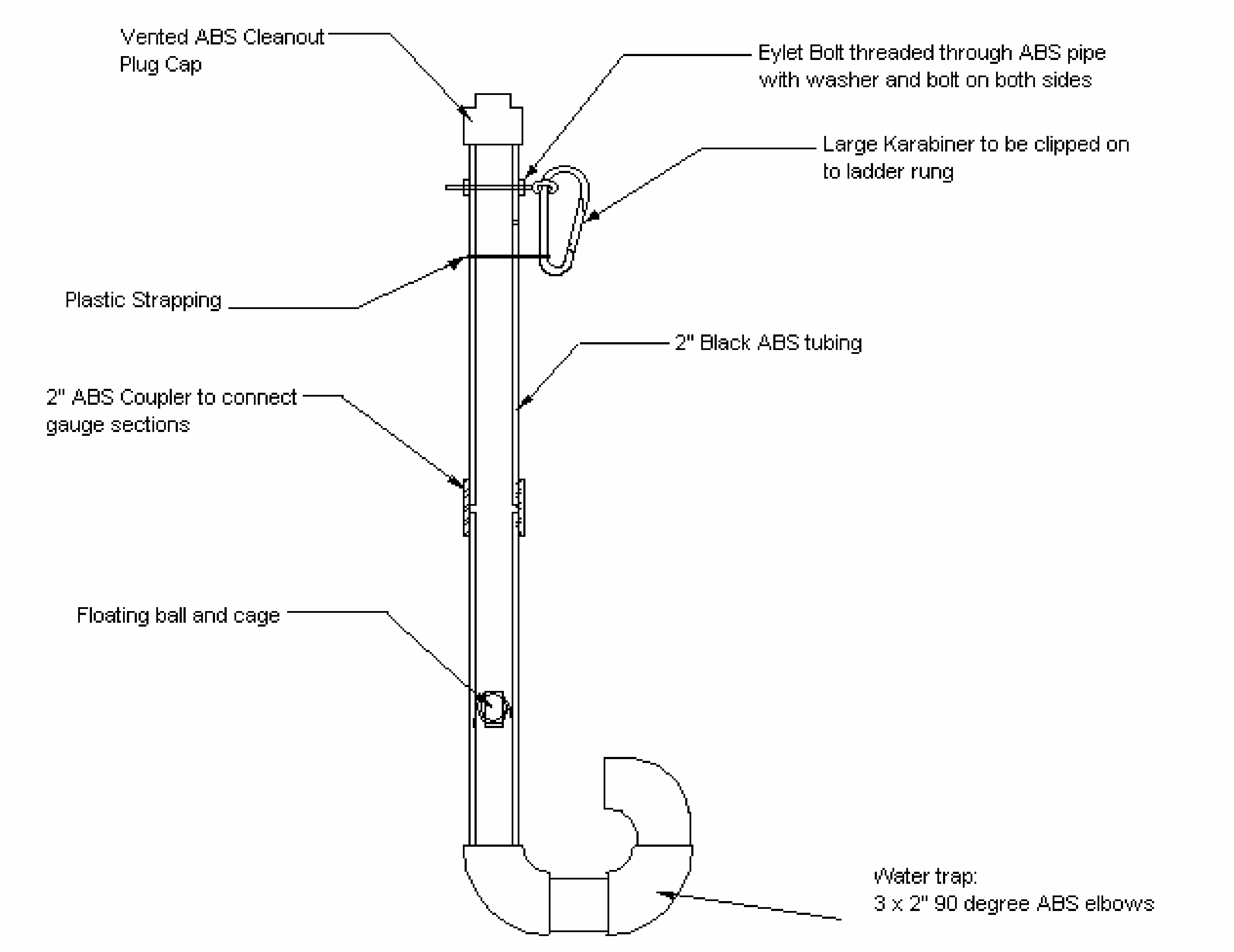

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Figure No.

Figure 2.10

Title

Surcharge Gauge Schematic

Legend

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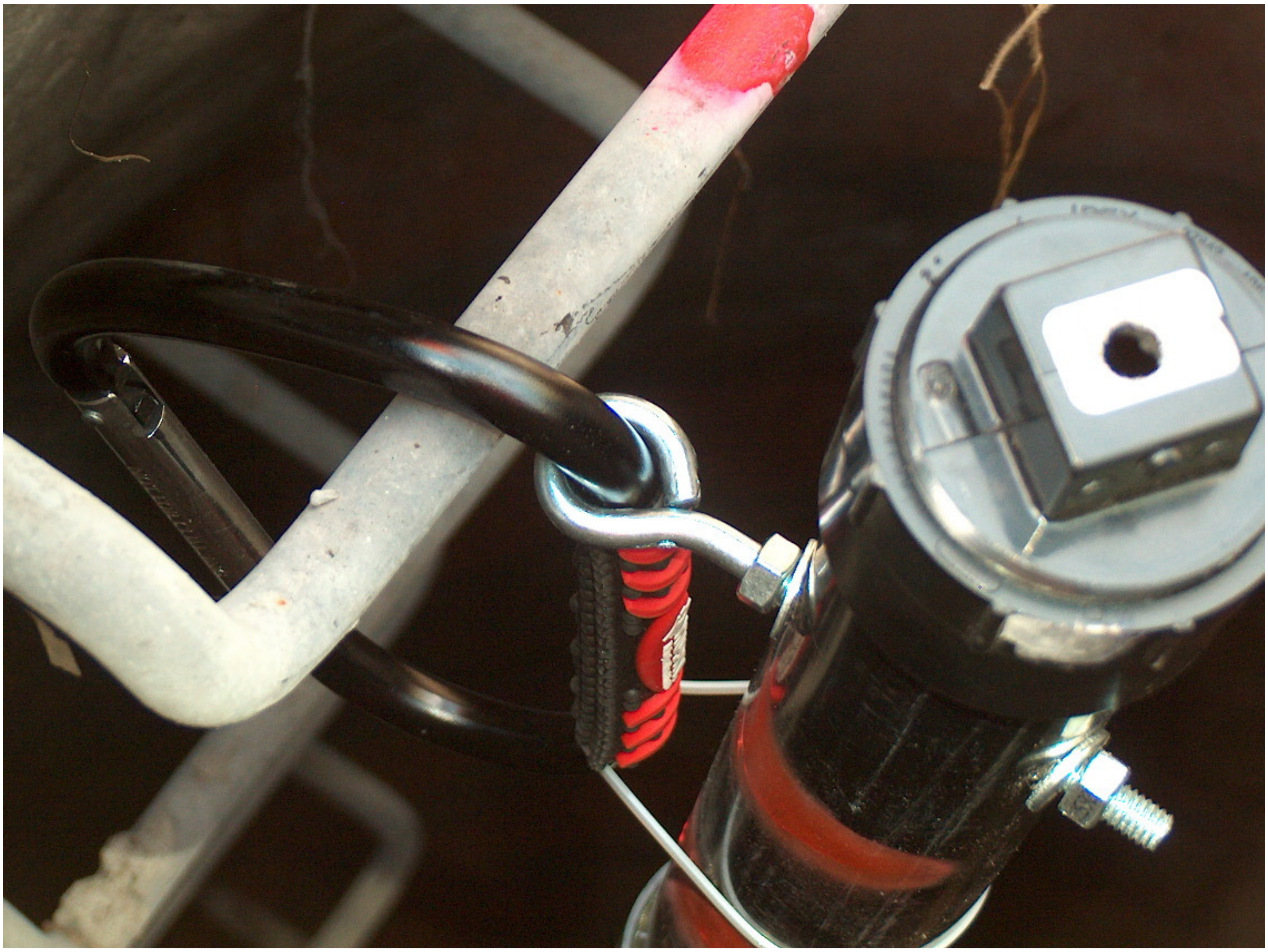
Wastewater Master Plan

Figure No.
Figure 2-11

Title

Ball and Cage Photograph



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Wastewater Master Plan

Figure No.
Figure 2-12

Title
Installed Karabiner Photograph

Legend

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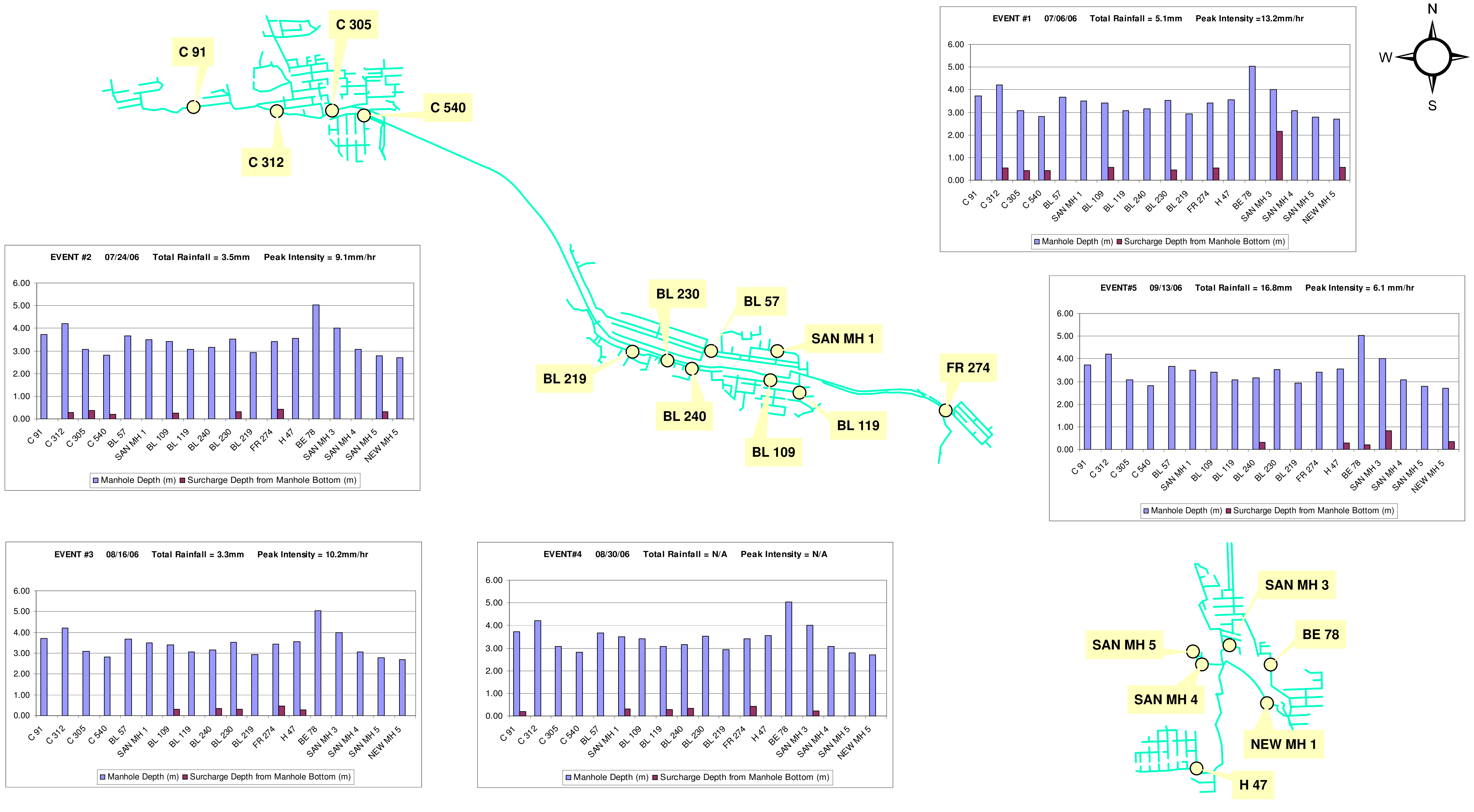
Wastewater Master Plan

Figure No.
Figure 2-13

Title

Installed Surcharge Gauge Photograph



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Legend

- Existing Wastewater System
- Surchage Gauge

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Figure No.
2-14

Title
Surcharge Gauge Locations
and Surcharge Levels

3.0 Model Development

3.1 MODEL SELECTION

To simulate the operation of Municipality of the Crowsnest Pass Sanitary Sewer Collection System, a computerized hydraulic model was created. The model was developed to represent the current state of wastewater flows and infrastructure in the Municipality of Crowsnest Pass.

The US Environmental Protection Agency Storm Water Management Model (SWMM) version 5.0.009 was used for the construction of the computer model. The installation files, source code and manuals for the model are available online at:

http://www.epa.gov/ednnrmrl/models/swmm/index.htm

The EPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. Typical applications include:

- design and sizing of drainage system components for flood control
- designing control strategies for minimizing combined sewer overflows
- evaluating the impact of inflow and infiltration on sanitary sewer overflows

The SWMM 5 model was determined to be the most appropriate software option for the analsysis of the Municipality of the Crowsnest Pass Sanitary Sewer Collection System.

3.2 SANITARY MODEL CONSTRUCTION

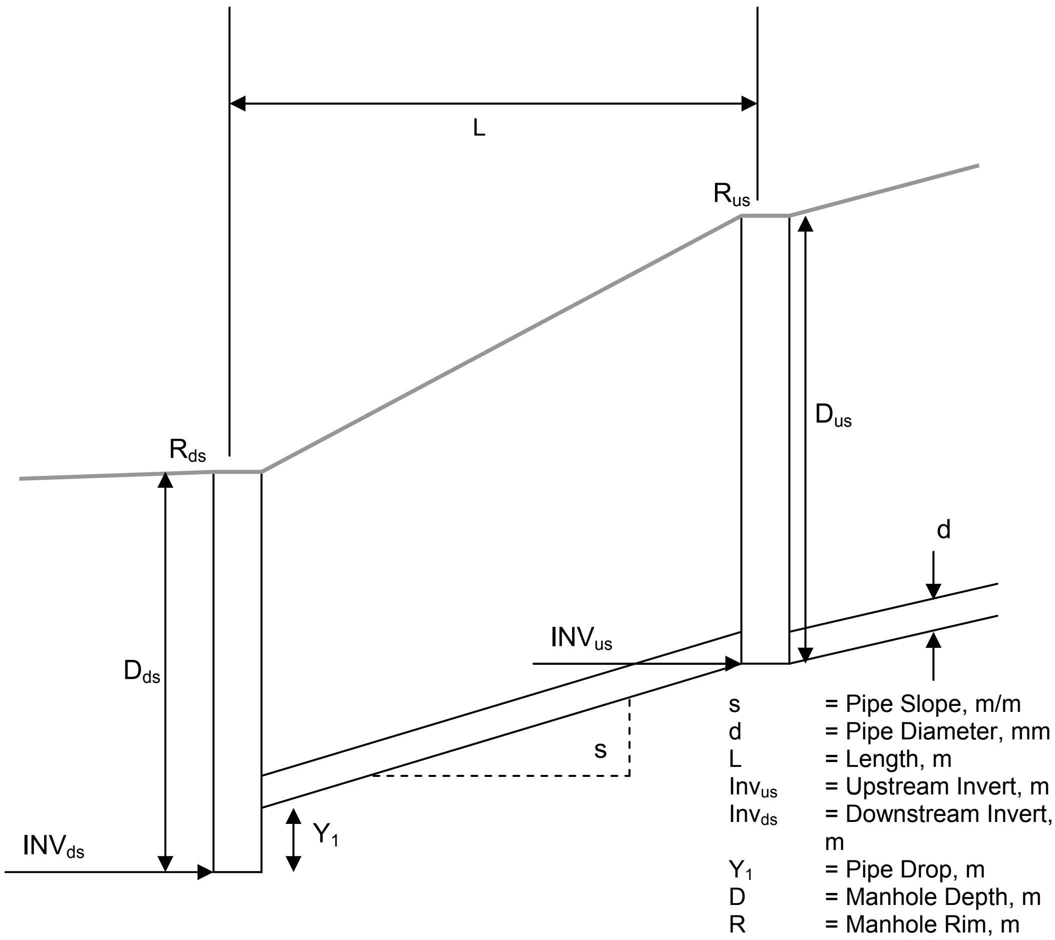
3.2.1 Collection System Infrastructure

The Municipality of Crowsnest Pass Sanitary Sewer Collection System infrastructure was imported into the computer model from the spreadsheet model developed by UMA in February 2000 for the report "Municipality of Crowsnest Pass Infrastructure Evaluation Sanitary System."

Figure 3-1 shows the collection system from the SWMM model.

The representation of the physical collection system in the model was reconstructed from the UMA data. The report contained pipe lengths and slopes that were related to manholes and pipes in the system. The spreadsheet model also provided some information about the collection system network connectivity.

The model infrastructure elevations were calculated using the following methodology:



$INV_{ds} = R_{ds} - D_{ds}$

R_{ds} ⟶ Rim extrapolated from digital elevation model
D_{ds} ⟶ An assumption is made for the manhole furthest downstream

$INV_{us} = INV_{ds} + Y_1 + (L)\ (s)$
$D_{us} = R_{us} - INV_{us}$

R_{us} ⟶ Rim extrapolated from digital elevation model
Y_1 ⟶ No information was available at this time (data not available)
L ⟶ UMA Infrastructure Evaluation Report (adjusted using GIS information)
s ⟶ UMA Infrastructure Evaluation Report

Note: the model representation of the physical wastewater infrastructure is not a true representation and should not be used for design purposes. Field survey of manhole locations and inverts should be verified and updated in the model as required.

3.2.2 Facilities

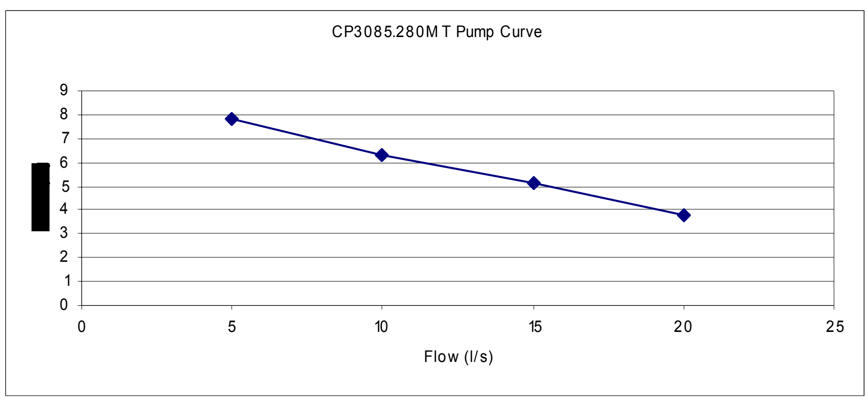
One lift station facility was simulated in the wastewater model.

The Riverbottom lift station is represented in the model by a storage node and a pump that discharges to the inverted siphon running to the Bellevue Lagoons. No data was available regarding the inflows to the station. A pump curve for the station was available and formed the basis of sizing the model representation.

The following assumptions were made for the physical and operating characteristics of the Riverbottom Lift Station:

- Wet Well Depth - 5 m
- Pump On - 1.5 m
- Pump Off - 1.0 m
- Pump On Rate - 5 l/s
- Wet Well Volume at 2.0 m - 2.3 m^3

Pump Curve	
(Assume CP3085.280MT)	
Q(l/s)	Head (m)
5	7.8
10	6.3
15	5.1
20	3.8



3.2.3 Sewage Generation Rates

Sewage generation rates are separated into two distinct types of flow: Dry weather flow (DWF) that is based on the diurnal pattern of water use, and wet weather flow (WWF) that is the result of rainfall dependent inflow and infiltration (RDII).

3.2.4 Dry weather Flow

Dry weather flow patterns were created from the flow monitoring data that was completed in 2006. **Figure 3-2** shows a chart of the dry weather flow pattern used on the model for dry weather flow.

3.2.5 Wet Weather Flow

The wet weather model was created using the Unit Hydrograph Method for generating rainfall dependant inflow and infiltration. The Rainfall Derived Inflow and Infiltration Hydrographs (RDII) tool in SWMM 5 was used to simulate inflow and infiltration during rainfall events.

The RDII hydrograph was estimated using flow monitoring data collected during a rain event that occurred on September 13, 2006. **Figure 3-3** shows the RDII hydrograph used in the Municipality of Crowsnest Pass wastewater model and presents the RDII constants in table form.

3.2.6 Dry Weather Model

The dry weather model was created using existing flow measurements from the flow monitoring program.

3.2.6.1 Calibration Results

Figure 3-5 is a map of the locations of calibration points in the model. Each corresponds to a point in the model where flow monitoring has occurred.

Figure 3-5 , Figure 3-6, Figure 3-7, Figure 3-8, Figure 3-9 and Figure 3-10 show dry weather calibration runs for each of the calibration points.

Table 3-1 is a summary of the calibration results for the existing system dry weather flows.

Table 3-1 Summary of Dry Weather Calibration Results

Area:	1	2	3	4	5	6
Flow Monitor:	FM-1	FM-2	FM-3	FM-4	FM-5	FM-6
Model Link:	24-754	26-759	22-21	552-553	7	421-352
AVG Q_{model}	3.851	9.199	9.707	13.169	19.734	9.251
AVG $Q_{measured}$	5.217	6.888	17.460	10.324	18.954	8.119
Difference (l/s)	-1.366	2.310	-7.753	2.845	0.780	1.132
% Difference	*-26.2%*	*33.5%*	*-44.4%*	*27.6%*	*4.1%*	*13.9%*
PEAK Q_{model}	6.470	15.490	16.270	22.400	34.030	13.040
PEAK $Q_{measured}$	8.124	11.485	35.324	15.799	30.136	10.698
Difference (l/s)	-1.654	4.005	-19.054	6.601	3.894	2.342
% Difference	*-20.4%*	*34.9%*	*-53.9%*	*41.8%*	*12.9%*	*21.9%*
BASE Q_{model}	1.330	2.910	3.100	3.980	5.870	5.840
BASE $Q_{measured}$	1.783	1.659	7.773	3.741	4.452	6.534
Difference (l/s)	-0.453	1.251	-4.673	0.239	1.418	-0.694
% Difference	*-25.4%*	*75.4%*	*-60.1%*	*6.4%*	*31.9%*	*-10.6%*
VOLUME Q_{model}	331.578	792.975	836.670	1134.609	1701.996	797.160
VOLUME $Q_{measured}$	478.503	604.401	875.116	900.241	1357.295	643.657
Difference (cubic meters)	-146.925	188.574	-38.446	234.368	344.701	153.503
% Difference	*-30.7%*	*31.2%*	*-4.4%*	*26.0%*	*25.4%*	*23.8%*

In general, the model is providing a reasonable estimate of dry weather flows in the wastewater system. In most cases peak flows are conservative. Much of the error is due to the small observed flows. When the calibration for area 5 is considered separately both the average and peak flow calibration is much closer.

The degree of calibration is also significantly impacted by the inherent error that was evident in some of the flow monitoring data.

The level of calibration is sufficient for master planning purposes. Additional data should be collected in the wastewater system and at the discharge points (Bellevue Lagoons and Frank WWTP), to increase the level of calibration of the model.

3.2.7 Wet Weather Model

The wet weather model was created using the Unit Hydrograph Method for generating rainfall dependant inflow and infiltration. The Rainfall Derived Inflow and Infiltration Hydrographs tool in SWMM 5 was used to simulate inflow and infiltration during rainfall events.

3.2.7.1 Wet Weather Verification

The rainfall event that occurred on September 13, 2006 was then used as a verification event to validate the degree of calibration in the model.

Figure 3-11 shows the rainfall event used for calibration purposes and **Figure 3-12** shows the flow monitoring data for the September 13 rainfall event. The Rainfall Event had an average intensity of 0.48 mm/hr over a period of 48 hours and a total event rainfall volume of 18.3 mm.

Figure 3-13, Figure 3-14, Figure 3-15, Figure 3-16, Figure 3-17and Figure 3-18 show the verification model runs for each flow monitoring site. The current state of the model provides a reasonable representation of the wet weather response that was observed at flow monitor sites on Sept 13, 2006.

3.2.7.2 Design Wet Weather Verification

The RDII unit hydrograph method is based on a gross estimate of the volume of extraneous flow during an 80 mm 24 hour rain event. **Figure 3-19** shows the “design” rainfall event. At the global scale, the volume of inflow and infiltration was approximated, then locally adjusted to account for local flooding conditions that were known to occur.

A peak wet weather inflow of 2000 l/c/day was used as the target RDII contribution for older neighborhoods that where age of infrastructure, design and construction practices lead to larger inflows during wet weather. The 2000 l/c/day target is based on the RDII value used in City of Lethbridge design requirements for older neighbourhoods.

The calibration for the wet weather model can be considered reasonable at the “Macro” scale. In general, the model is predicting potential problem areas. Ongoing flow monitoring and rainfall measurements should be completed to provide sufficient data to complete the calibration of the wet weather flow sewer model.

Table 3-2 shows a summary of the gross estimate loadings used in the calibration of the model.

Table 3-2 Model Flow Summary

	Coleman	Blairmore	Bellevue*	Hillcrest
Population (2001), UMA	2,565	2,411	1,009	802
Average Dry Weather Flow (l/s)	3.9	9.3	16.9	4.0
Peak Dry Weather Flow (l/s)	6.5	16.4	23.2	7.5
Average Dry Weather Flow (l/c/d)	130	334	1,448	427
Peak Dry Weather Flow (l/c/d)	218	588	1,989	812
Peak Wet Weather Flow (l/s)	68.12	66.67	44.07	20.55
RDII (l/s)	66.67	54.11	27.06	10.45

RDII (l/c/d)	2,246	1,939	2,318	1,126

* The flows from Bellevue are exceptionally high due to the contribution of base infiltration that was detected in the system through flow monitoring.

3.2.8 Data Gaps

The current model does not have accurate inverts and depths and does not represent the true physical wastewater collection system in the Crowsnest Pass.

A limited survey of inverts was completed to assist in the construction of the model. These inverts have been collected into a database of wastewater infrastructure data that can be incorporated into corporate GIS systems.

A comprehensive survey of the wastewater collection system should be carried out to complete the database for the wastewater collection system. This will also verify the connectivity of the collection system network and the associated pipe slopes and capacities.

3.3 LIST OF FIGURES FOR SECTION 3

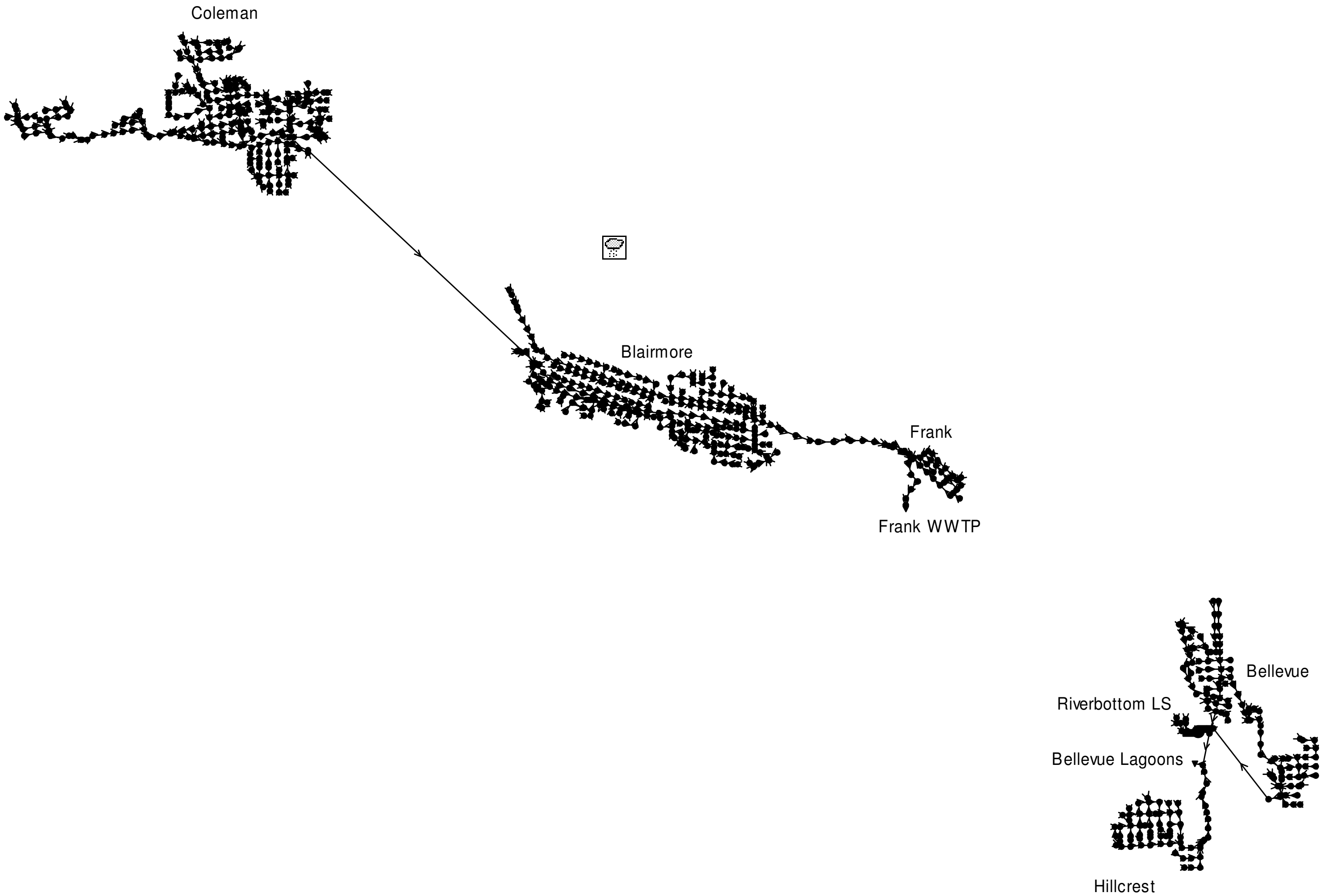


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Figure No.

3.1

Title

SWMM Collection System Layout

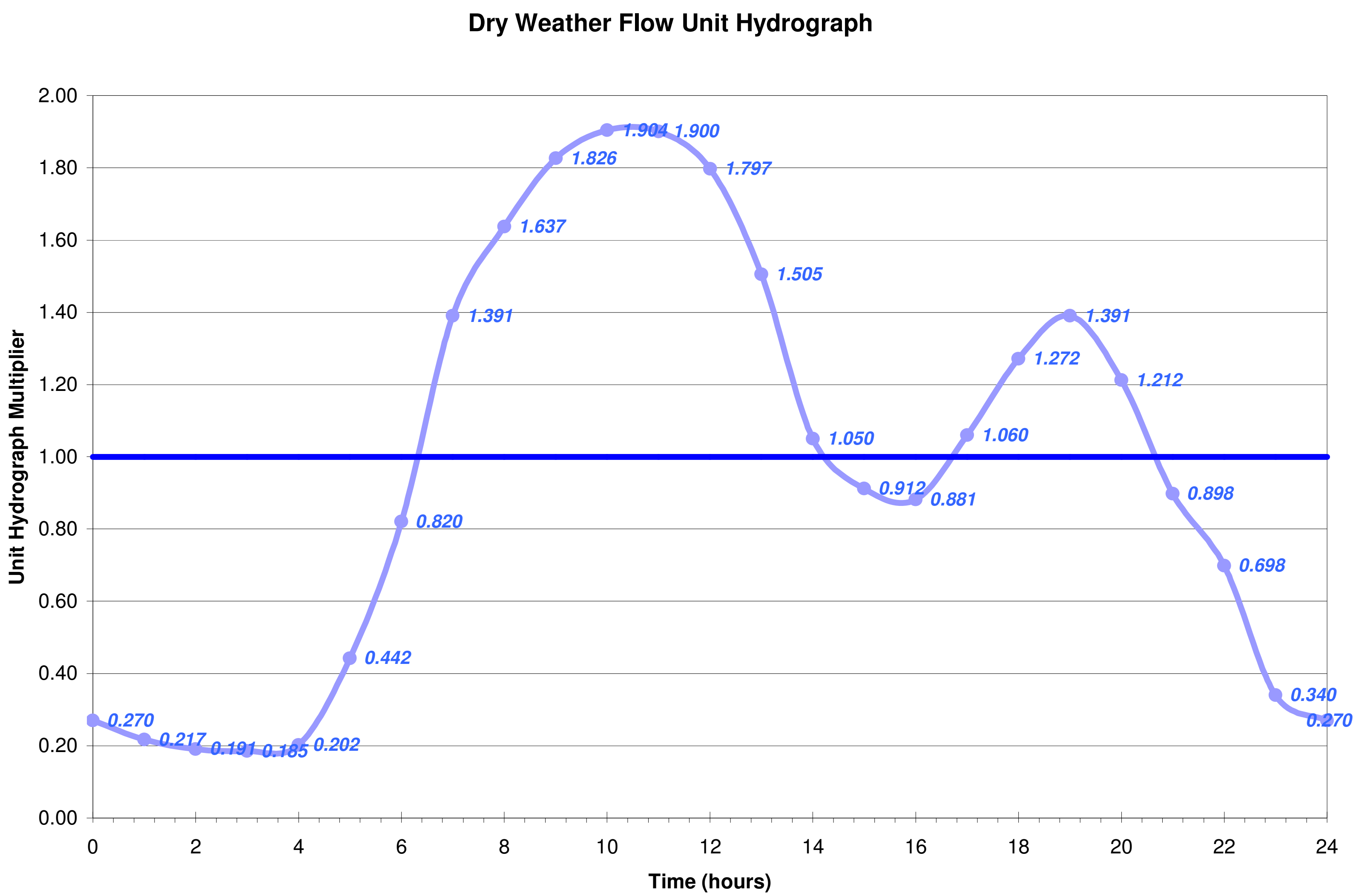

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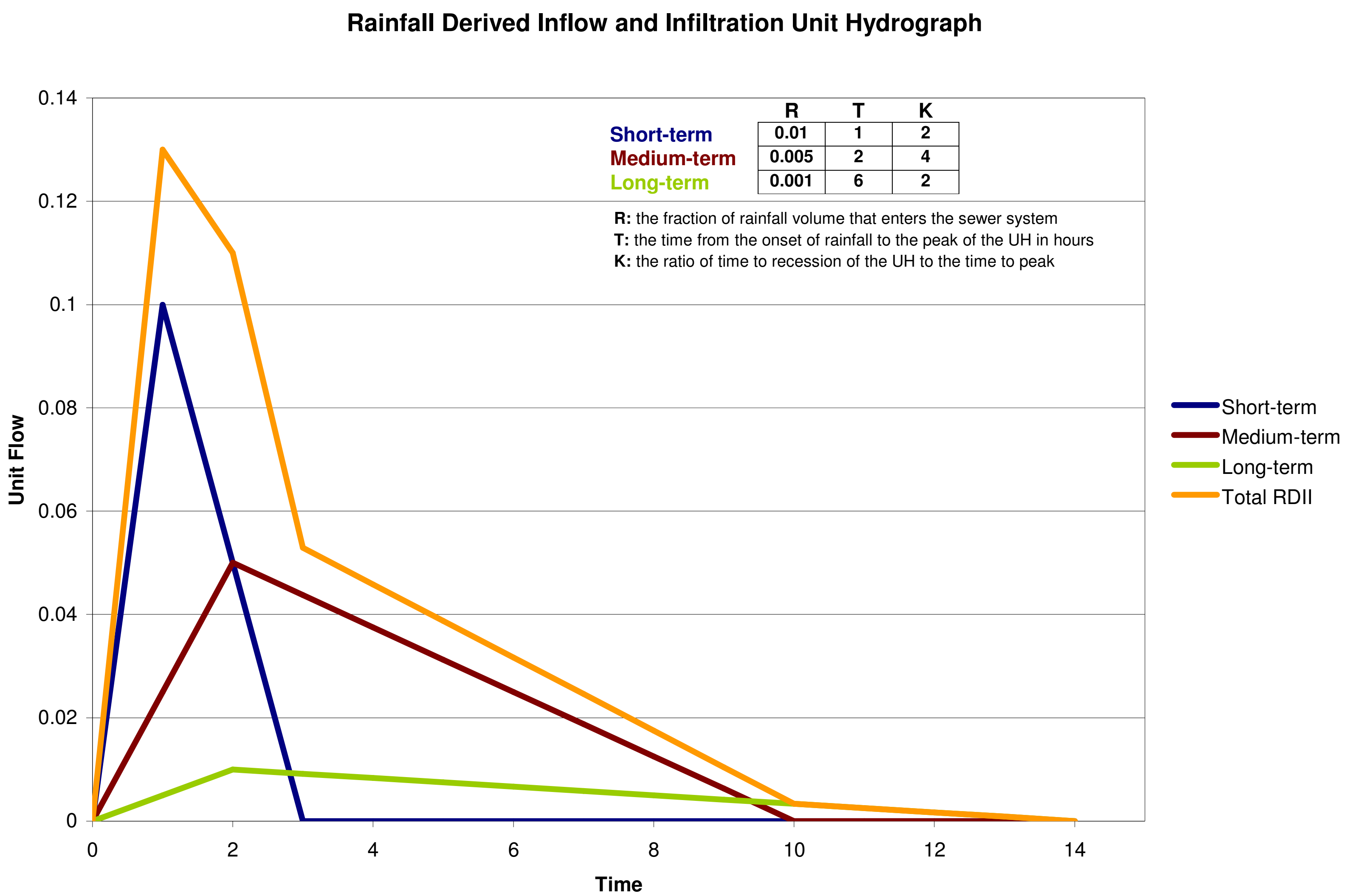
Figure No.
3.2

Title

Dry Weather Flow Hydrograph



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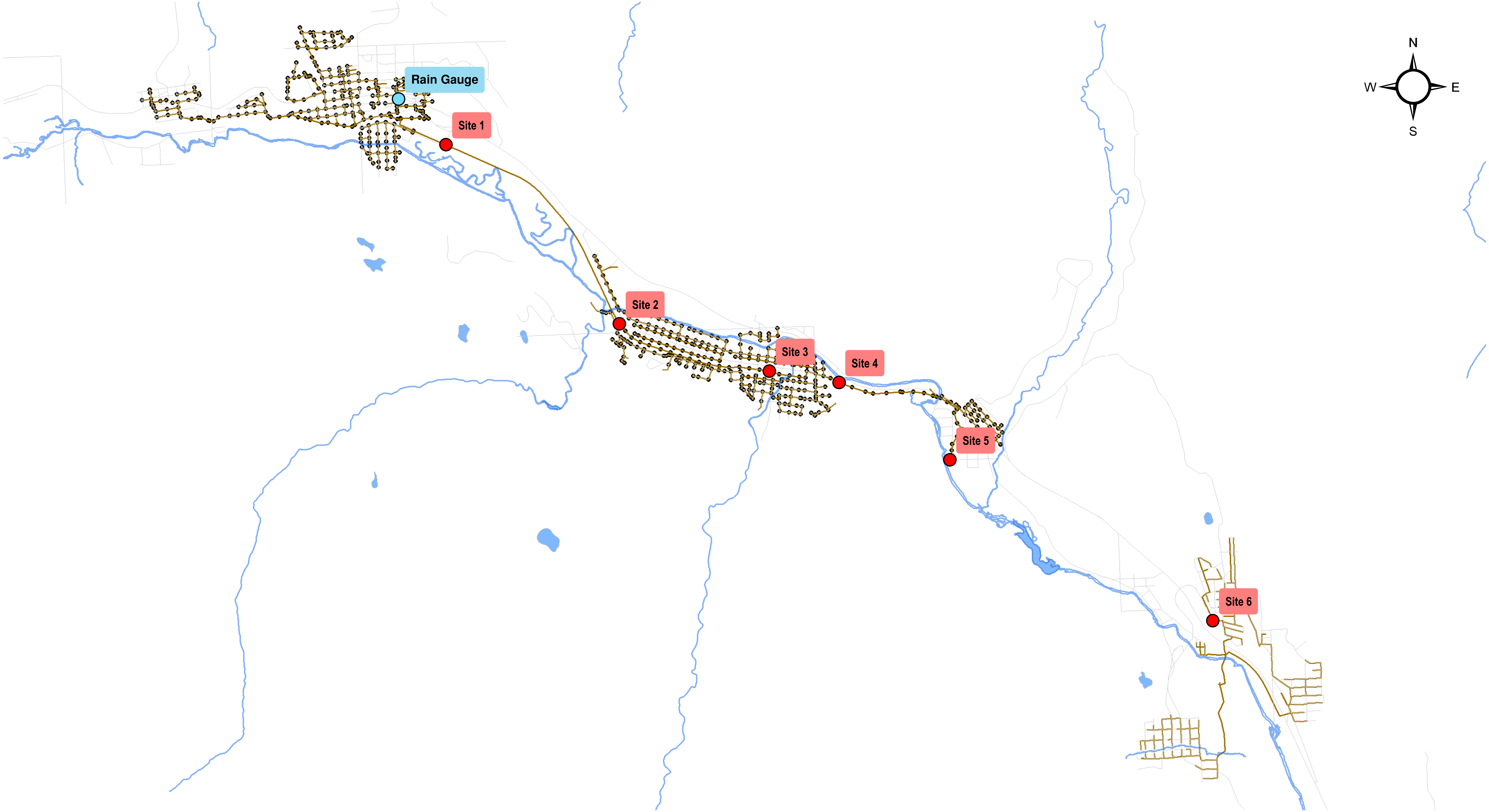
Wastewater Master Plan

Figure No.
3.3

Title

Rainfall Derived Inflow and Infiltration Hydrograph



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WASTEWATER MASTER PLAN

Figure No.

3-4

Title

Model Calibration Points

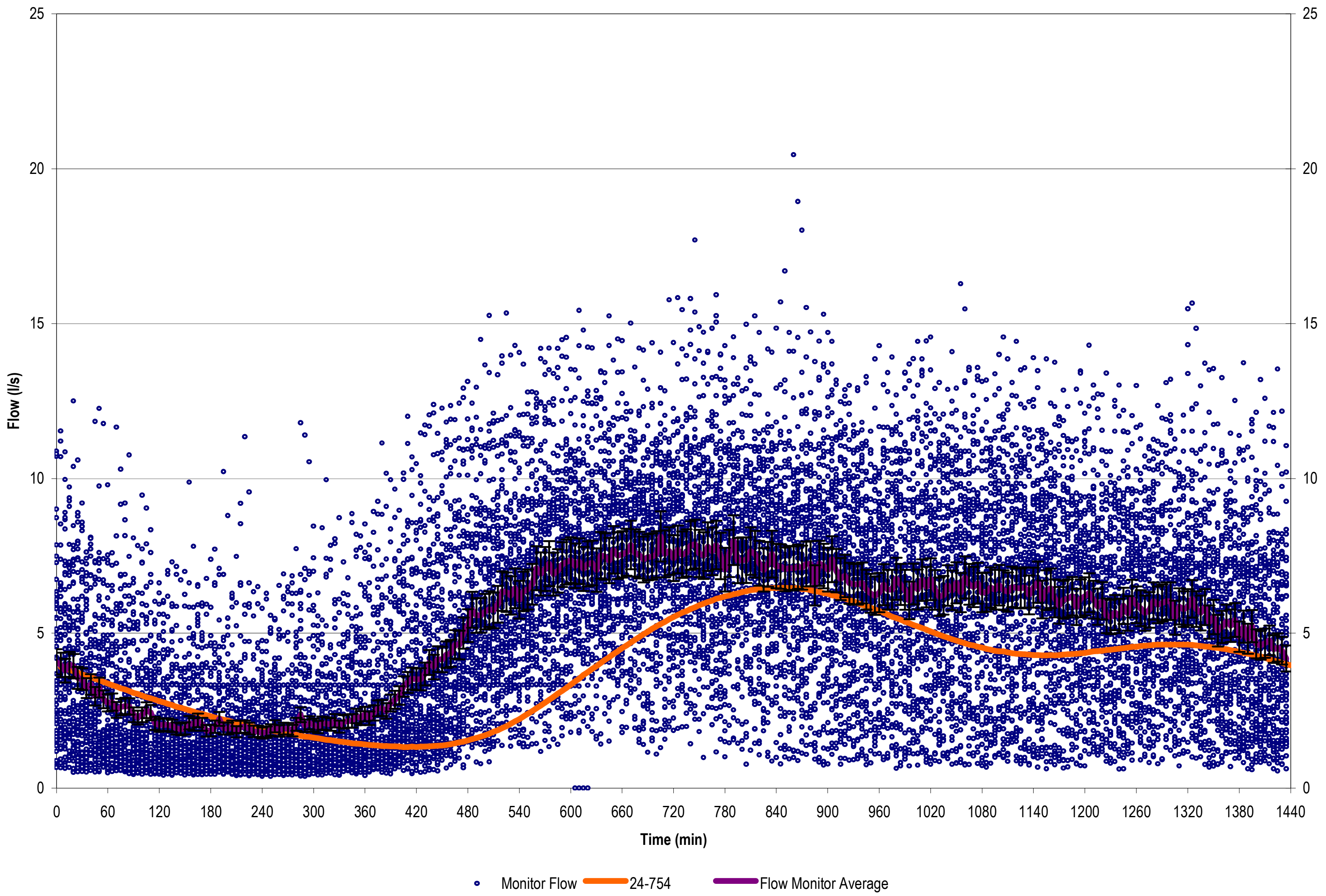

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Figure No.

3.5

Title

Site 1 Dry Weather Calibration

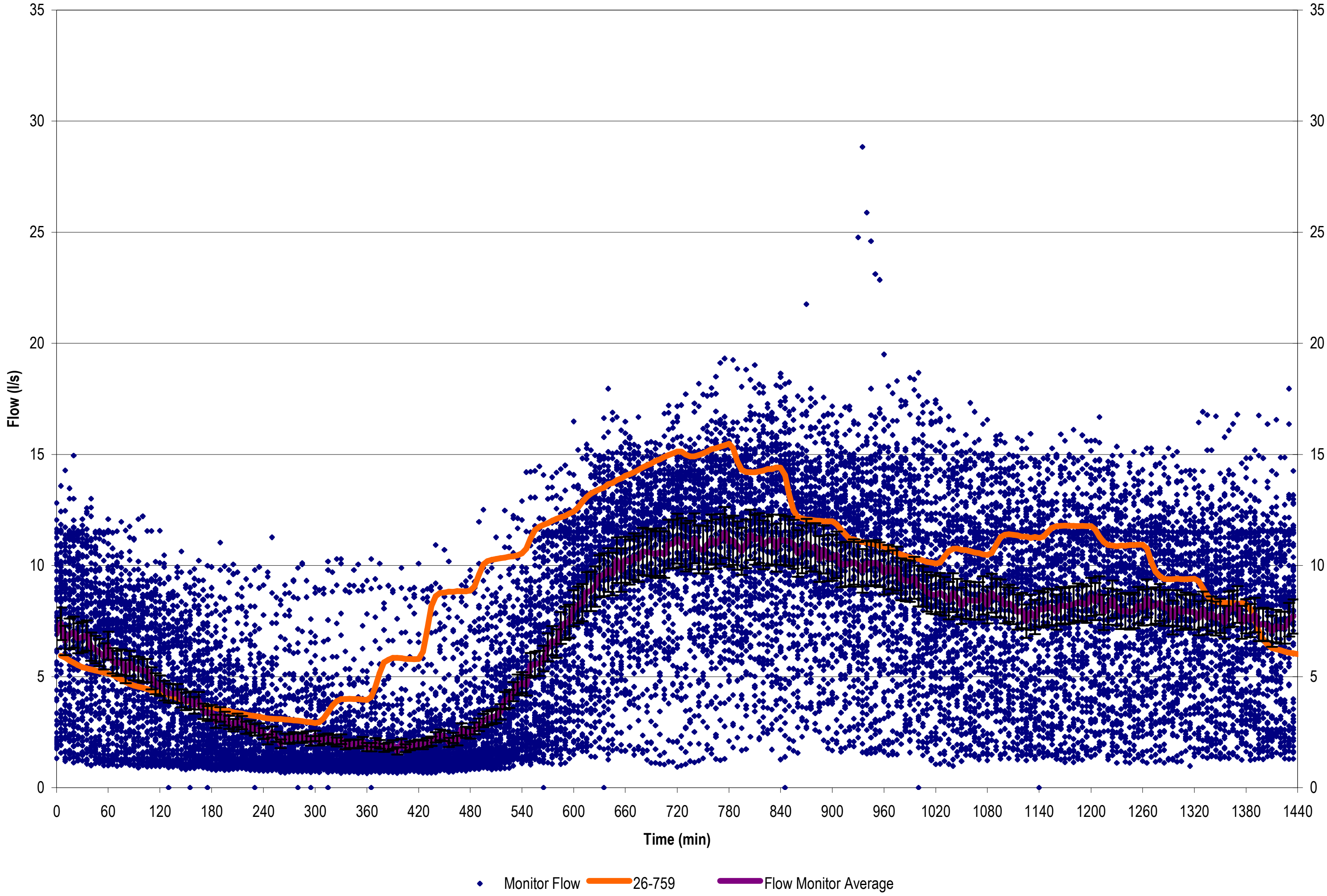

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Figure No.
3.6

Title

Site 2 Dry Weather Calibration

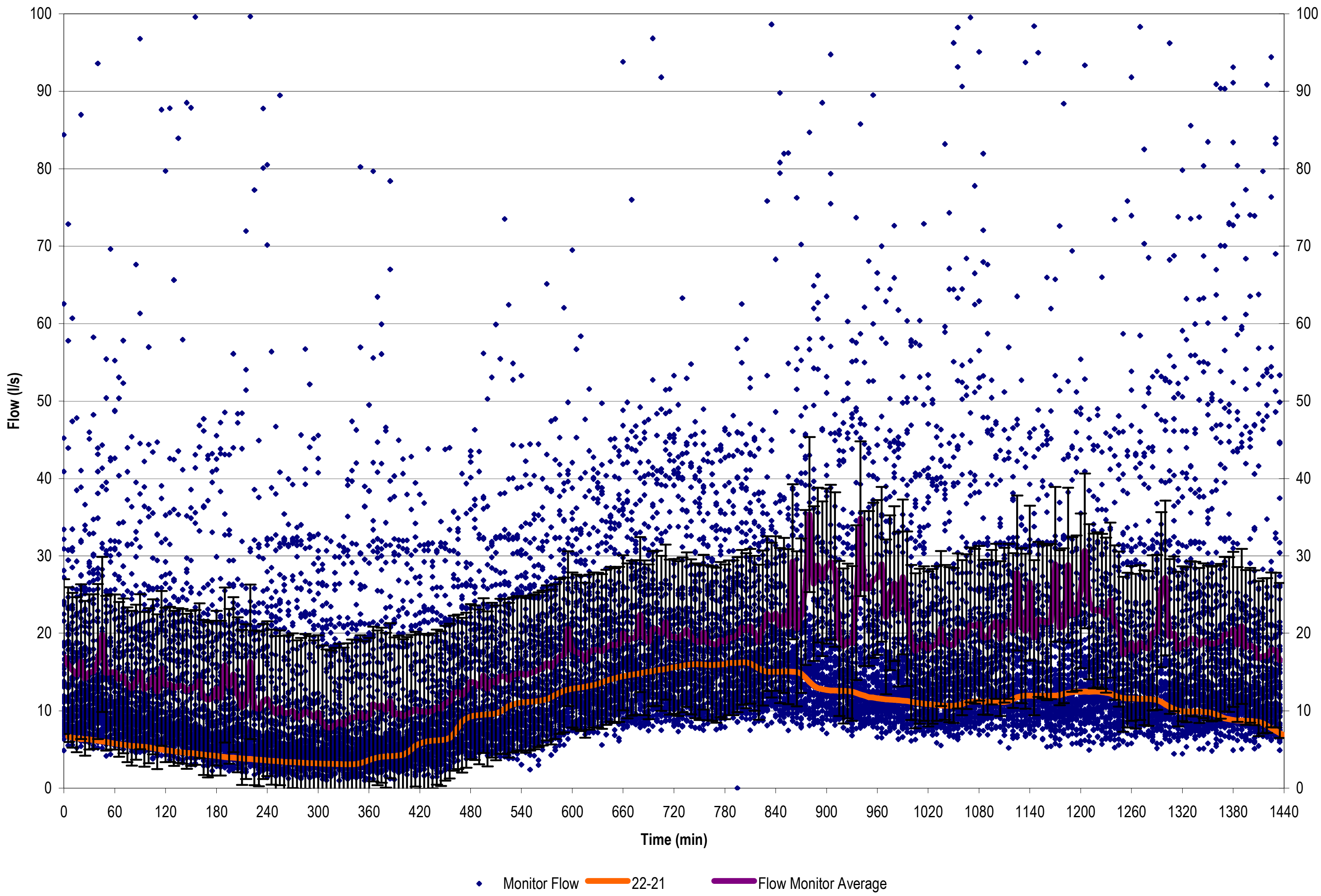

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Figure No.
3.7

Title

Site 3 Dry Weather Calibration

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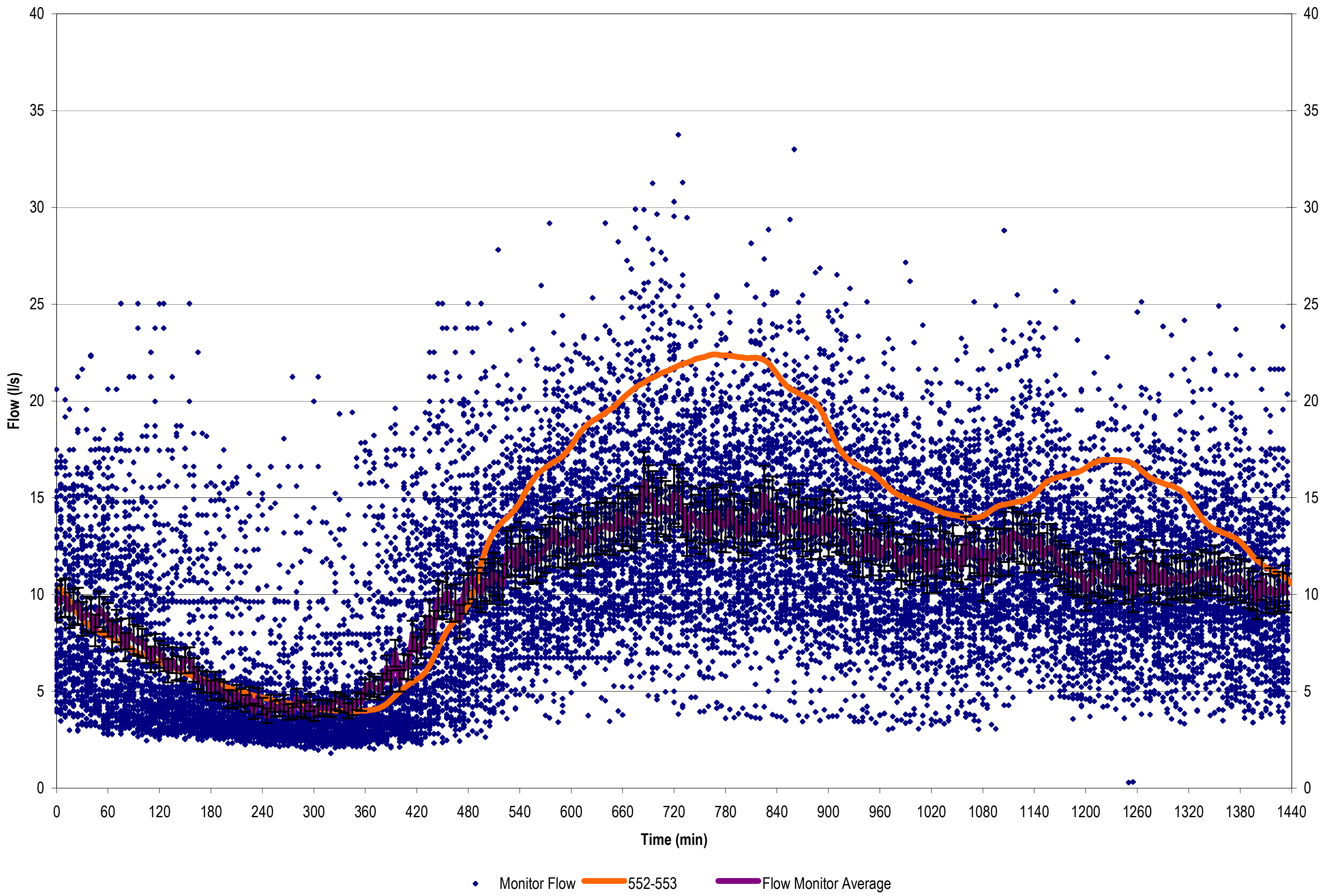

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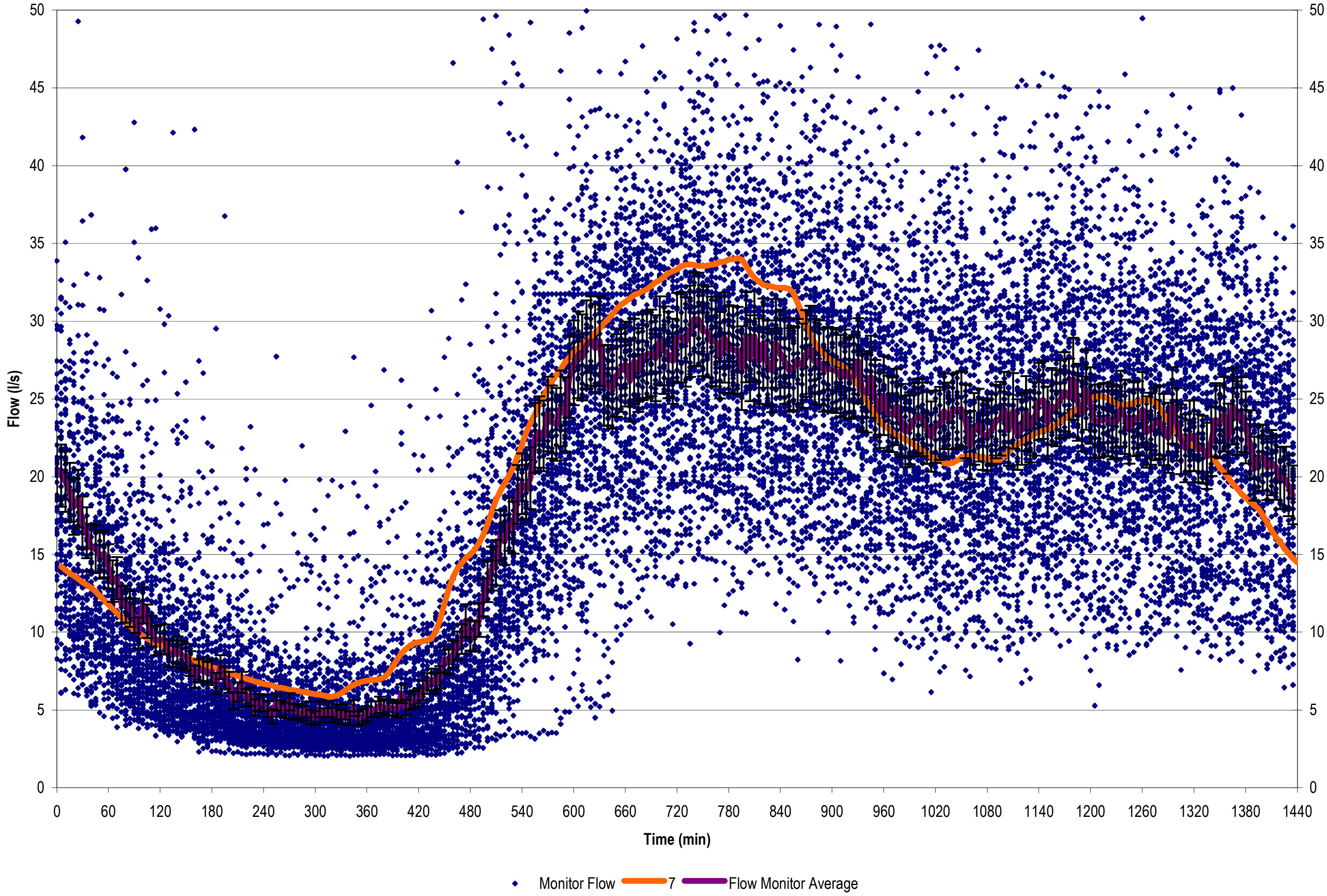
Figure No.
3.8

Title

Site 4 Dry Weather Calibration



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Wastewater Master Plan

Figure No.
3.9

Title

Site 5 Dry Weather Calibration

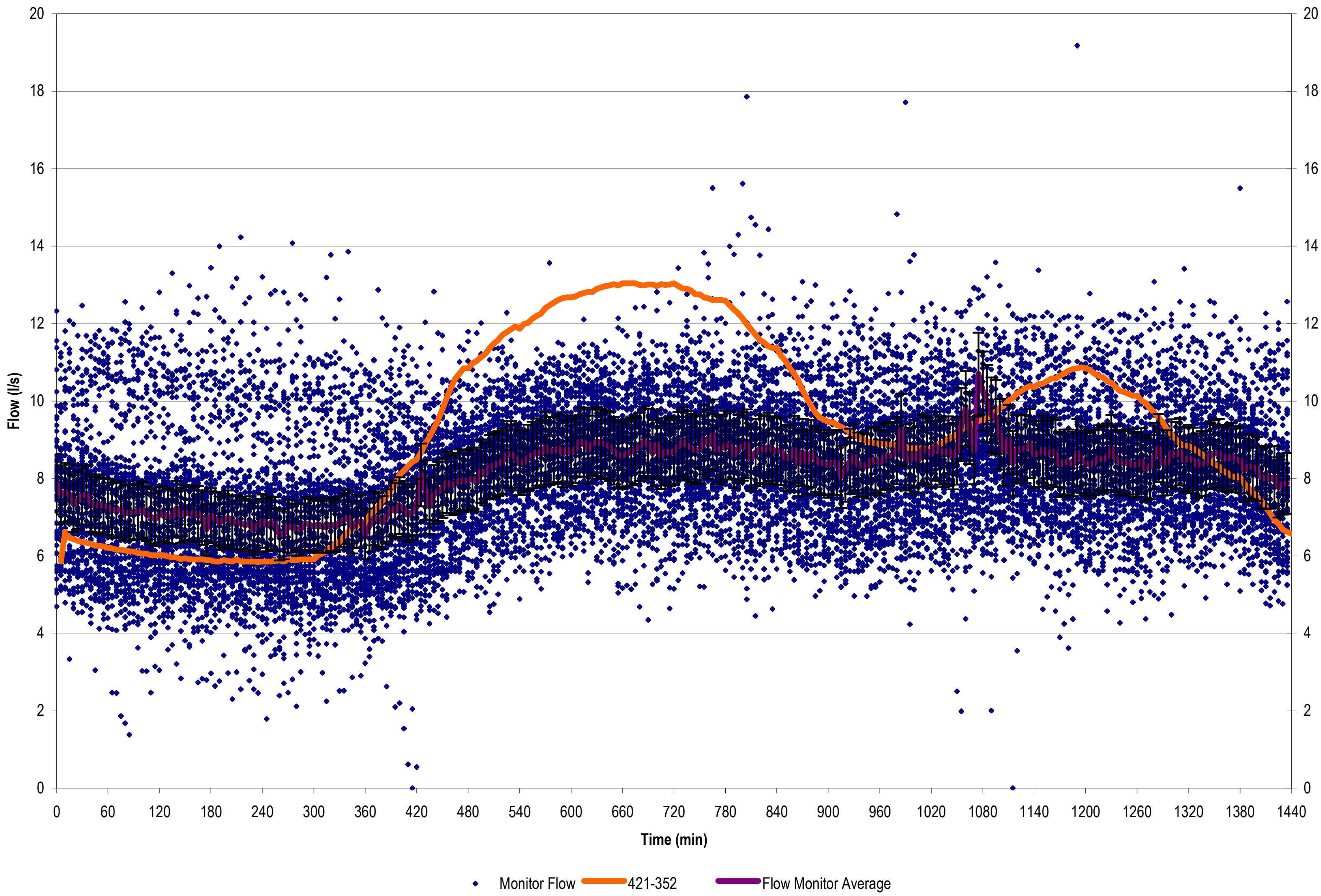

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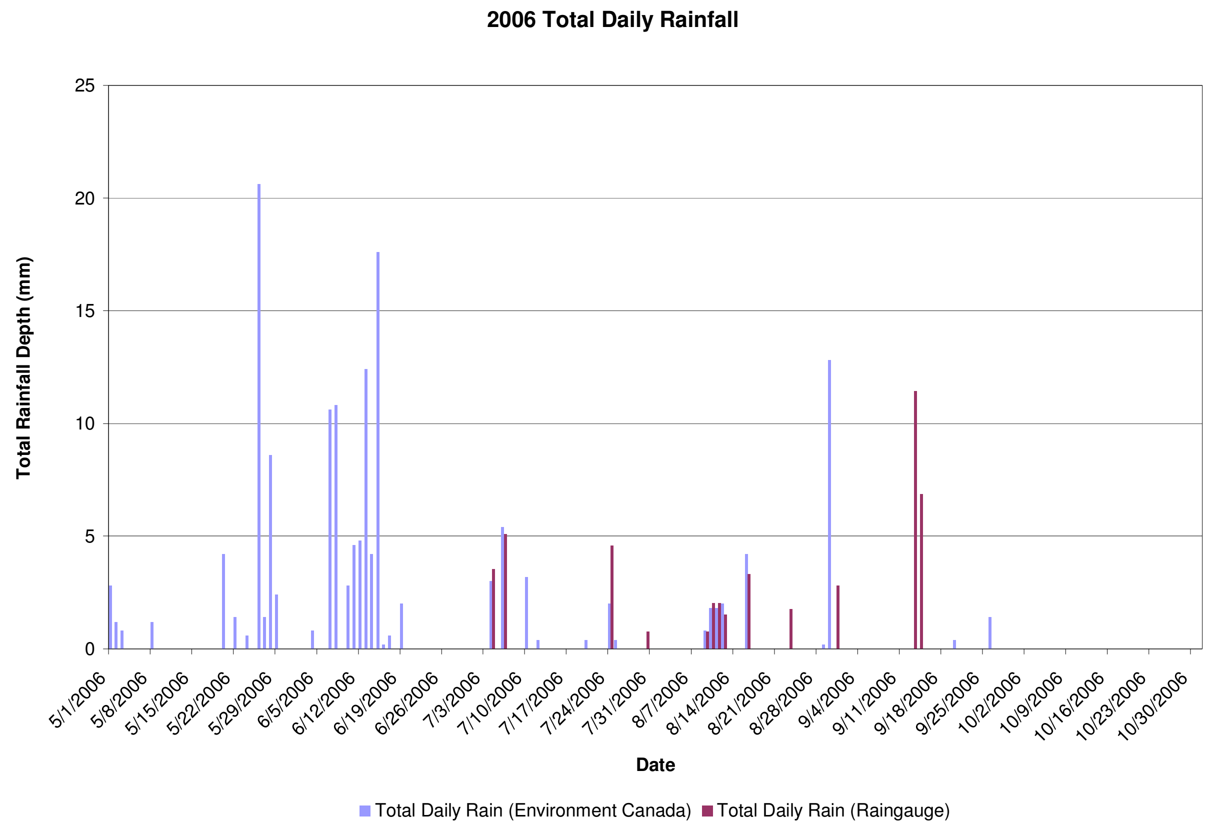
Figure No.
3.10

Title

Site 6 Dry Weather Calibration



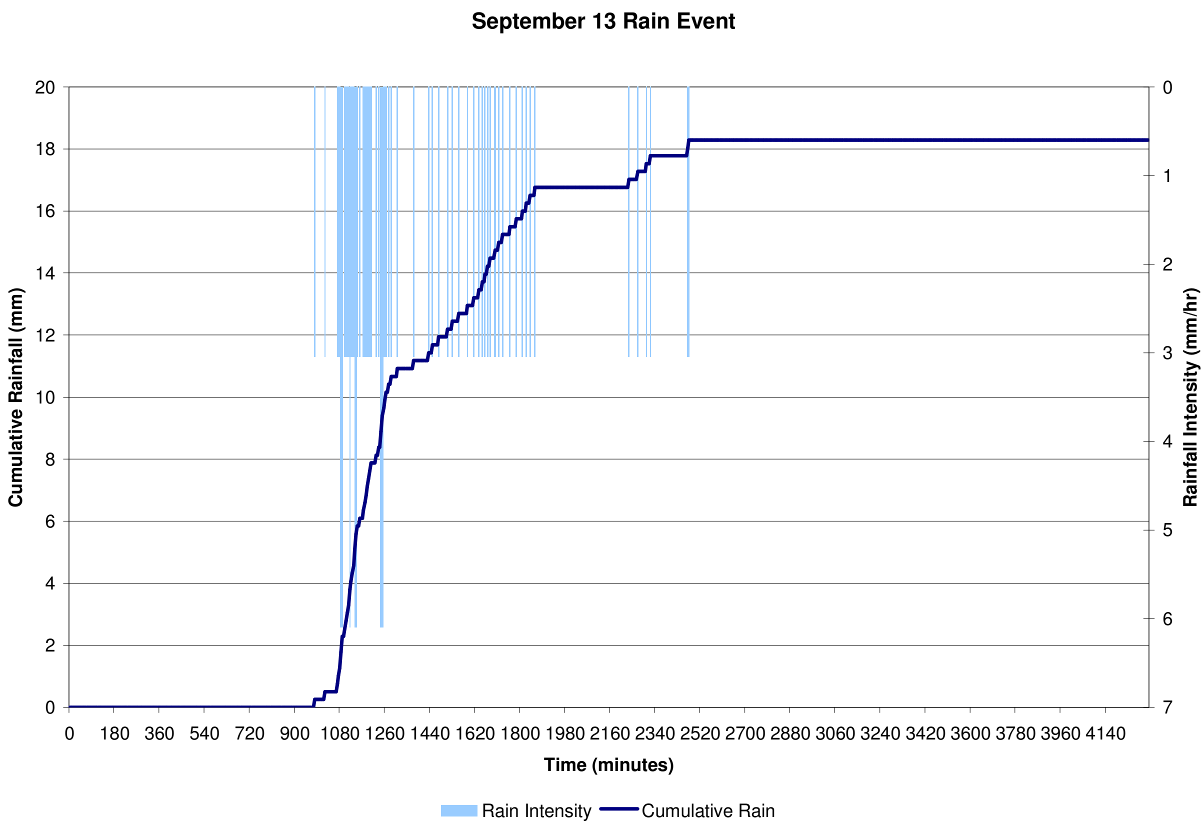


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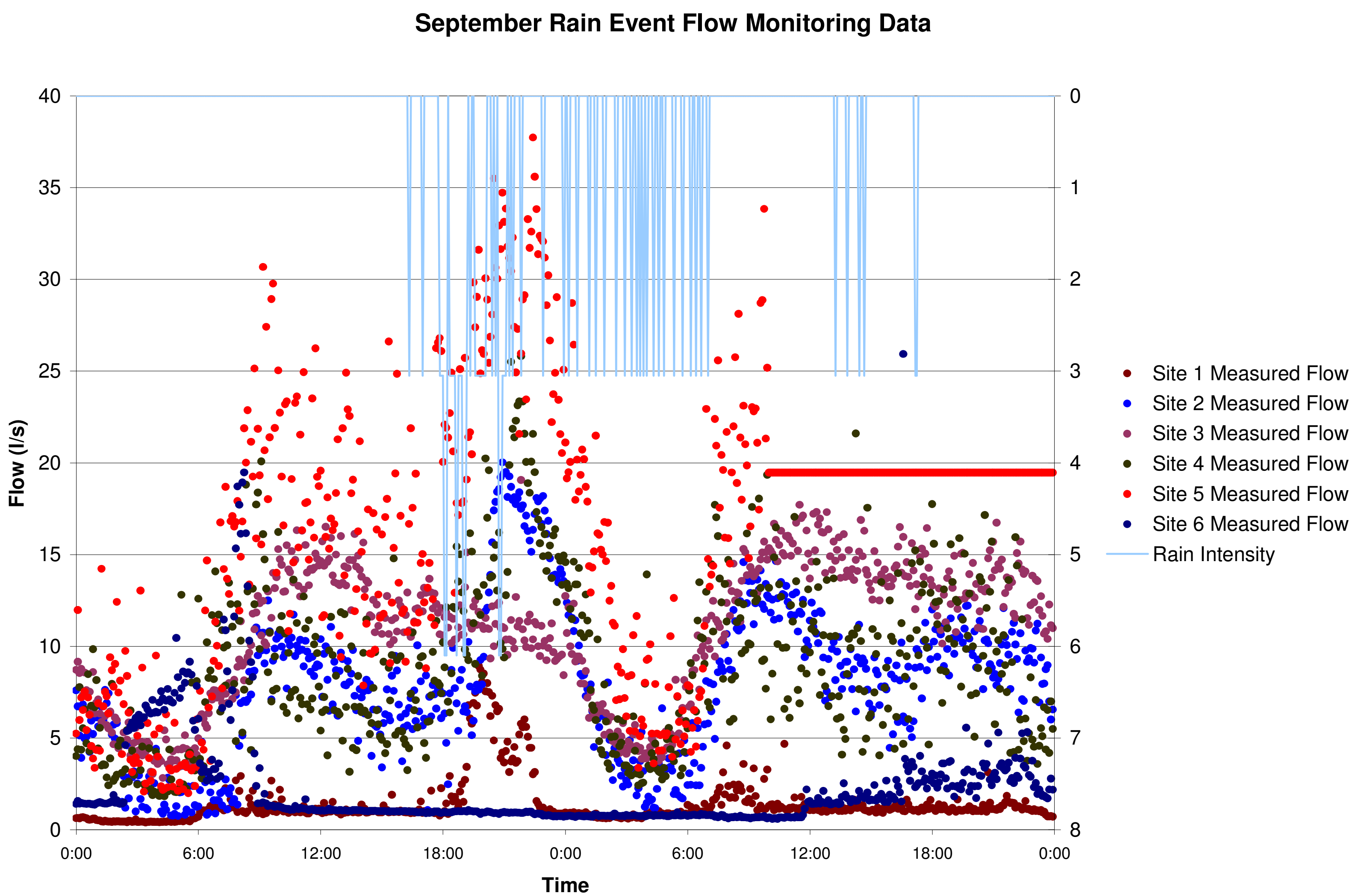
Figure No.

3.11

Title

Wet Weather Verification Rainfall Event



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Wastewater Master Plan

Figure No.
3.12

Title

Wet Weather Verification Flow Monitor Data

Flow Monitor Site 1 - WWF Verification

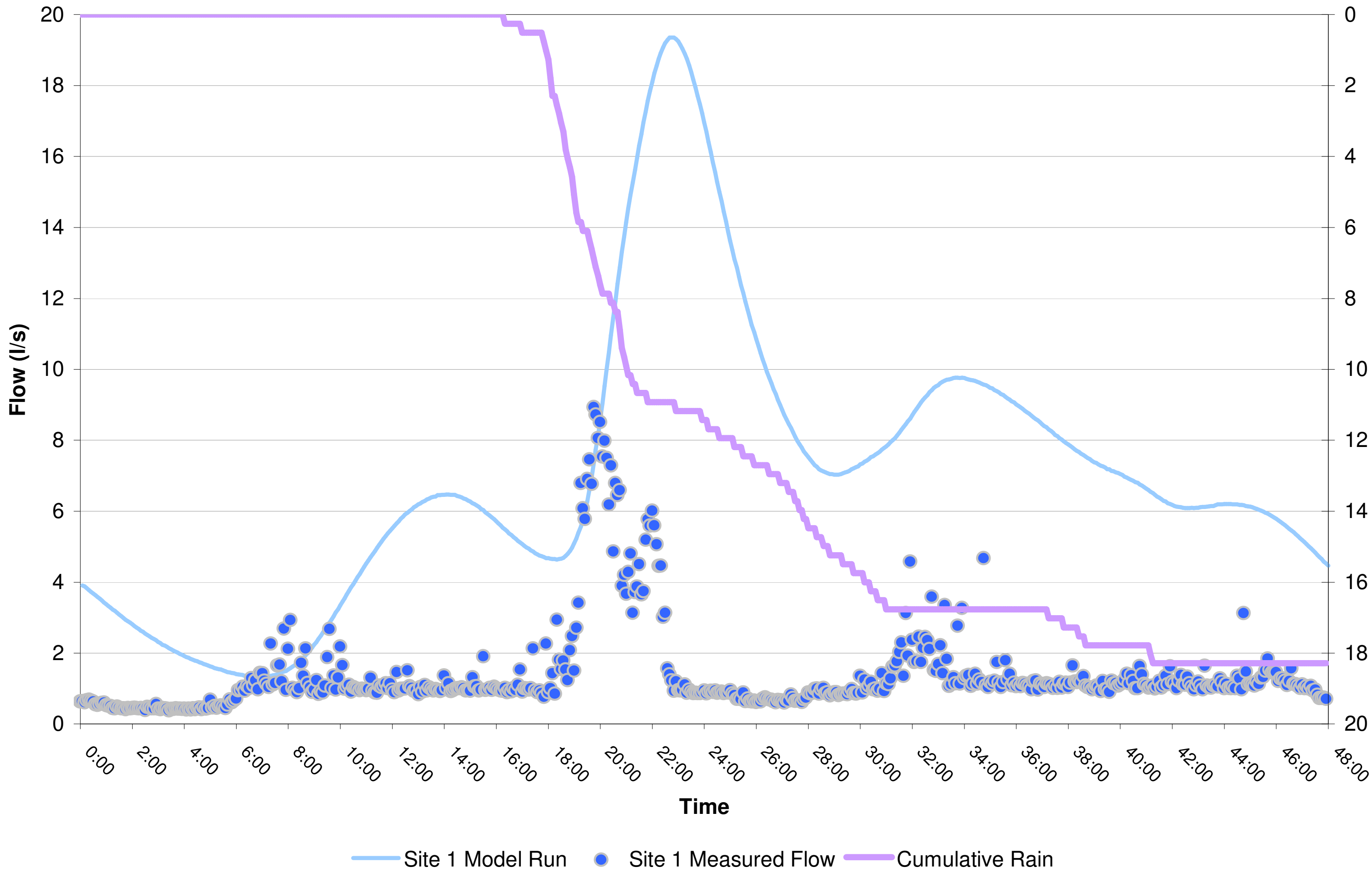

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Figure No.
3.13

Title

Site 1 Wet Weather Flow Verification

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Flow Monitor Site 2 - WWF Verification

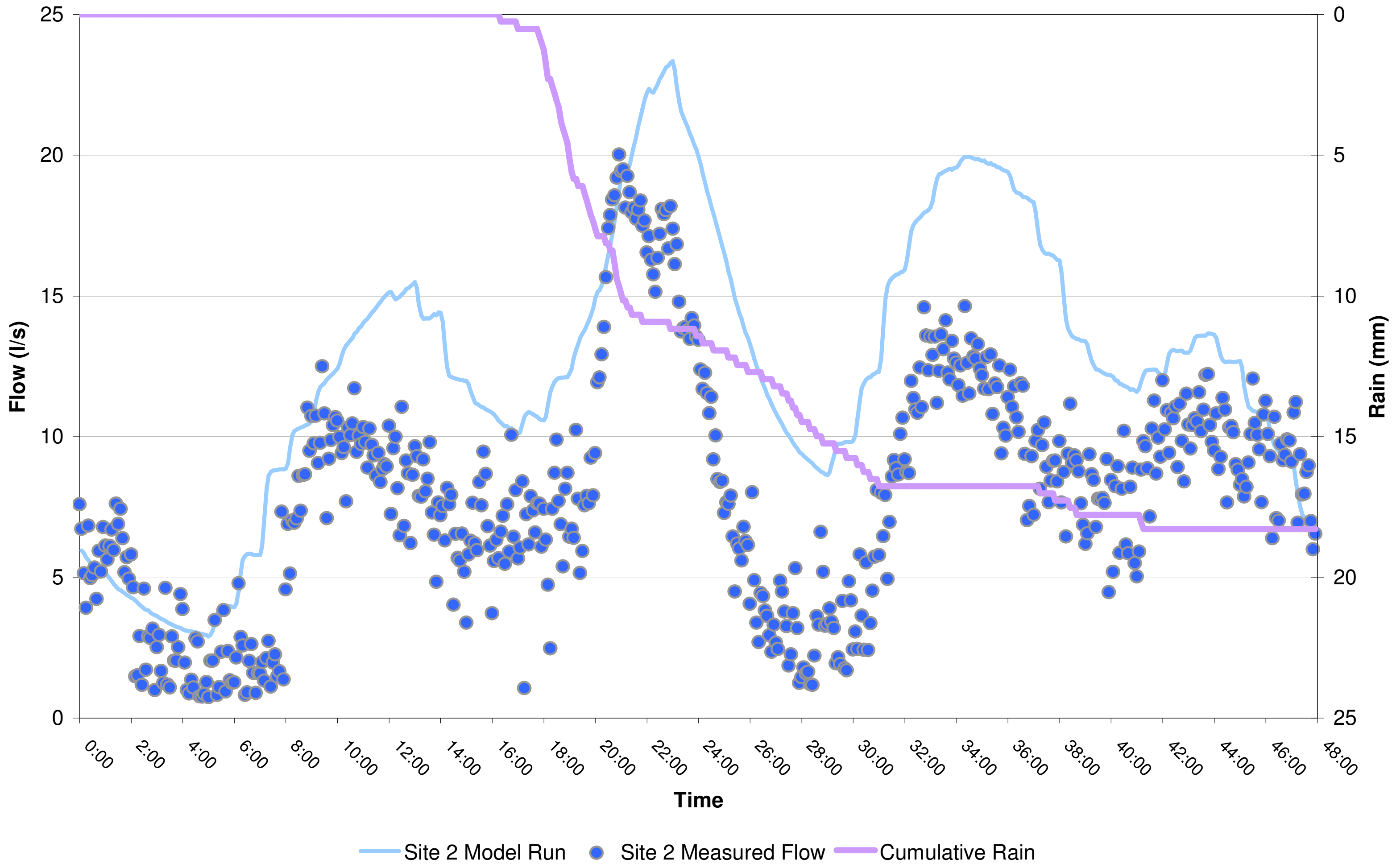

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Figure No.
3.14

Title

Site 2 Wet Weather Flow Verification

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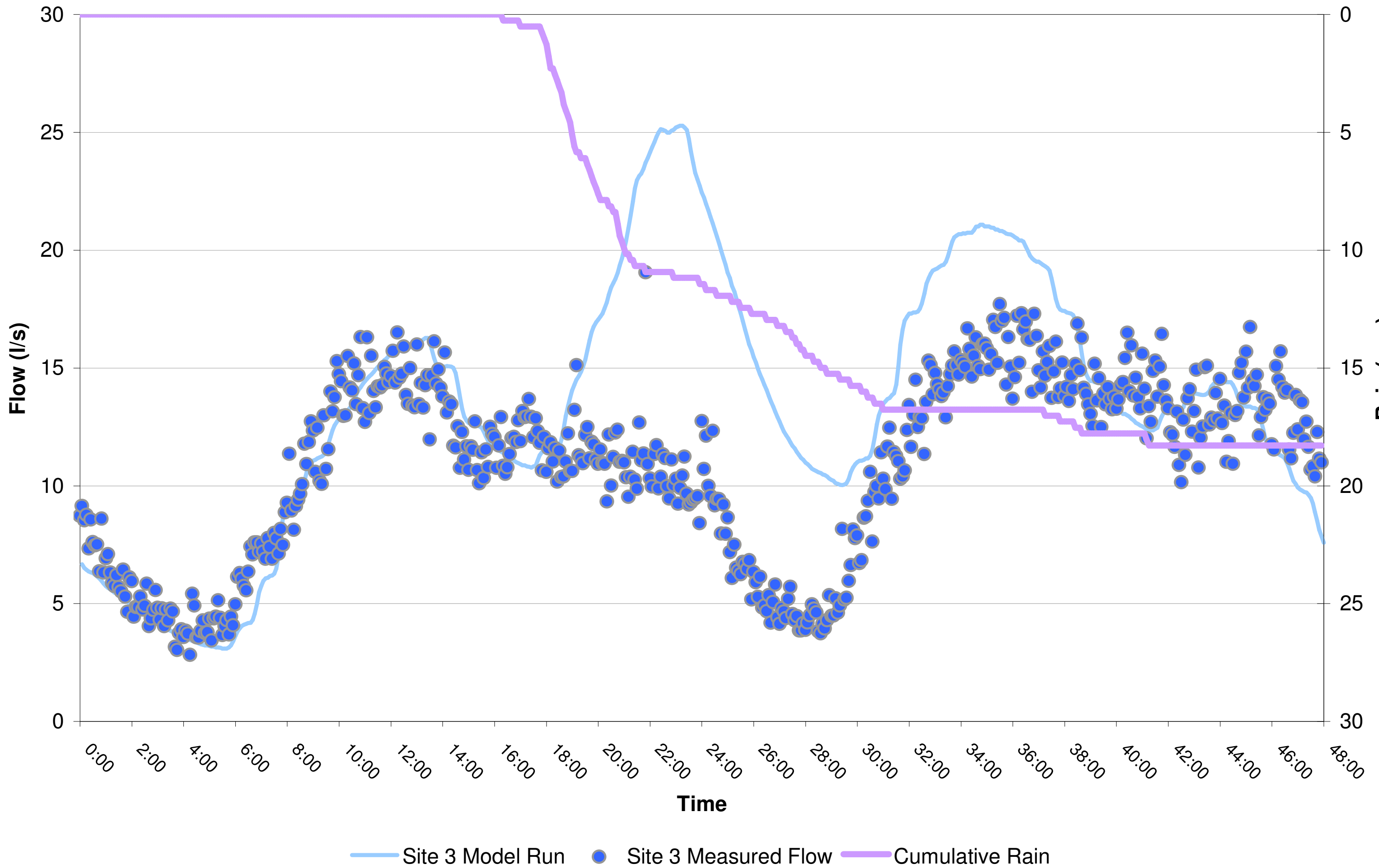
Flow Monitor Site 3 - WWF Verification



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Wastewater Master Plan

Figure No.
3.15

Title

Site 3 Wet Weather Flow Verification

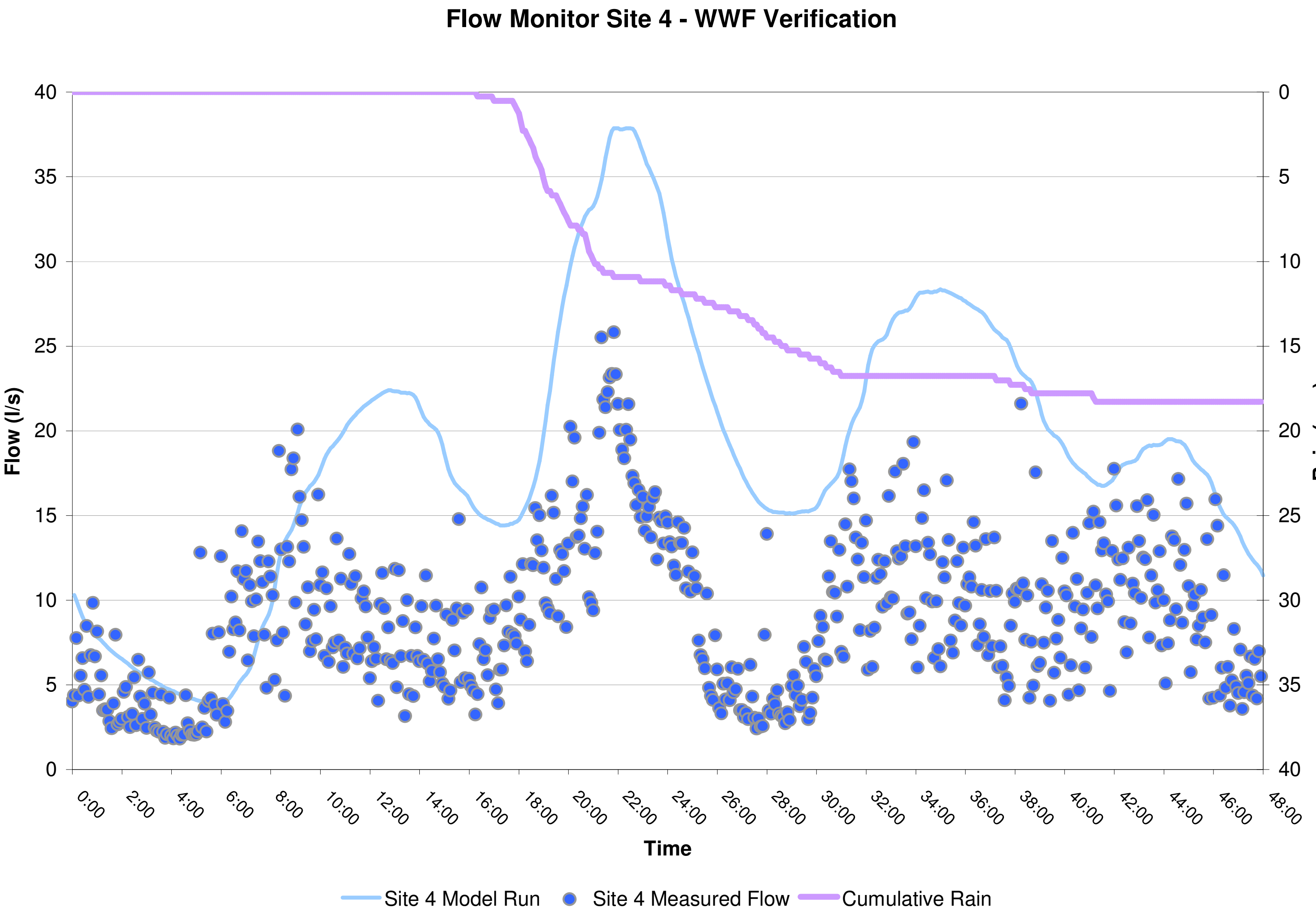

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Figure No.
3.16

Title

Site 4 Wet Weather Flow Verification

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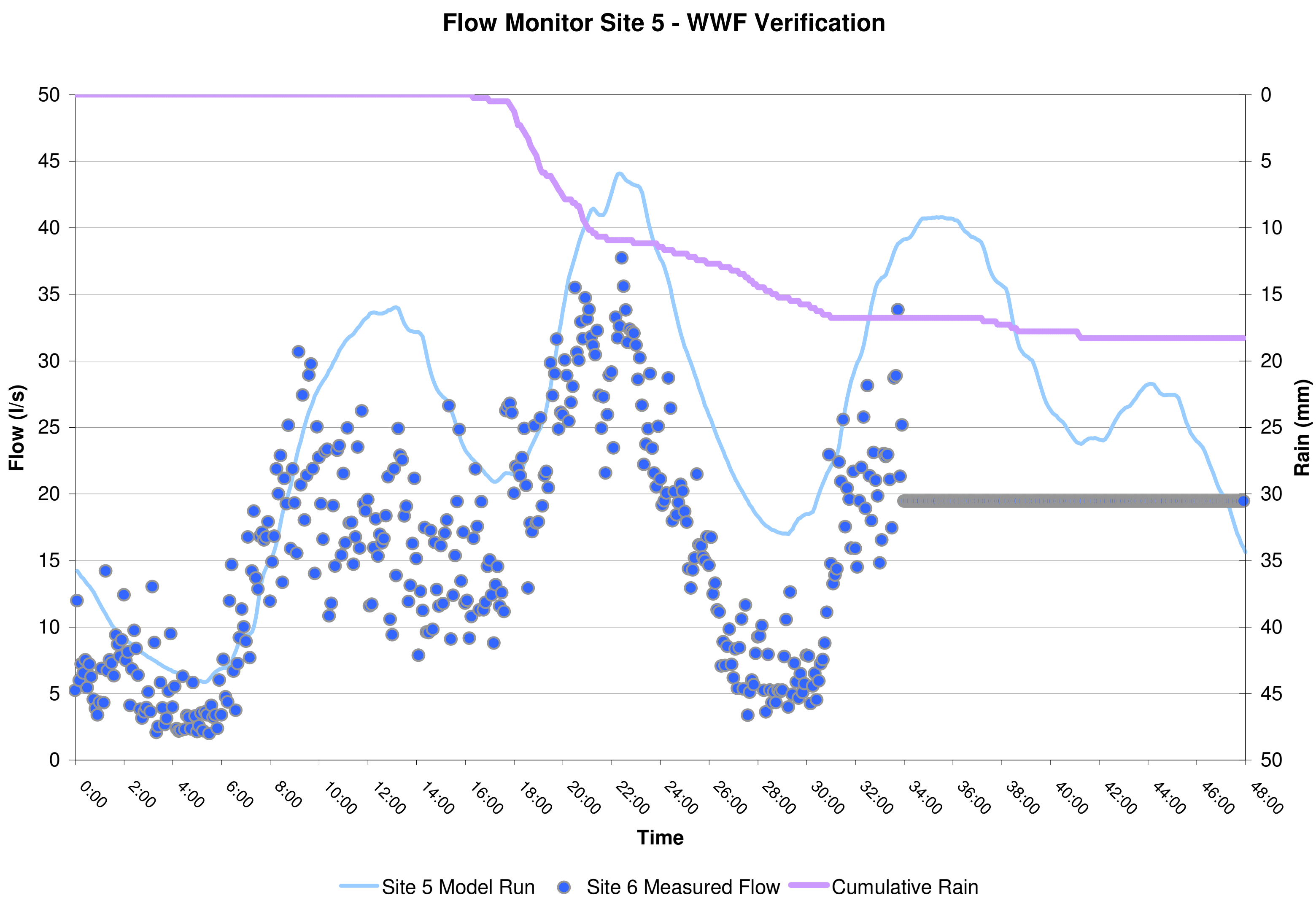

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Figure No.
3.17

Title

Site 5 Wet Weather Flow Verification

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Flow Monitor Site 6 - WWF Verification

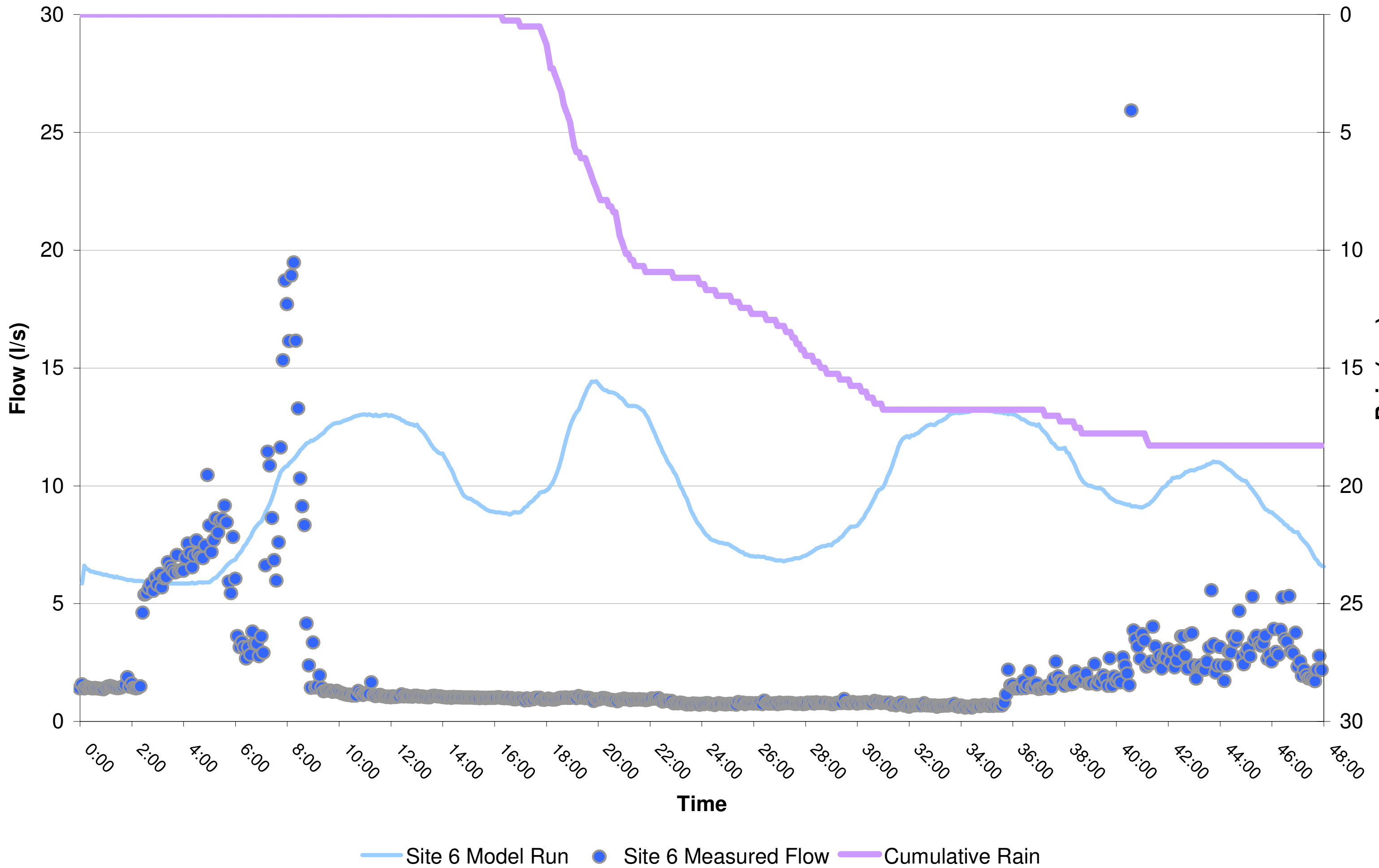

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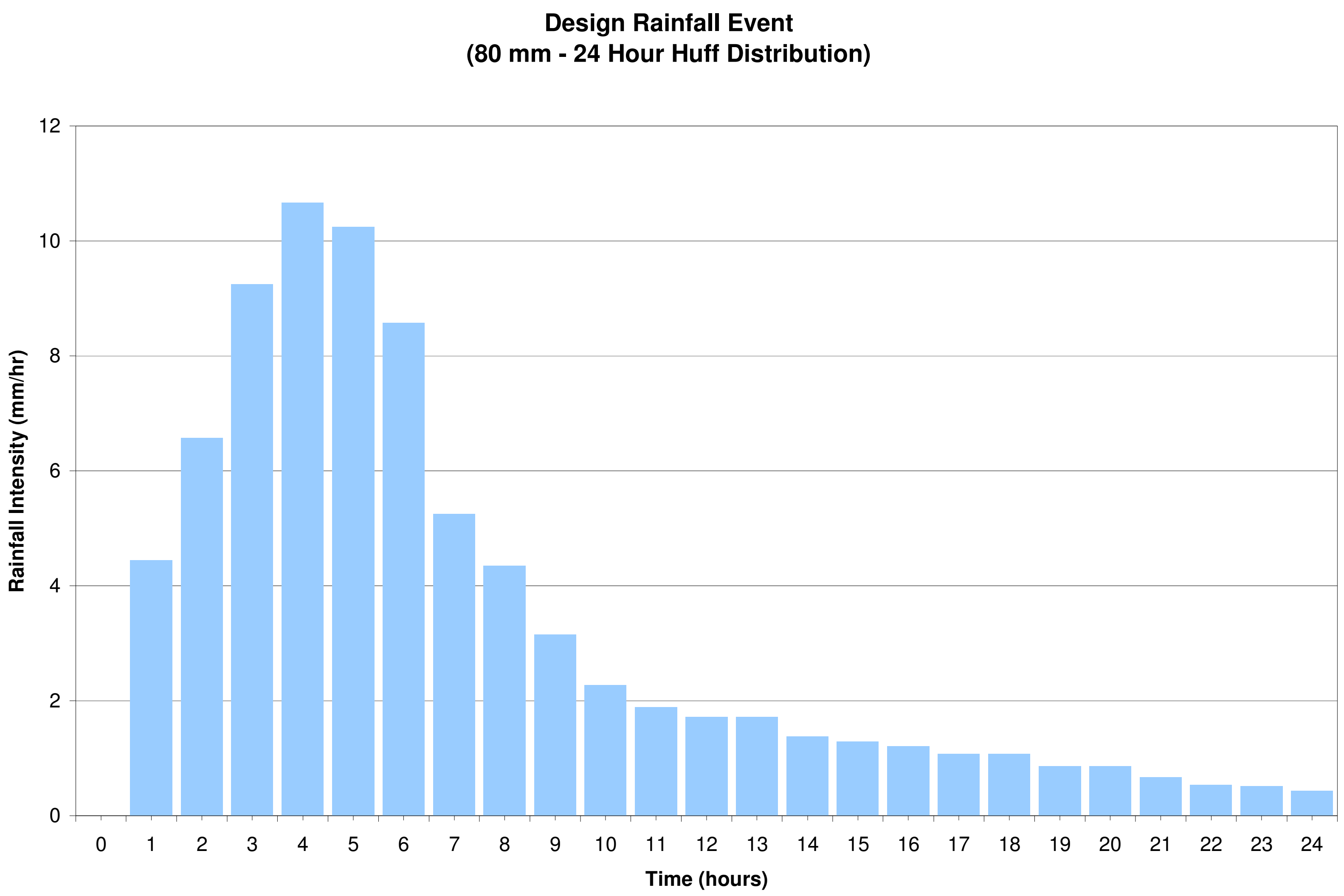
Figure No.
3.18

Title

Site 6 Wet Weather Flow Verification



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Wastewater Master Plan

Figure No.
3.19

Title

Wet Weather Design Rainfall Event

4.0 Existing System Evaluation

4.1 EXISTING SYSTEM CAPACITY

The performance of the sanitary sewer system was analyzed using the sanitary sewer computer model developed during this study. This model calculates flows and hydraulic grades for every pipe in the system. A two-day duration model simulation requires approximately 10 minutes of computing time on a current top of the line computer.

4.1.1 Model Results

The figures described below are a hydrographs from key points within the model. These hydrographs show the modeled dry weather flows and the peak design wet weather flows within the system.

- **Figure 4-1** Bellevue Lagoons Dry Weather Flow
- **Figure 4-2** Frank Water Treatment Plant Dry Weather Flow
- **Figure 4-3** Bellevue Lagoons Wet Weather Flow
- **Figure 4-4** Frank Water Treatment Plant Wet Weather Flow

These design flows are used to demonstrate the performance measures that form the basis of the existing system evaluation. **Table 4-1** is a summary of simulated flows from key points in the collection system.

Table 4-1 Peak Wastewater Flows

	Peak Dry Weather Flow (l/s)	Peak Wet Weather Flow (l/s)
Hillcrest	7.5	20.6
Bellevue	23.2	44.1
Bellevue Lagoons	34.8	69.8
Coleman	6.5	68.1
Blairmore	22.4	61.4
Frank WWTP	34.0	143.1

4.1.2 Collection System

The existing system was assessed based on three performance measures:

1. Hydraulic Capacity Rating

   The hydraulic capacity rating of a pipe segment in the system is calculated by comparing the peak modeled flow by the calculated maximum pipe capacity (Manning's Equation).

$$HC = \frac{Q_{simulated}}{Q_{calculated}} \cdot 100\%$$

$Q_{simulated}$ = *Peak Modeled Flow*

HC = Pipe Hydraulic Capacity

$$Q_{calculated} = \frac{1}{n} \cdot A \cdot R^{2/3} \cdot s^{1/2}$$

R = Hydraulic Radius

s = Pipe Slope

A = Pipe Area

n = Manning's Roughness

A hydraulic capacity rating below 100% represents a pipe where the peak modeled flow is still within the calculated pipe capacity. Hydraulic capacity ratio above 100% will result in systemic problems including system surcharging and elevated risk of sanitary sewer overflow (SSO) and basement flooding.

2. Pipe Residual Capacity

The hydraulic capacity rating of a pipe segment in the system is calculated by subtracting the peak modeled flow from the calculated maximum pipe capacity (Manning's Equation).

$$PCR = \frac{(Q_{calculated} - Q_{simulated})}{Q_{calculated}} \cdot 100\%$$

$Q_{simulated}$ = *Peak Modeled Flow*

PCR = Pipe Capacity Remaining

$$Q_{calculated} = \frac{1}{n} \cdot A \cdot R^{2/3} \cdot s^{1/2}$$

R = Hydraulic Radius

s = Pipe Slope

A = Pipe Area

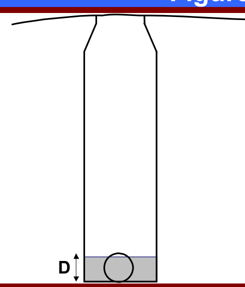
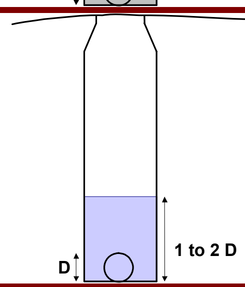
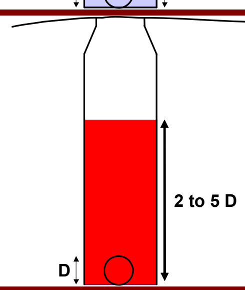
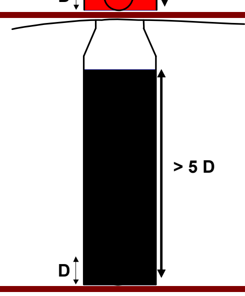
n = Manning's Roughness

A hydraulic capacity rating below 10% represents a pipe where the peak modeled flow is above the capacity limit defined by Alberta Design Standards. A pipe capacity remaining value of less than 10% may result in systemic problems including system surcharging and elevated risk of sanitary sewer overflow (SSO) and basement flooding.

3. Manhole Surcharging Severity

The manhole surcharging severity rating is calculated by comparing the peak depth of water in a manhole with the depth of the outgoing pipe. **Table 4-2** illustrates the definitions of surcharging severity. Generally, the degree of surcharging can be extrapolated to the risk of flooding to adjacent properties connected to the sewer system and the risk of the occurrence of an SSO to the environment.

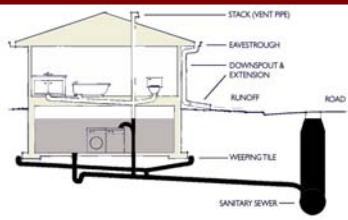
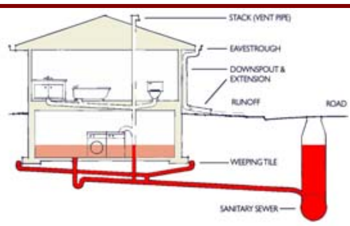
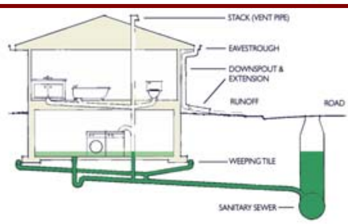
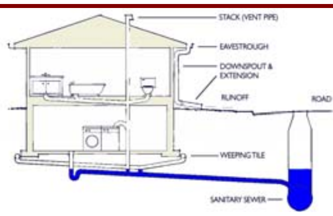
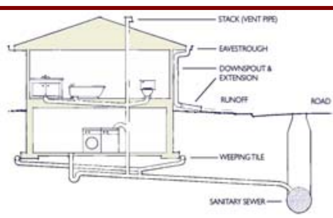
Table 4-2 Definitions for Severity of Manhole Surcharging

Rating	Figure	Description
No Surcharging		The depth of sewage remains less than the pipe diameter.
Minor Surcharging		The depth of sewage rises to between 1 and 2 times the pipe diameter.
Moderate Surcharging		The depth of sewage rises to between 2 and 5 times the pipe diameter.
Severe Surcharging		The depth of sewage rises to over 5 times the pipe diameter.

4. *Hydraulic Grade Line Factor (Risk to property)*

   Once the elevation model has been updated an additional performance measure should be added to the overall system performance assessment.

Table 4-3 Definitions for Potential Flood Damage

Risk Factor Illustration	*Potential for Flood Damage due to Wet Weather Related Sanitary Backup*
	***Highly Probable*** ***Hydraulic Grade Line to Surface*** ***0.0 to 1.0 m***
	***Probable*** ***Hydraulic Grade Line to Surface*** ***1.0 to 1.5 m***
	***Likely*** ***Hydraulic Grade Line to Surface*** ***1.5 to 2.0 m***
	***Unlikely*** ***Hydraulic Grade Line to Surface*** ***2.0 to 2.5 m***
	***No Risk*** ***Hydraulic Grade Line to Surface*** ***Greater than 2.5 m or no surcharging***

4.1.3 Dry Weather Capacity

The existing collection system performs well during dry weather flow with no pipe capacity constraints. The results of the three performance measures are described below.

4.1.3.1 Pipe Hydraulic Rating

Figure 4-5 shows the location of pipes with the hydraulic capacity ratings described in **Table 4-4.** During dry weather flows 99.4% of the collection system operates within the required design pipe hydraulic rating of 80% of pipe full capacity. The 0.6% that does not is due to the Bellevue inverted siphons running under pressure.

Table 4-4 Dry Weather Pipe Hydraulic Rating

Hydraulic Rating		Pipe Length (m)	Percentage of System
Less than 80%		65,763	99.4%
80% - 100%		-	0.0%
100% - 125%		-	0.0%
125% - 150%		-	0.0%
150% - 250%		11	0.0%
Greater than 250%		358	0.5%

4.1.3.2 Pipe Residual Capacity

Table 4-5 summarizes the capacity remaining in the sanitary sewer collection system**.** During dry weather flows 99.4% of the collection system has 50% or more of its pipe capacity available. The 0.6% that does not is due to the Bellevue inverted siphons running under pressure.

Table 4-5 Dry Weather Pipe Residual Capacity

Percentage of Capacity Remaining		Pipe Length (m)	Percentage of System
Less than 10%		369	0.6%
10% - 25%		-	0.0%
25% - 50%		4	0.0%
50% - 80%		3,672	5.6%
80% - 100%		62,087	93.9%

4.1.3.3 Manhole Surcharging Severity

Figure 4-6 shows the location of manholes with surcharge ratings described in **Table 4-6.** During dry weather flows the wastewater collection system experiences no capacity related surcharging. The three manholes shown in the chart are junction nodes used to simulate the Bellevue inverted siphon system.

Table 4-6 Dry Weather Manhole Surcharging Severity

Severity of Surcharging		Number of Manholes	Percentage of System
Severe		3	0.4%
Moderate		-	0.0%
Minor		-	0.0%
No Surcharging		807	99.6%

4.1.4 Wet Weather Capacity

The existing collection system experiences some stresses on pipe capacity in localized problem areas. The majority of the system still operates within the pipe capacity. The results of the three performance measures are described below.

4.1.4.1 Pipe Hydraulic Rating

Figure 4-7 shows the location of pipes with the hydraulic capacity ratings described in **Table 4-7.** During wet weather flows 95.9% of the collection system operates within the required design pipe hydraulic rating of 80% of pipe full capacity. A further 2.0% of the system operates within the pipe full capacity. That leaves 1.6% of the collection system operating over its pipe full capacity.

The additional 0.6% is due to the Bellevue inverted siphons running under pressure.

Table 4-7 Wet Weather Pipe Hydraulic Rating

Hydraulic Rating		Pipe Length (m)	Percentage of System
Less than 80%		63,444	95.9%
80% - 100%		1,310	2.0%
100% - 125%		572	0.9%
125% - 150%		437	0.7%
150% - 250%		-	0.0%
Greater than 250%		369	0.6%

4.1.4.2 Pipe Residual Capacity

Table 4-8 summarizes the capacity remaining in the sanitary sewer collection system**.** During wet weather flows 87.5% of the collection system has 50% or more of its pipe capacity available. 9.6% of the system has between 10% and 50% of its capacity available. A further 2.4% of the system has less than 10% of its pipe full capacity available.

The 0.6% that does not is due to the Bellevue inverted siphons running under pressure.

Table 4-8 Wet Weather Pipe Residual Capacity

Percentage of Capacity Remaining		Pipe Length (m)	Percentage of System
Less than 10%		1,867	2.8%
10% - 25%		1,023	1.5%
25% - 50%		5,388	8.1%
50% - 80%		13,207	20.0%
80% - 100%		44,647	67.5%

4.1.4.3 Manhole Surcharging Severity

Figure 4-8 shows the location of manholes with surcharge ratings described in **Table 4-9.** During wet weather flows 96.9% of the system manholes experience no surcharging. 2.8% of the manholes now experience minor or moderate surcharging. The additional 3 manholes (0.6%) that experience severe surcharging are due to the Bellevue inverted siphons running under pressure.

Table 4-9 Wet Weather Manhole Surcharging Severity

Severity of Surcharging		Number of Manholes	Percentage of System
Severe		3	0.4%
Moderate		15	1.9%
Minor		7	0.9%
No Surcharging		785	96.9%

4.2 EXISTING SYSTEM DEFICIENCIES

4.2.1 Deficiencies Demonstrated by Computer Modeling

1. Coleman "Sub-Trunk"

   The computer model currently predicts one potential problem area during peak wet weather flows. **Figure 4-9** shows the capacity problems present in the Coleman "Sub-Trunk" that runs west to east along 16 Ave parallel to the future Sentinel Trunk Extension.

This deficiency is related to localized pipe capacity constraints. The severity of surcharging is moderate to minor and may or may not pose a risk of sanitary sewer overflow to private property or the environment. A review of historical flooding complaints in the area should verify the extent of the impacts of the local capacity constraints.

The upgrade for this deficiency is discussed in Section 5.3.

4.2.2 Deficiencies Not Demonstrated by Computer Modeling

In addition to the problems identified through computer modeling, additional problem areas were identified during the data collection phase of the project.

2. Bellevue Inverted Siphon:

   The Bellevue Inverted Siphon line is the 150 mm pipe that runs from the manhole at the top of the hill (216 St Bellevue) to the inverted siphons that cross the Crowsnest River to the Bellevue Lagoons. The manhole at the top of the hill surcharges after relatively small rainfall events.

   The most likely cause of the capacity restriction is ill-conditioned hydraulics in the pipe due to insufficient inlet capacity and a pressurized downstream boundary condition.

   The Bellevue Siphon line deficiency is shown in **Figure 4-10**.

   The upgrade for this deficiency is discussed in Section 5.3.

3. Riverbottom Lift Station

   Under some flow conditions the existing lift station located in the Riverbottom area has insufficient capacity to pump existing incoming flows from its tributary area. The 100 mm force main from the lift station discharges to the exiting siphon system that discharges to the Bellevue Lagoons.

   During peak flows the hydraulic grade in the siphons is too high for the pumps in the lift station to overcome. As a result the existing pumps are ineffective when flows peak and there is a resultant risk of flooding upstream of the lift station.

   This condition is not simulated by the model. The Riverbottom Lift Station problems that have been identified are based on discussions with Municipal operations staff.

   The upgrade for this deficiency is discussed in Section 5.3.

4. Service Related Deficiencies

Additional surcharging was noted during the surcharge gauging program. This surcharging generally occurred during very small rain events. The model does not predict these levels of surcharging during more extreme events.

The cause of this problem should be investigated. The investigation program should include detailed data collection of the physical attributes of the collection system. In addition a CCTV survey will assist in determining potential service defects that may cause localized hydraulic blockages.

Figure 4-11, Figure 4-12, Figure 4-13 and **Figure 4-14** show some examples of the service related deficiencies found during field investigations.

Upgrade Options: Operational programs should be considered that will address these operating issues in the collections system. Programs should include:

- *CCTV Inspection Program:* The program should attempt to capture condition data from the entire collection system on a regular interval based on the criticality of the specific pipe in the system. For pipes smaller than 300mm the interval should be 5 to15 years depending on the current state of the infrastructure. For pipes 300mm and larger the interval should be 2 to10 years depending on the current state of the infrastructure.

- *Collection System Cleaning Program:* Pipes in the collection system should be cleaned on a 2-3 year rotation. Mains that experience regular debris buildup should be cleaned either annually or biannually.

- *Inflow and Infiltration Reduction:* Programs should be implemented to reduce the amount of extraneous flow in the collection system. Known problem areas should be targeted to determine the most effective control measures.

  Control measures may include cross connection identification and disconnection, smoke testing, CCTV inspections, additional flow monitoring or infrastructure replacement.

  New development should be constructed in a manner that minimizes the potential for inflow and infiltration. Newly constructed sanitary sewers may require exfiltration testing to verify water-tight installation of new services.

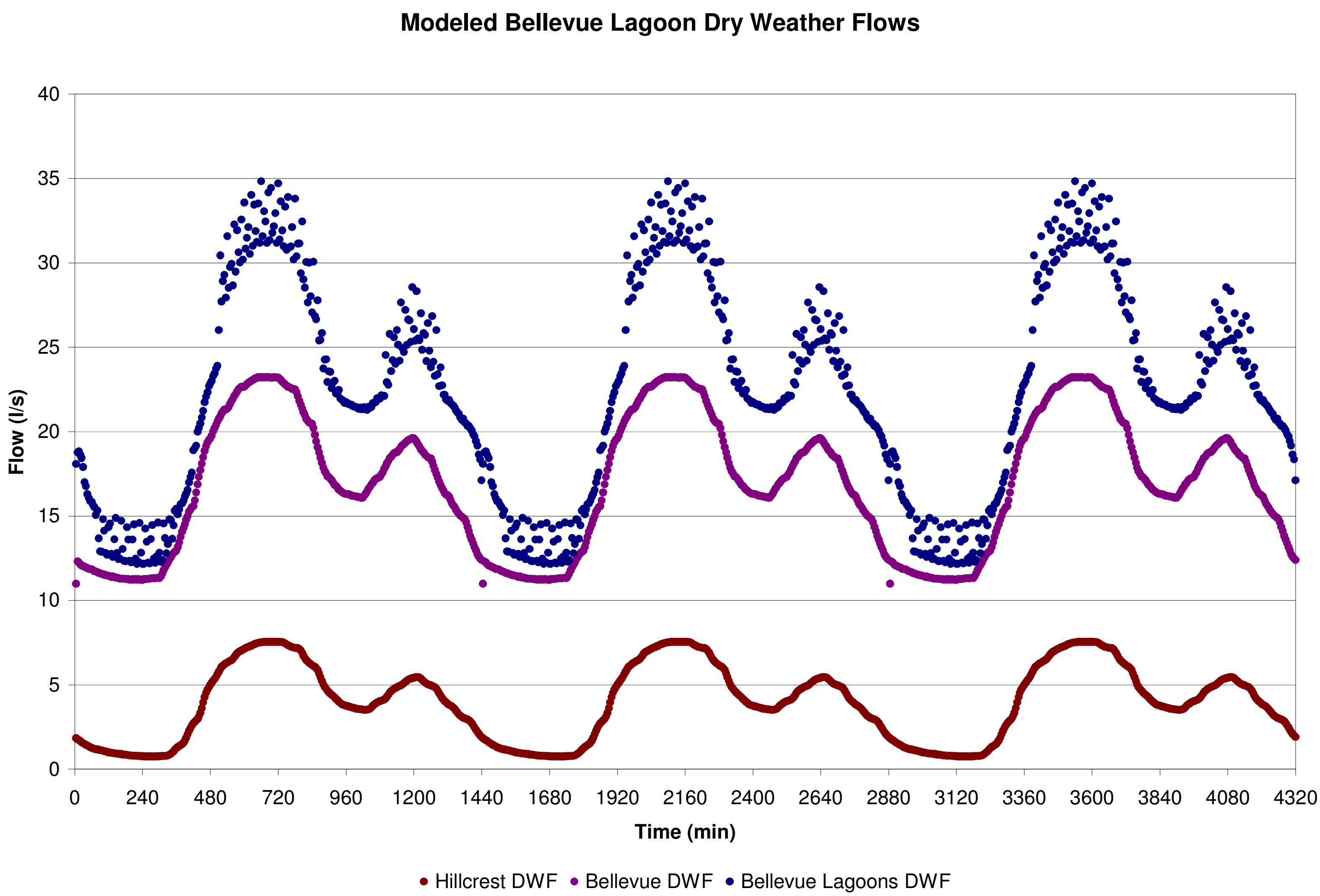
- *Surcharging Problem Area Identification:* Areas prone to surcharging should be monitored periodically to collect additional data to verify the success (or lack thereof) of programs implemented to increase the collection system reliability.

4.3 EXISTING SYSTEM REMAINING CAPACITY

The existing system analysis allows for a detailed assessment of the capacity of the existing system and creates the basis for developing growth strategies for the municipality.

Figure 4-15 provides an inventory of the pipe capacity remaining in the collection system under existing peak flow conditions.

List of Figures for Section 4



Legend

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Client/Project

Municipality of Crowsnest Pass

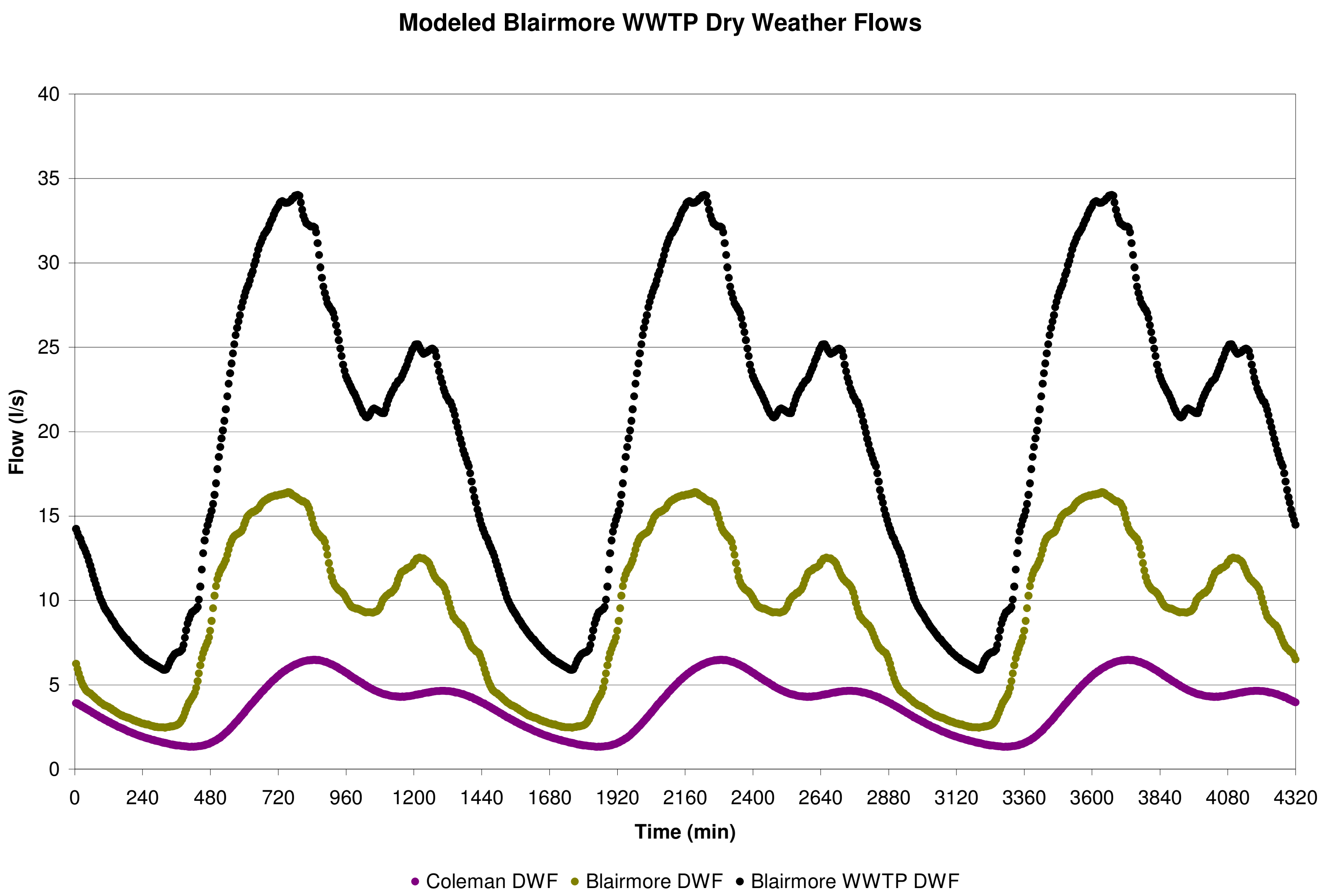
Wastewater Master Plan

Figure No.

4.1

Title

Bellevue Lagoons Dry Weather Flow



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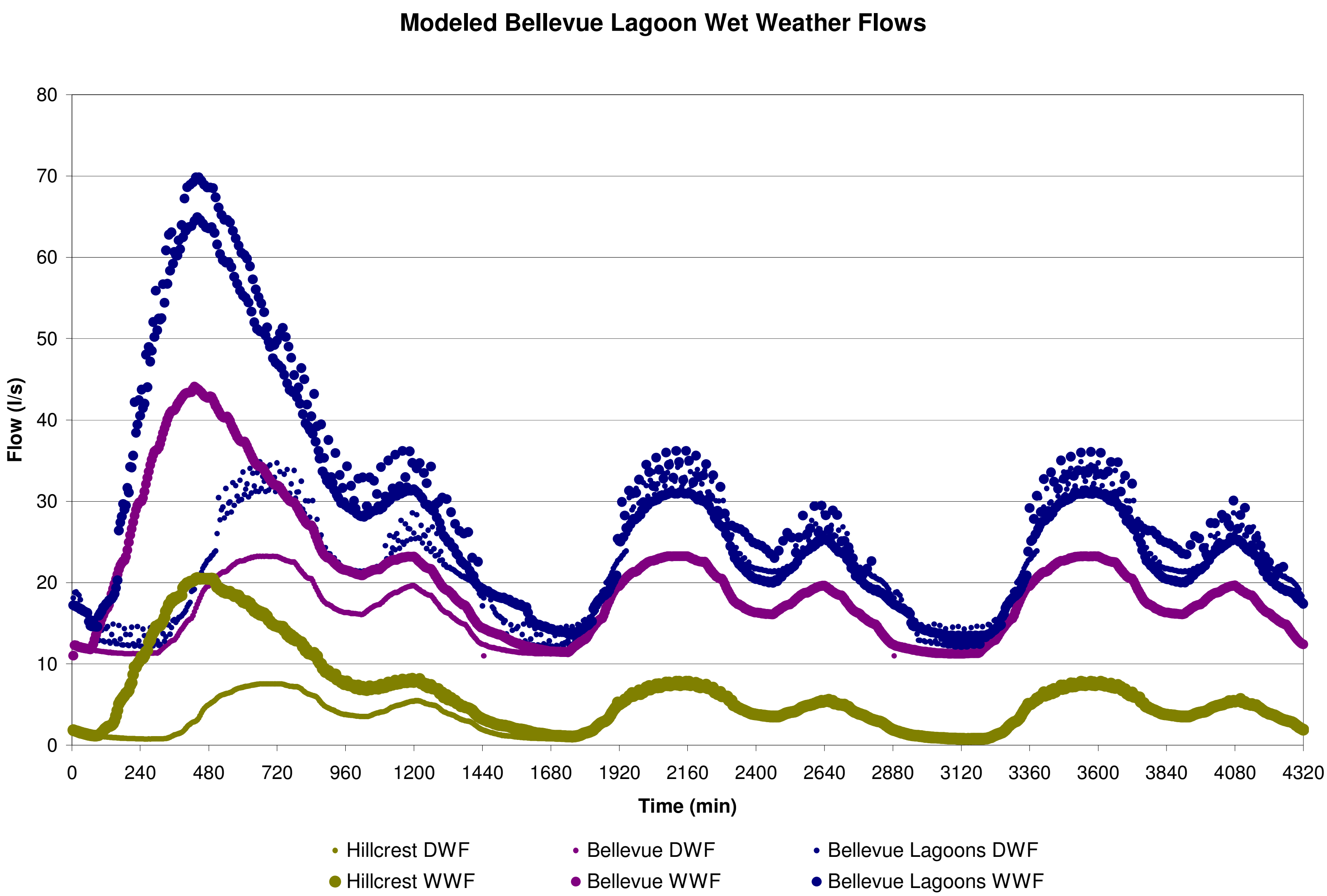
Wastewater Master Plan

Figure No.
4.2

Title

Frank Water Treatment Plant Dry Weather Flow



Legend

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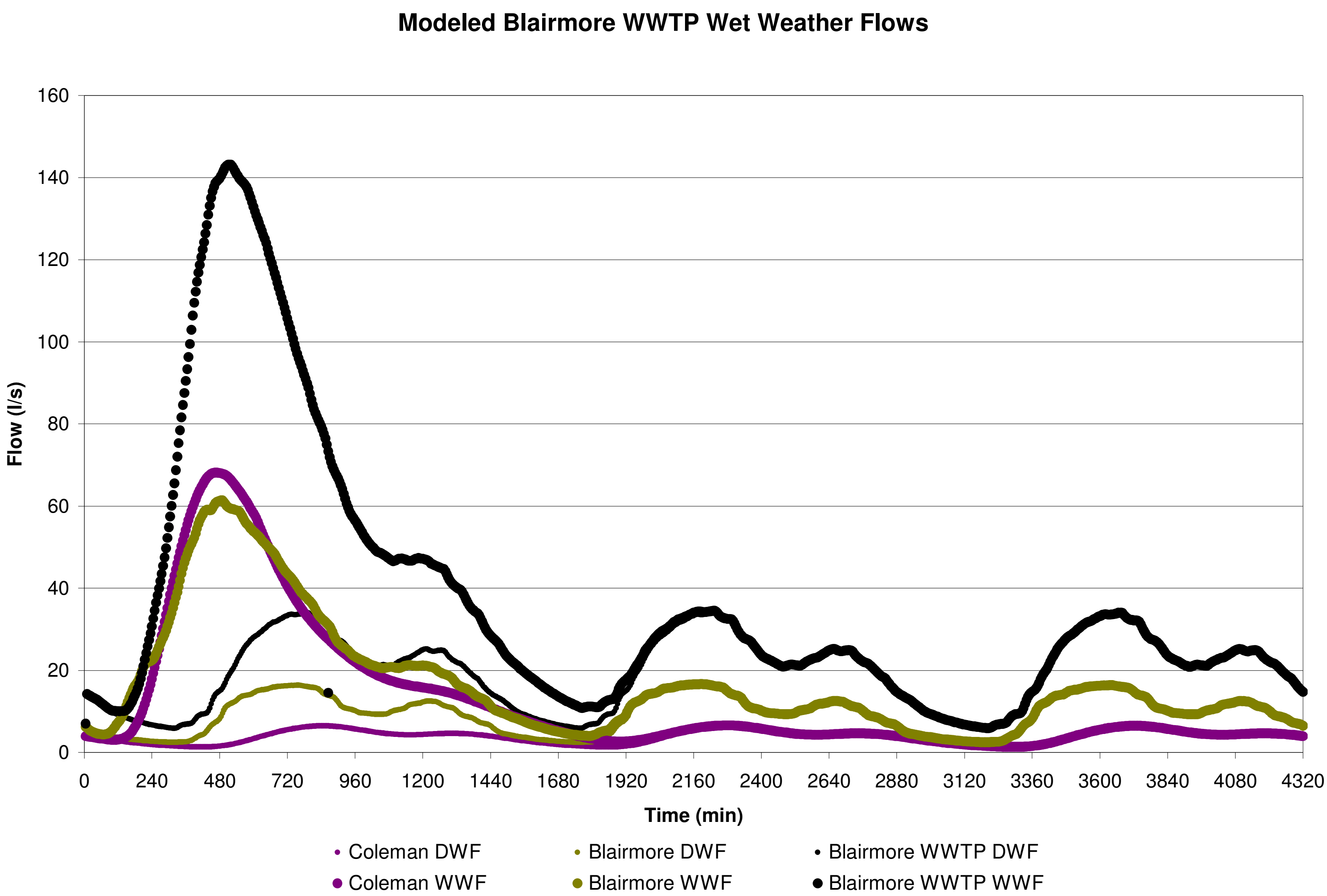
Wastewater Master Plan

Figure No.
4.3

Title

Bellevue Lagoons Wet Weather Flow



Legend

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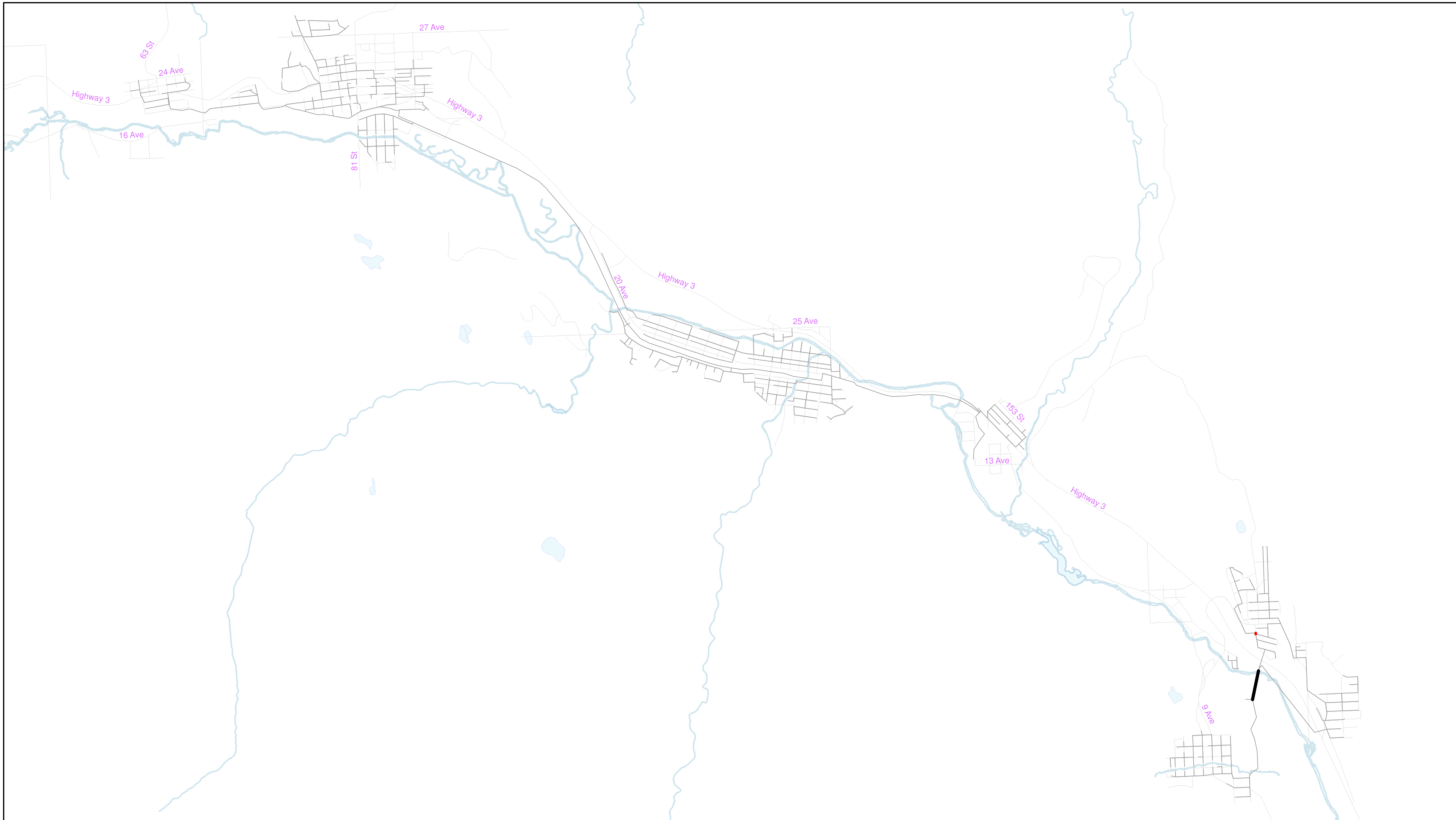
Wastewater Master Plan

Figure No.
4.4

Title

Frank Water Treatment Plant Wet Weather Flow



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Legend

Percent Utilization of Full Pipe Capacity

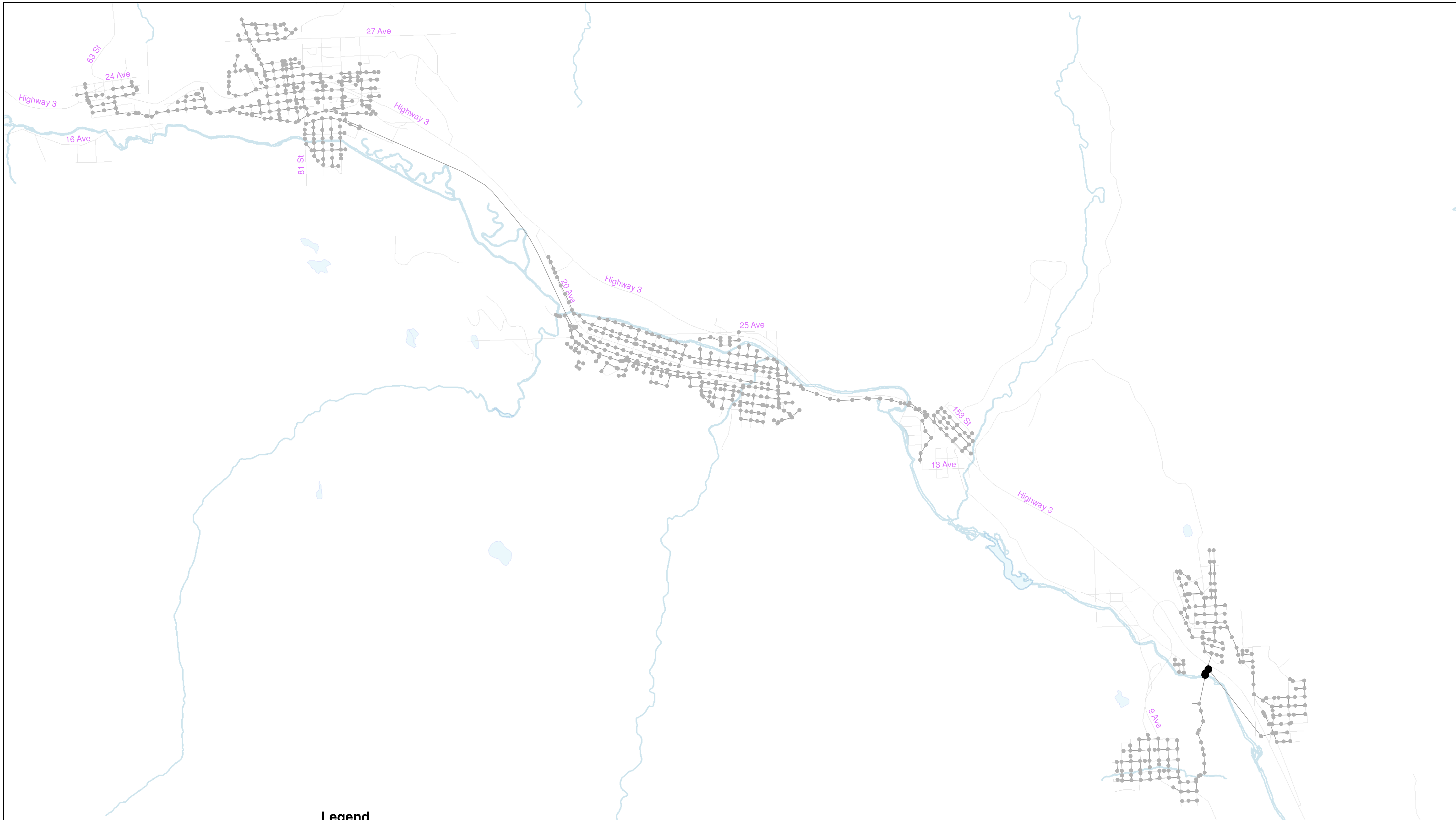
- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
4.5

Title
Existing System Dry Weather Flow
Pipe Hydraulic Rating Factor

MUNICIPALITY OF CROWSNEST PASS



Legend

Manhole Surcharging

- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging
- mss_Link

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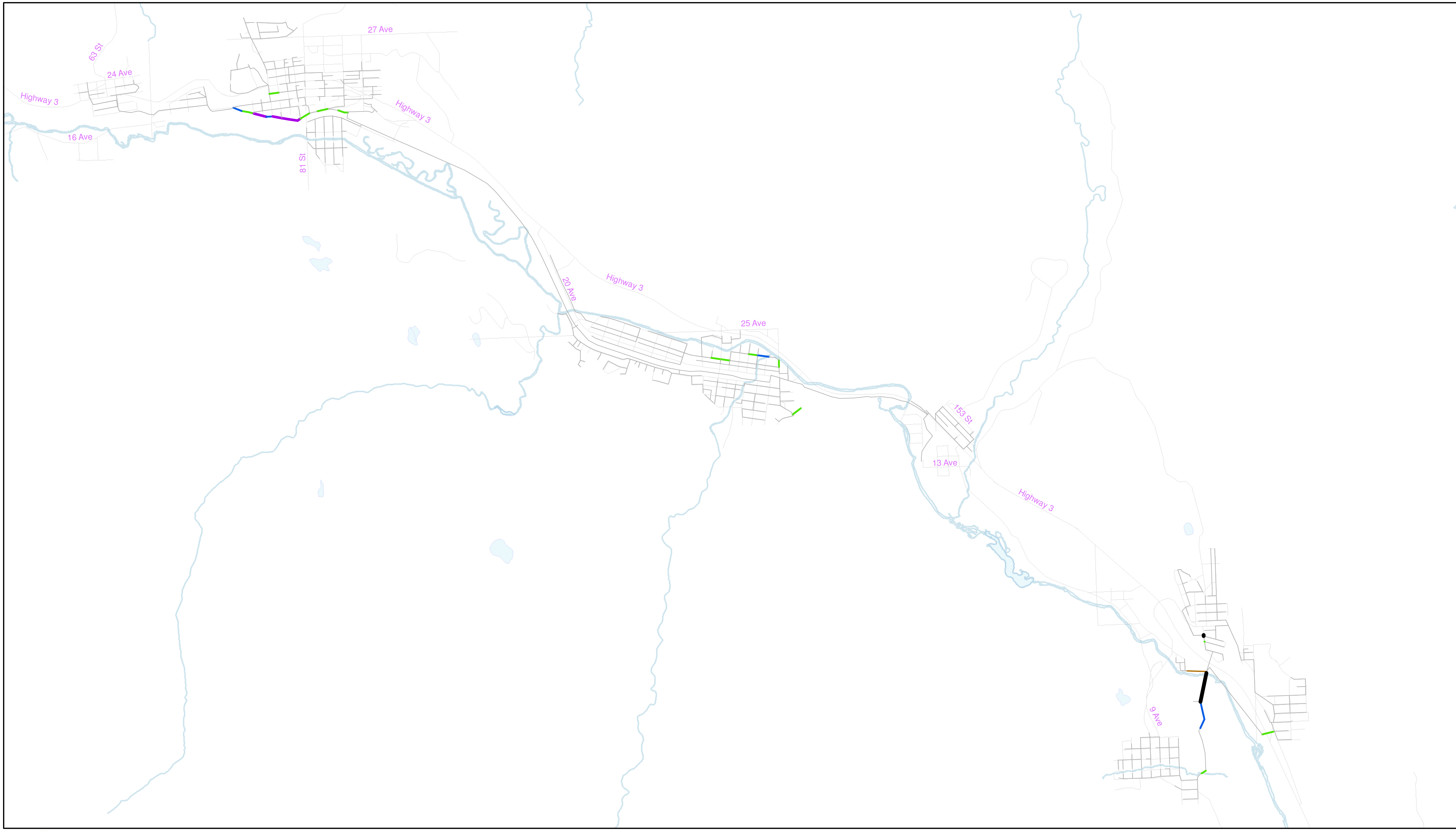
Figure No.

4.6

Title

Existing System Dry Weather Flow Surcharge Severity

MUNICIPALITY OF CROWSNEST PASS



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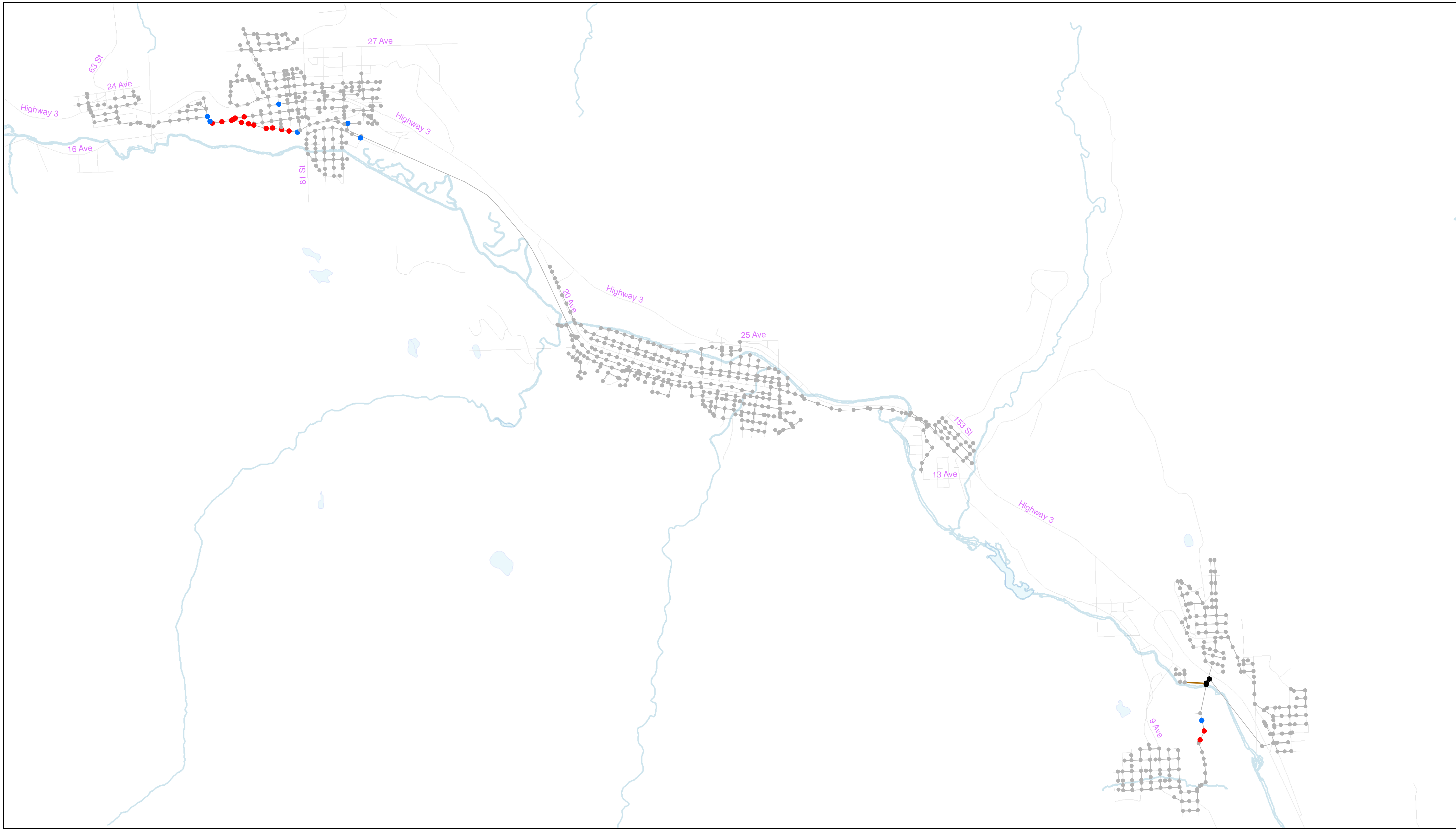
Percent Utilization of Full Pipe Capacity

- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
4-7

Title
Existing System Wet Weather Flow
Pipe Hydraulic Rating Factor



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Manhole Surcharging

- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

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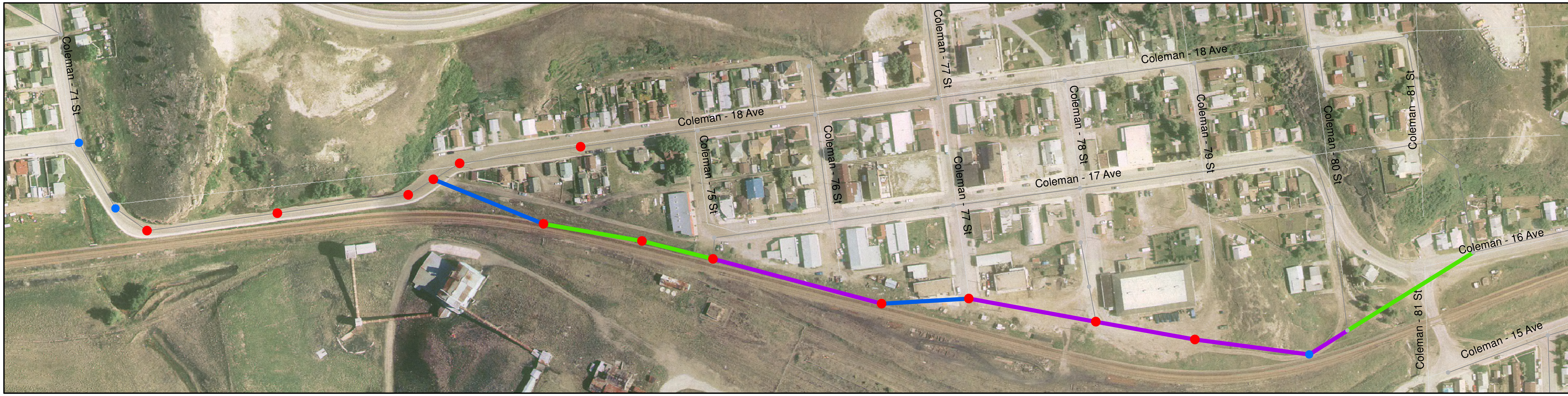
Proposed Developments

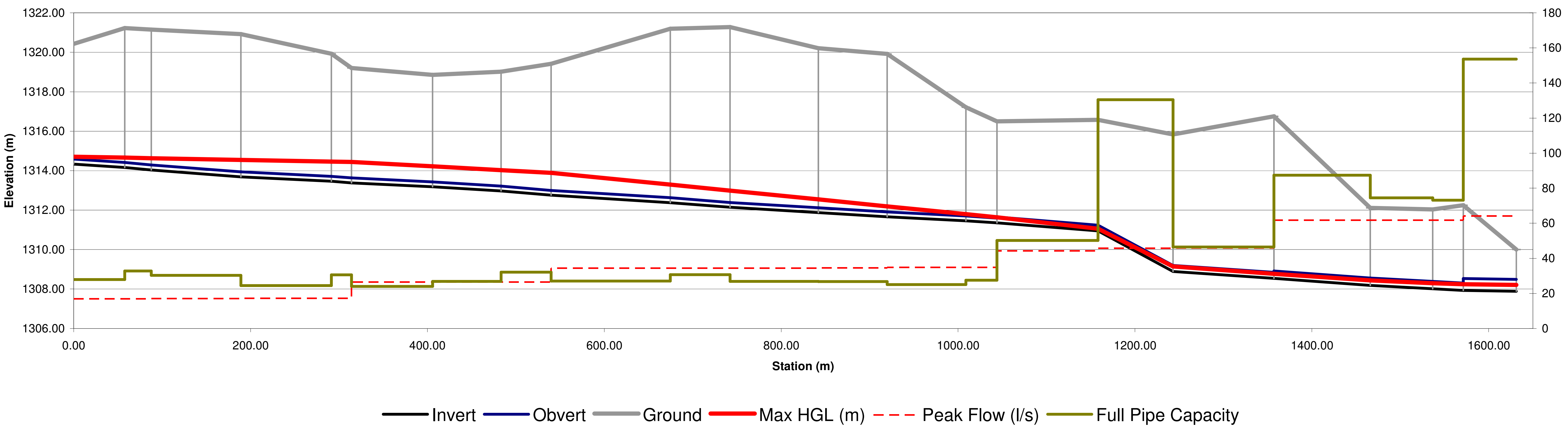
Figure No.

4-8

Title

Existing System Wet Weather Flow
Surcharge Severity





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Legend

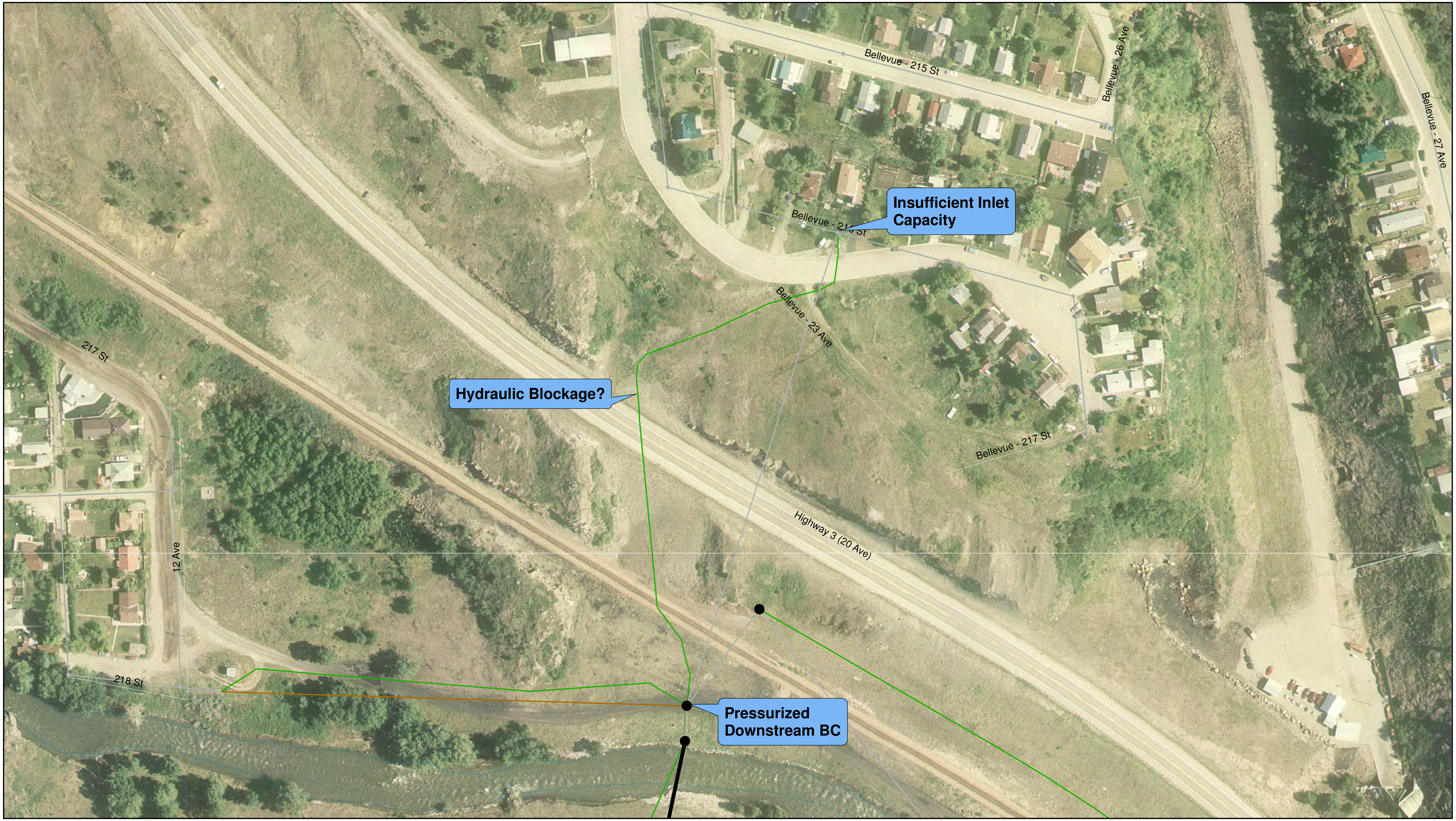
Manhole Surcharging
- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

Percent Utilization of Full Pipe Capacity
- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
4-9

Title
Existing System Deficiencies
Coleman Sub-Trunk



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Legend

Manhole Surcharging
- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

MCNP Sewer Main Locations

Percent Utilization of Full Pipe Capacity
- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
4-10

Title
Existing System Deficiencies
Bellevue Siphon Inlet Line

MUNICIPALITY OF CROWSNEST PASS

Potential Groundwater Infiltration

Blairmore – York Creek Lodge MH

Potential Groundwater Infiltration

BL119 MH

Legend

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Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.

4.11

Title

Service Related Deficiencies (Inflow and Infiltration)

Poor Manhole
Benching

BL119 MH

Legend

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Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
4.12

Title

Service Related Deficiencies
(Construction Related Problems)

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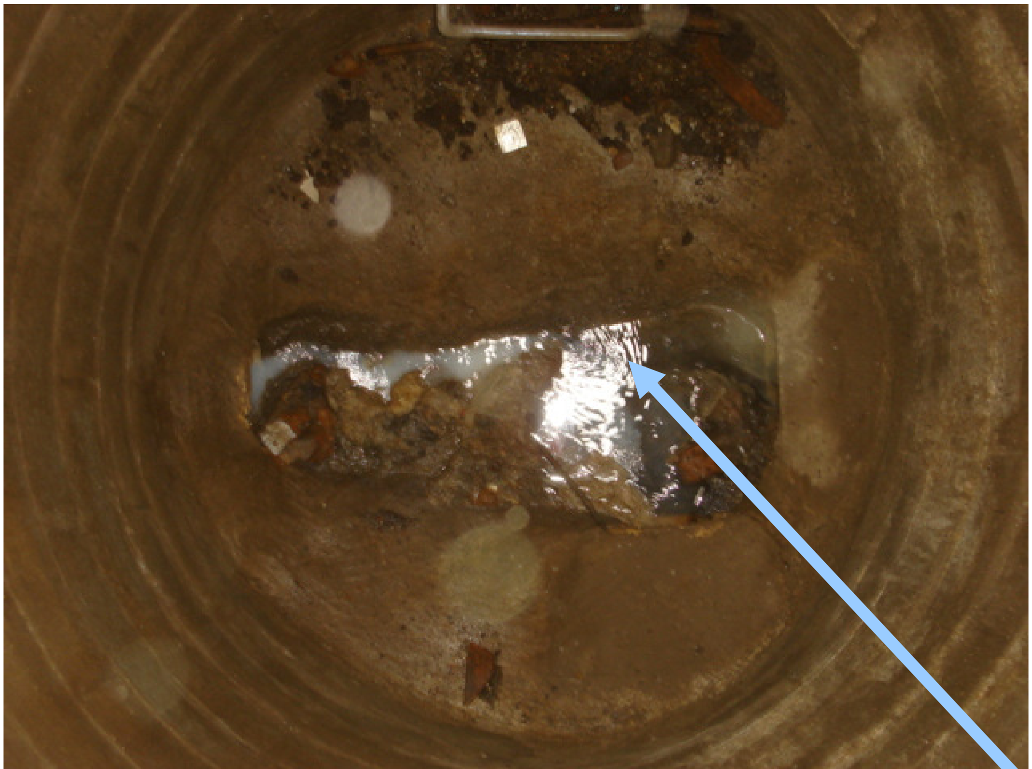

BL138 MH

Severe Debris Buildup

C525 MH

Legend

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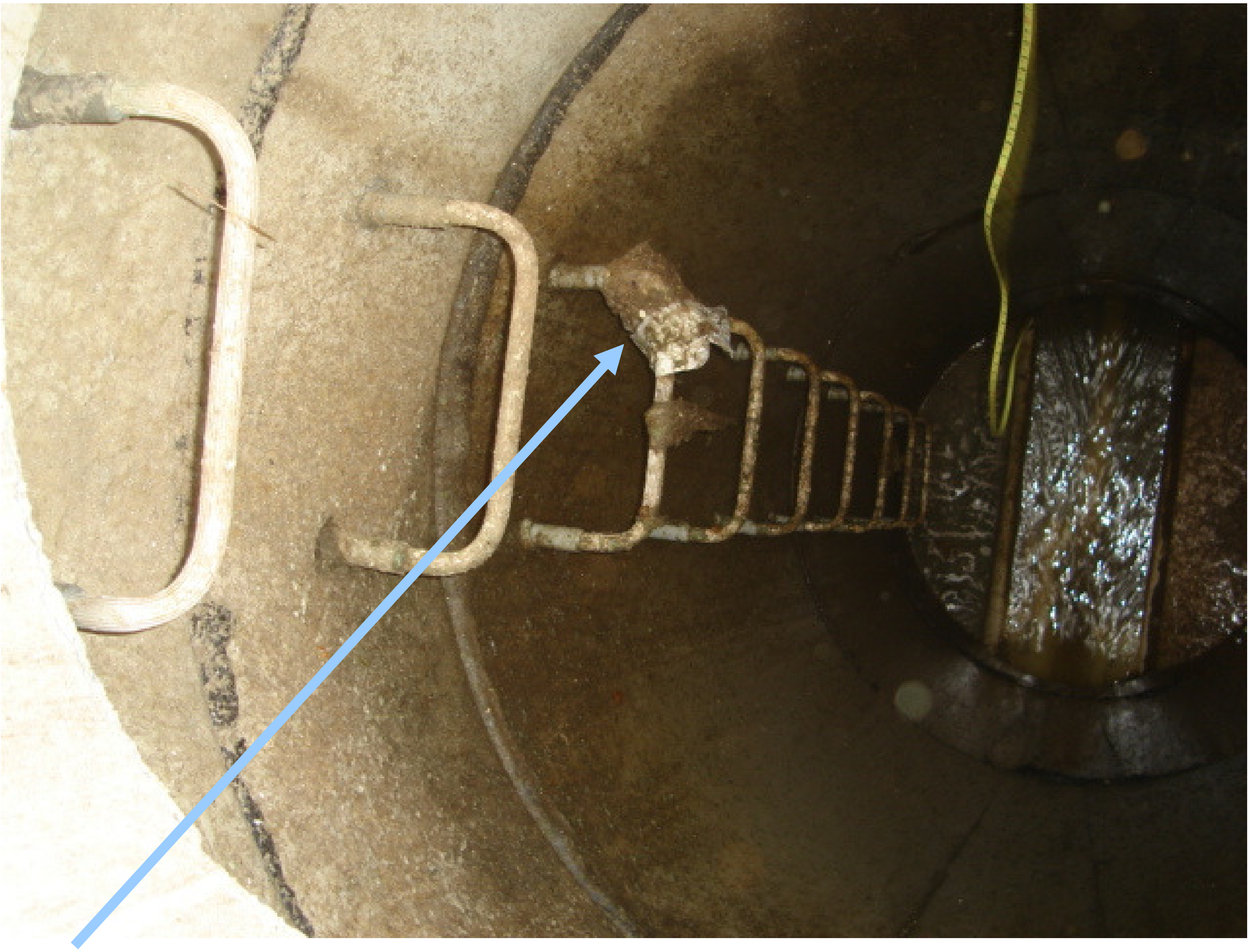
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.

4.13

Title

Service Related Deficiencies (Debris Buildup)



Evidence of
Severe Surcharging

Legend

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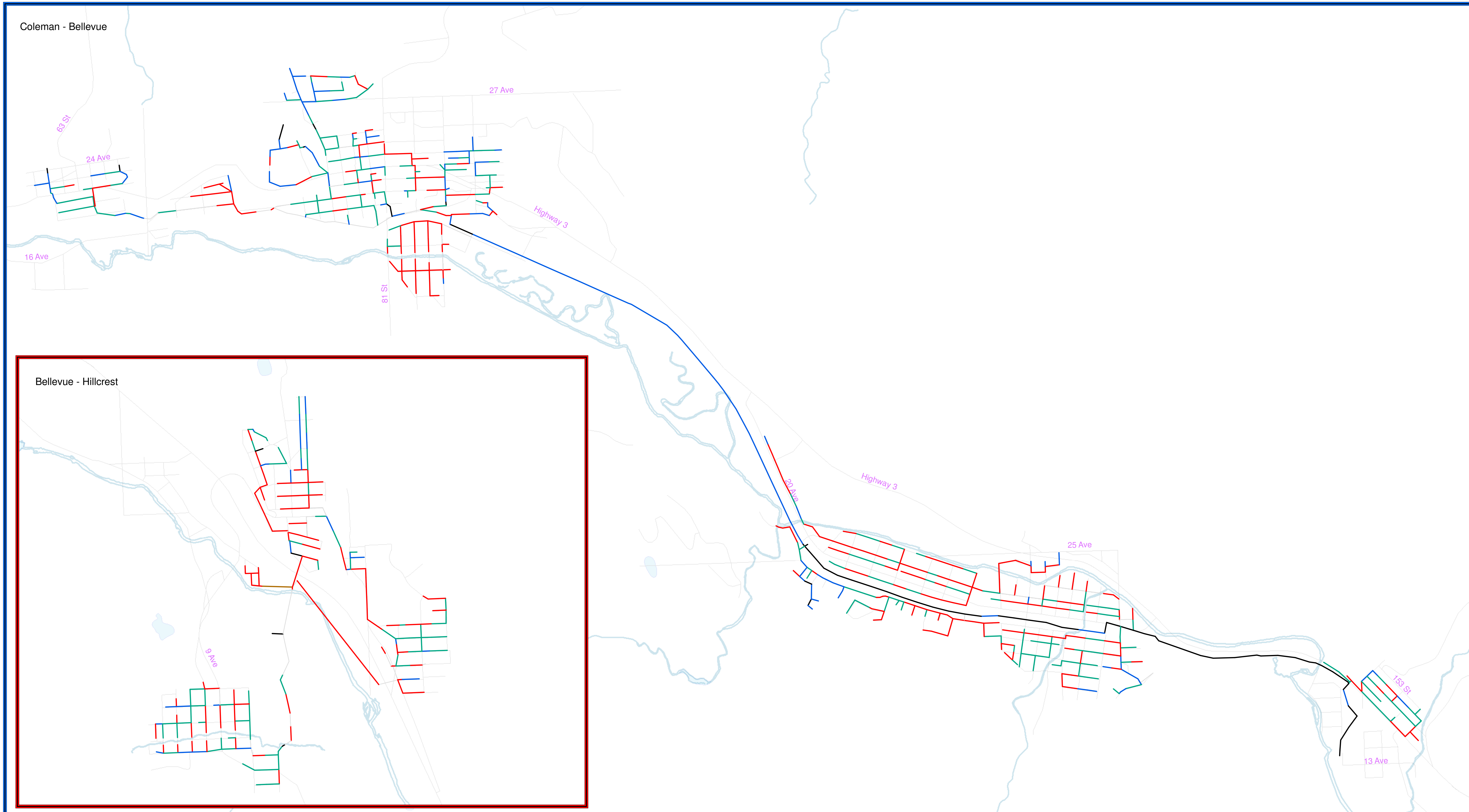
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.

4.14

Title

Service Related Deficiencies
(Evidence of Surcharging)



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Legend

Residual Pipe Capacity

- Less than 10 l/s
- 10 to 25 l/s
- 25 to 50 l/s
- 50 to 100 l/s
- More than 100 l/s

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
4-15

Title
Existing System Peak Flow Condition
Pipe Capacity Remaining in the System

5.0 Future System Evaluation

5.1 FUTURE SYSTEM DEVELOPMENT

5.1.1 Future Growth Areas

The proposed future development area used in the Municipality of Crowsnest Pass Preliminary Design For Water and Sanitary Sewer Servicing Sentinel / Crowsnest Mountain Resort report was used as the basis of this master plan. The future growth scenario also includes areas in Coleman, Blairmore, Bellevue and Hillcrest.

Figure 5-1 shows the proposed future development areas. The total proposed developable area is 1741 ha.

5.1.2 Future Wastewater Generation Scenarios

Table 5-1 provides the design criteria that were used to develop peak wastewater flows. The criteria included in this table are taken from the Sentinel Servicing Study.

Table 5-1 Wastewater Flow Generation Criteria

Densities:		
Low	40	Lots per 1/4section
Medium	100	Lots per 1/4section
High	150	Lots per 1/4section
Pop Density	2.5	People/lot
Water Consumption		
ADD Residential	400	L/capita/day
ADD Residential	0.40	m^3/capita/day
ADD Commercial	30	m^3/ha/day
ADD Industrial	40	m^3/ha/day
MDD / ADD Multiplier	2	
PHD / ADD Multiplier	4	
Sewage Dry Weather Flows		
Residential	1,600	L/capita/day
Residential	1.60	m^3/capita/day
Commercial	20	m^3/ha/day
Industrial	30	m^3/ha/day
Sewage I&I		
Residential	650	L/capita/day
Residential	0.65	m^3/capita/day
Commercial	10	m^3/ha/day
Industrial	10	m^3/ha/day

From: Sentinal Servicing Report Design Criteria.

Table 5-2 shows the overall breakdown of land uses and estimated populations assumed for each land use type. The projected peak flow from the future growth areas is 762.7 l/s.

Table 5-2 – Total Future Wastewater Flows

Land Use	Area (ha)	Population	DWF (m^3/day)	WWF (m^3/day)	Total Flow (m^3/day)
Residential	1,600.8	6185	9,896.0	4,020.3	13,916.3
Industrial	140.6	0	22,488.0	1,405.5	23,893.5
Commercial	81.7	0	9,807.6	817.3	10,624.9
Crowsnest Mountain Resort	22.5	1400	2,240.0	910.0	3,150.0
Bridgegate Resort Village	9.0	3750	6,000.0	2,437.5	8,437.5
River Run	25.0	3040	4,864.0	1,976.0	6,840.0
Total	1,879.7	14,375	55,295.6	11,566.6	66,862.2
		Flow (l/s)	640.0	133.9	773.9

Figure 5-2 shows the Sentinel growth areas and peak flows from each area. **Table 5-3** shows the overall breakdown of land uses and estimated populations assumed in for the Sentinel growth area. The projected peak flow from the Sentinel growth areas is 562.7 l/s.

Table 5-3 Sentinel Future Wastewater Flows

Land Use	Area (ha)	Population	DWF (m^3/day)	WWF (m^3/day)	Total Flow (m^3/day)
Residential	623.0	2,407	3,851.2	1,564.5	5,415.7
Industrial	140.6		22,495.0	1,405.9	23,900.9
Commercial	58.5		7,017.5	584.8	7,521.5
Crowsnest Mountain Resort	22.5	1,400	2,318.1	915.8	3,231.4
Bridgegate Resort Village	9.0	3,750	6,091.2	2,462.4	8,545.0
Total	853.5	7,557	41,773.0	6,933.4	48,614.6
		Flow (l/s)	483.5	80.2	562.7

Figure 5.3 shows the Coleman / Blairmore growth areas and peak flows from each area. **Table 5-4** shows the overall breakdown of land uses and estimated populations assumed in for the Blairmore / Coleman growth area. The projected peak flow from the Blairmore / Coleman growth areas is 185.1 l/s.

Table 5-4 Blairmore / Coleman Future Wastewater Flows

Land Use	Area (ha)	Population	DWF (m^3/day)	WWF (m^3/day)	Total Flow (m^3/day)
Residential	828.0	3203	5124.8	2082.0	7206.8
Commercial	23.3		4,388.8	1,783.0	6,171.7
River Run	25.0		5,471.1	1,349.0	6,820.1
Total	757.4	2743	12,654.7	3,364.8	15,989.1
		Flow (l/s)	146.5	38.9	185.1

Figure 5-4 shows the Bellevue / Hillcrest growth areas and peak flows from each area. **Table 5-5** shows the overall breakdown of land uses and estimated populations assumed in for the Bellevue / Hillcrest growth area. The projected peak flow from the Bellevue / Hillcrest growth areas is 15.0 l/s.

Table 5-5 Bellevue / Hillcrest Future Wastewater Flows

Land Use	Area (ha)	Population	DWF (m^3/day)	WWF (m^3/day)	Total Flow (m^3/day)
Residential	150.0	575	920.0	373.8	1,293.7
Total	150.0	575	10.6	4.3	15.0
		Flow (l/s)	10.6	4.3	15.0

5.2 FUTURE SYSTEM CAPACITY

The capacity of the existing system was tested using the computer model to identify the effects of the future projected flows on the existing collection system.

5.2.1 Dry Weather Capacity

The existing collection system can not accommodate the total dry weather flows from future development. The system experiences significant surcharging along trunk mains and in a number of locations spill to the surface.

The results of the three performance measures are described in the following sections.

5.2.1.1 Pipe Hydraulic Rating

Figure 5-5 shows the location of pipes with the hydraulic capacity ratings described in **Table 5-6.** During future dry weather flows 89.9% of the collection system operates within the required design pipe hydraulic rating of 80% of pipe full capacity.

Table 5-6 Dry Weather Pipe Hydraulic Rating

Hydraulic Rating		Pipe Length (m)	Percentage of System
Less than 80%		96,268	89.9%
80% - 100%		5,369	5.0%
100% - 125%		2,699	2.5%
125% - 150%		2,056	1.9%
150% - 250%		314	0.3%
Greater than 250%		369	0.3%

5.2.1.2 Pipe Residual Capacity

Table 5-7 summarizes the capacity remaining in the sanitary sewer collection system**.** During future dry weather flows 82.9% of the collection system has 50% or more of its pipe capacity available.

Table 5-7 Dry Weather Pipe Residual Capacity

Percentage of Capacity Remaining		Pipe Length (m)	Percentage of System
Less than 10%		7,078	6.6%
10% - 25%		4,046	3.8%
25% - 50%		7,125	6.7%
50% - 80%		13,970	13.0%
80% - 100%		74,856	69.9%

5.2.1.3 Manhole Surcharging Severity

Figure 5-6 shows the location of manholes with surcharge ratings described in **Table 5-8.** During future dry weather flows 90.3% of the system manholes experience no surcharging. 5.0% of the manholes now experience minor or moderate surcharging. An additional 3.7% of system manholes experience severe surcharging including the Bellevue inverted siphons.

Table 5-8 Dry Weather Manhole Surcharging Severity

Severity of Surcharging		Number of Manholes	Percentage of System
Severe		36	3.7%
Moderate		22	2.2%
Minor		37	3.8%
No Surcharging		883	90.3%

5.2.2 Wet Weather Capacity

The existing collection system can not accommodate the total wet weather flows from future development. The system experiences additional surcharging along trunk mains and in a number of locations spills to the surface.

The results of the three performance measures are described in the following sections.

5.2.2.1 Pipe Hydraulic Rating

Figure 5-7 shows the location of pipes with the hydraulic capacity ratings described in **Table 5-9.** During future wet weather flows 86.6% of the collection system operates within the required design pipe hydraulic rating of 80% of pipe full capacity.

Table 5-9 Wet Weather Pipe Hydraulic Rating

Hydraulic Rating		Pipe Length (m)	Percentage of System
Less than 80%		92,735	86.6%
80% - 100%		6,074	5.7%
100% - 125%		4,472	4.2%
125% - 150%		3,011	2.8%
150% - 250%		414	0.4%
Greater than 250%		369	0.3%

5.2.2.2 Pipe Residual Capacity

Table 5-10 summarizes the capacity remaining in the sanitary sewer collection system**.** During future wet weather flows 77.6% of the collection system has 50% or more of its pipe capacity available.

Table 5-10 Wet Weather Pipe Residual Capacity

Percentage of Capacity Remaining		Pipe Length (m)	Percentage of System
Less than 10%		10,637	9.9%
10% - 25%		5,284	4.9%
25% - 50%		8,054	7.5%
50% - 80%		18,666	17.4%
80% - 100%		64,435	60.2%

5.2.2.3 Manhole Surcharging Severity

Figure 5-8 shows the location of manholes with surcharge ratings described in **Table 5-11.** During future wet weather flows 84.6% of the system manholes experience no surcharging. 8.7% of the manholes now experience minor or moderate surcharging. An additional 6.7% of system manholes experience severe surcharging including the Bellevue inverted siphons.

Table 5-11 Wet Weather Manhole Surcharging Severity

Severity of Surcharging		Number of Manholes	Percentage of System
Severe		65	6.7%
Moderate		58	5.9%
Minor		27	2.8%
No Surcharging		827	84.6%

5.3 IMPROVEMENTS REQUIRED FOR FUTURE SYSTEM

There is insufficient capacity in the existing trunk system to service all of the proposed growth areas. Additional Trunk Capacity is required in a number of key points in the system.

5.3.1 Sentinel Trunk

The new trunk main from the Sentinel Growth areas will require a peak capacity of 560 l/s.

The upgrade consists of approximately 8,100 m of 750 mm pipe and related work.

The proposed conceptual routing is illustrated in **Figure 5-9**

5.3.2 Blairmore-Coleman Trunk Main

Option 1 – Trunk Upgrade - Twinning

A full trunk upgrade should be completed to provide the full capacity of the projected existing and future flows. The existing trunk may be twinned to create additional capacity or a new trunk may be constructed to the full required capacity.

- Option 1A - Twinning Existing Trunk - The upgrade consists of approximately 8,100 m of 750 mm pipe and related work.
- Option 1B - Construction of New Trunk – The upgrade consists of approximately 6,700 m of 900 mm pipe, 1,400 m of 1,050 mm pipe and related work.

This improvement option is shown in **Figure 5-10**

Option 2 – Lift Station

In order to provide capacity for future wastewater flows, a staged lift station will be constructed to provide capacity for the full range of future flows that cannot be accommodated in the existing trunk main that extends from the Frank WWTP to Coleman.

The upgrade consists of a 450 l/s pump station including 4 – 150 hp pumps, wet well, and related structures. The pump station will require an 8,000 m 600 mm force main.

This improvement option is shown in **Figure 5-11**

Option 3 – New Sentinel Wastewater Treatment Plant

In order to minimize the construction of new sewers in the existing corridor between the Coleman and the Frank WWTP a new WWTP would be constructed manage flows from the Sentinel Growth area.

Minor trunk upgrades may be also required to account for small bottlenecks between Coleman and the Frank WWTP to accommodate future growth flows from Coleman and Blairmore.\

The upgrade will involve the construction of a 560 l/s wastewater treatment plant in the Sentinel Growth area. The Coleman / Blairmore trunk upgrades are limited to localized de-bottlenecking. The Sentinel Trunk requirement will be reduced to 4,000 m of 750 mm pipe.

This improvement option is shown in **Figure 5-12**

5.3.3 Coleman Trunk Improvements

The existing trunk in Coleman experiences some capacity related stress during peak wet weather flows. Additional flows from the Coleman growth areas will add to the existing problem.

Option 1: Upgrade the existing trunk main for the full required capacity.

- Option 1 consists of approximately 1,250 m of 375 mm pipe and related work.

Option 2: Bypass extra flows to the new Sentinel Trunk Main.

- Option 2 consists of approximately 250 m of 300 mm pipe and related work.

The improvement options for Coleman Trunk Improvements are shown in **Figure 5-13**

5.3.4 Bellevue Inverted Siphons

A new siphon inlet chamber will be constructed on the north side of the Crowsnest River. The new chamber will provide a hydraulic grade that will accommodate future flows through the existing inverted siphon to the Bellevue Lagoons.

The upgrade consists of approximately 250 m of 300 mm pipe to replace the 150 mm siphon inlet line from Bellevue. In addition, a new siphon inlet chamber will be required at the upstream end of the inverted siphons.

This proposed improvement is shown in **Figure 5-14**

5.3.5 Bellevue Trunk Improvements

The new growth areas added to the southeast of Bellevue stress the capacity of the trunk that extends through the southernmost portion of Bellevue to the Inverted Siphons. The capacity of the main will require upgrade to accommodate the addition of future flows.

The upgrade consists of approximately 325 m of 300 mm pipe as well as related manholes and associated work.

This proposed improvement is shown in **Figure 5-15**

5.3.6 Hillcrest Trunk Main

The new growth areas added to the Hillcrest Trunk stress the capacity of the trunk that extends to the through the southernmost portion of Bellevue to the Inverted Siphons. The capacity of the main will require upgrade to accommodate the addition of future flows.

The upgrade consists of approximately 1,150 m of 250 mm pipe as well as related manholes and associated work.

This proposed improvement is shown in **Figure 5-16**

5.3.7 Riverbottom Lift Station

Upgrade the existing 100mm force main by diverting it to the upstream end of the siphon system, or replace with a new 150mm main from the lift station to the inlet to the lagoons. The existing pumps will also require upgrading to ensure the required head and pumping capacity are sufficient to pass the required range of flows.

5.4 FUTURE LEVEL OF SERVICE

5.4.1 Dry Weather Capacity

The proposed collection system was analyzed using trunk upgrade Option 1 as described in Section 5.3.2 to assess the future level of service. The results of the three performance measures are described below.

5.4.1.1 Pipe Hydraulic Rating

Figure 5-17 shows the location of pipes with the hydraulic capacity ratings described in **Table 5-12.** During future dry weather flows 89.9% of the collection system operates within the required design pipe hydraulic rating of 80% of pipe full capacity.

Table 5-12 Dry Weather Pipe Hydraulic Rating

Hydraulic Rating		Pipe Length (m)	Percentage of System
Less than 80%		101,448	95.5%
80% - 100%		3,747	3.5%
100% - 125%		390	0.4%
125% - 150%		213	0.2%
150% - 250%		441	0.4%
Greater than 250%		-	0.0%

Pipe Residual Capacity

Table 5-13 summarizes the capacity remaining in the sanitary sewer collection system**.** During future dry weather flows 87.8% of the collection system has 50% or more of its pipe capacity available.

Table 5-13 Dry Weather Pipe Residual Capacity

Percentage of Capacity Remaining	Pipe Length (m)	Percentage of System
Less than 10%	1,634	1.5%
10% - 25%	3,542	3.3%
25% - 50%	7,985	7.5%
50% - 80%	13,782	13.0%
80% - 100%	79,295	74.6%

5.4.1.2 Manhole Surcharging Severity

Figure 5-18 shows the location of manholes with surcharge ratings described in **Table 5-14.** During future dry weather flows 99.3% of the system manholes experience no surcharging. 0.7% of the manholes now experience minor or moderate surcharging.

Table 5-14 Dry Weather Manhole Surcharging Severity

Severity of Surcharging	Number of Manholes	Percentage of System
Severe	-	0.0%
Moderate	2	0.2%
Minor	5	0.5%
No Surcharging	972	99.3%

5.4.2 Wet Weather Capacity

The proposed collection system was analyzed using trunk upgrade Option 1 to assess the future level of service. The results of the three performance measures are described below.

5.4.2.1 Pipe Hydraulic Rating

Figure 5-19 shows the location of pipes with the hydraulic capacity ratings described in **Table 5-15.** During future wet weather flows 91.5% of the collection system operates within the required design pipe hydraulic rating of 80% of pipe full capacity.

Table 5-15 Wet Weather Pipe Hydraulic Rating

Hydraulic Rating		Pipe Length	Percentage of System
Less than 80%		96,895	91.2%
80% - 100%		7,109	6.7%
100% - 125%		1,580	1.5%
125% - 150%		112	0.1%
150% - 250%		-	0.0%
Greater than 250%		542	0.5%

5.4.2.2 Pipe Residual Capacity

Table 5-16 summarizes the capacity remaining in the sanitary sewer collection system**.** During future dry weather flows 84.5% of the collection system has 50% or more of its pipe capacity available.

Table 5-16 Wet Weather Pipe Residual Capacity

Percentage of Capacity Remaining		Pipe Length	Percentage of System
Less than 10%		4,550	4.3%
10% - 25%		5,802	5.5%
25% - 50%		6,563	6.2%
50% - 80%		20,431	19.2%
80% - 100%		68,890	64.8%

5.4.2.3 Manhole Surcharging Severity

Figure 5-20 shows the location of manholes with surcharge ratings described in **Table 5-17.** During future dry weather flows 98.4% of the system manholes experience no surcharging. 1.3% of the manholes now experience minor or moderate surcharging. An additional 0.3% of the system manholes experience severe surcharging, including the Bellevue siphon system.

Table 5-17 Wet Weather Manhole Surcharging Severity

Severity of Surcharging		Number of Manholes	Percentage of System
Severe		3	0.3%
Moderate		4	0.4%
Minor		9	0.9%
No Surcharging		960	98.4%

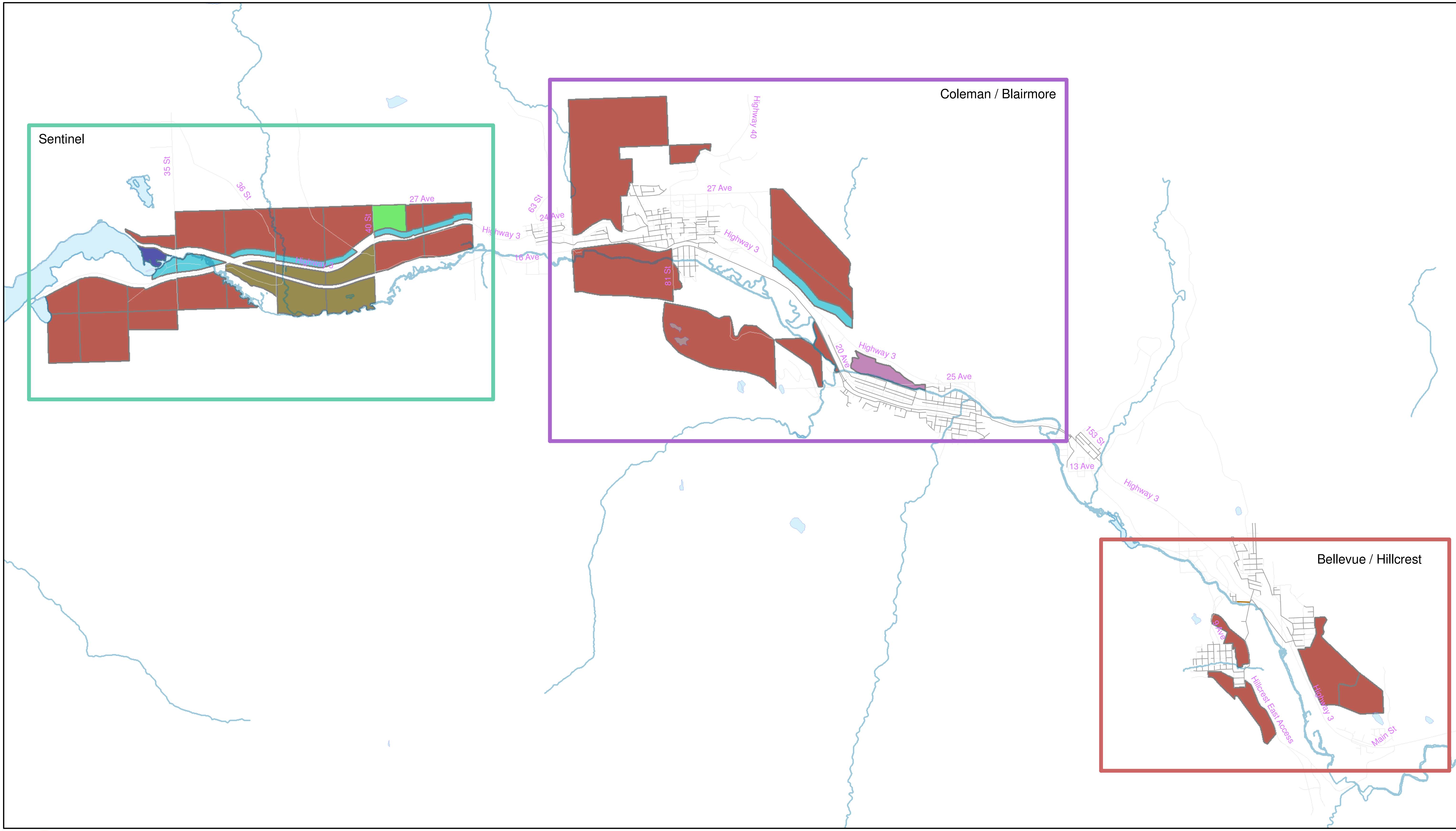
5.5 DEVELOPMENT STANDARDS

Table 5-18 contains the recommended design criteria for Municipality of Crowsnest Pass sanitary sewer system. Pipe sizes will be determined using the calculated capacity requirement divided by 0.86 to provide an appropriate factor of safety as required by Alberta Environment.

Table 5-18 Recommended Development Design Standards

Sewage Dry Weather Flows	
Residential	400 L/capita/d
Commercial	20 m^3/ha/d
Institutional	40 m^3/ha/d
Industrial	30 m^3/ha/d
Residential Density ***(2.5 persons per lot)***	
Low	0.63 lots per hectare (*40 lots per ¼ section*)
Medium	1.56 lots per hectare (*100 lots per ¼ section*)
High	2.34 lots per hectare (*150 lots per ¼ section*)
Recommended	Planning Forecast (*Actual Densities based on Planning Documents*)
Peaking Factor	
Harmon's Peaking	$\frac{14}{4+\sqrt{p}}+1$
Sewage Wet Weather Flows *(in addition to Dry Weather Flows)*	
Residential (new developments)	650 L/capita/d
Residential (older developments)	2000 L/capita/d
Commercial	10 m^3/ha/d
Institutional	10 m^3/ha/d
Industrial	10 m^3/ha/d
Infiltration Allowance	
In areas where the ground water table is at a depth of 3 meters or less below the surface, a groundwater infiltration allowance should be accounted for as follows:	
Residential	150 L/capita/d
Industrial	2.25 m^3/ha/d
Commercial	2.25 m^3/ha/d
Institutional	2.25 m^3/ha/d

5.6 LIST OF FIGURES FOR SECTION 5



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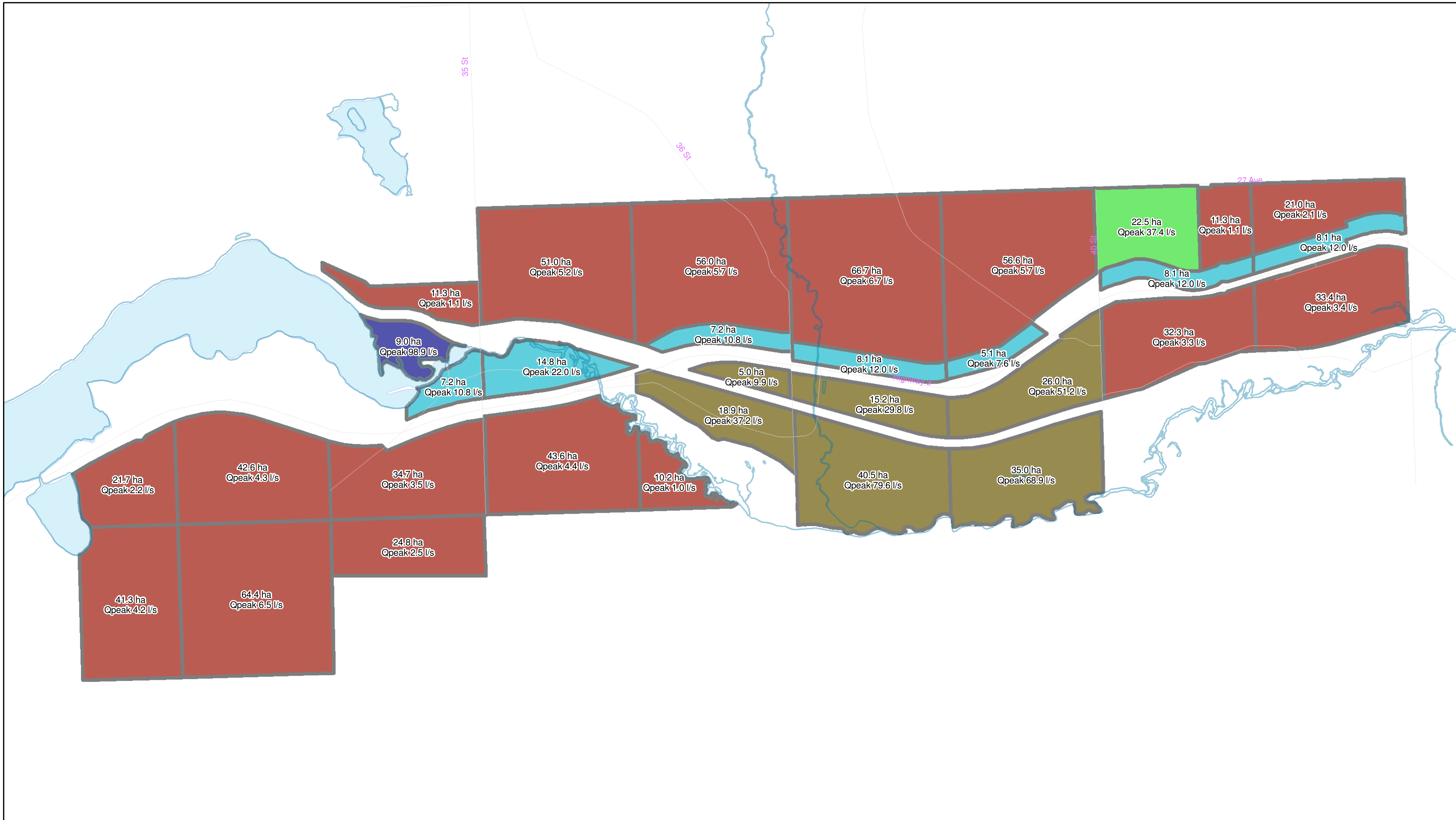
Legend

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-1

Title
Future Growth Areas



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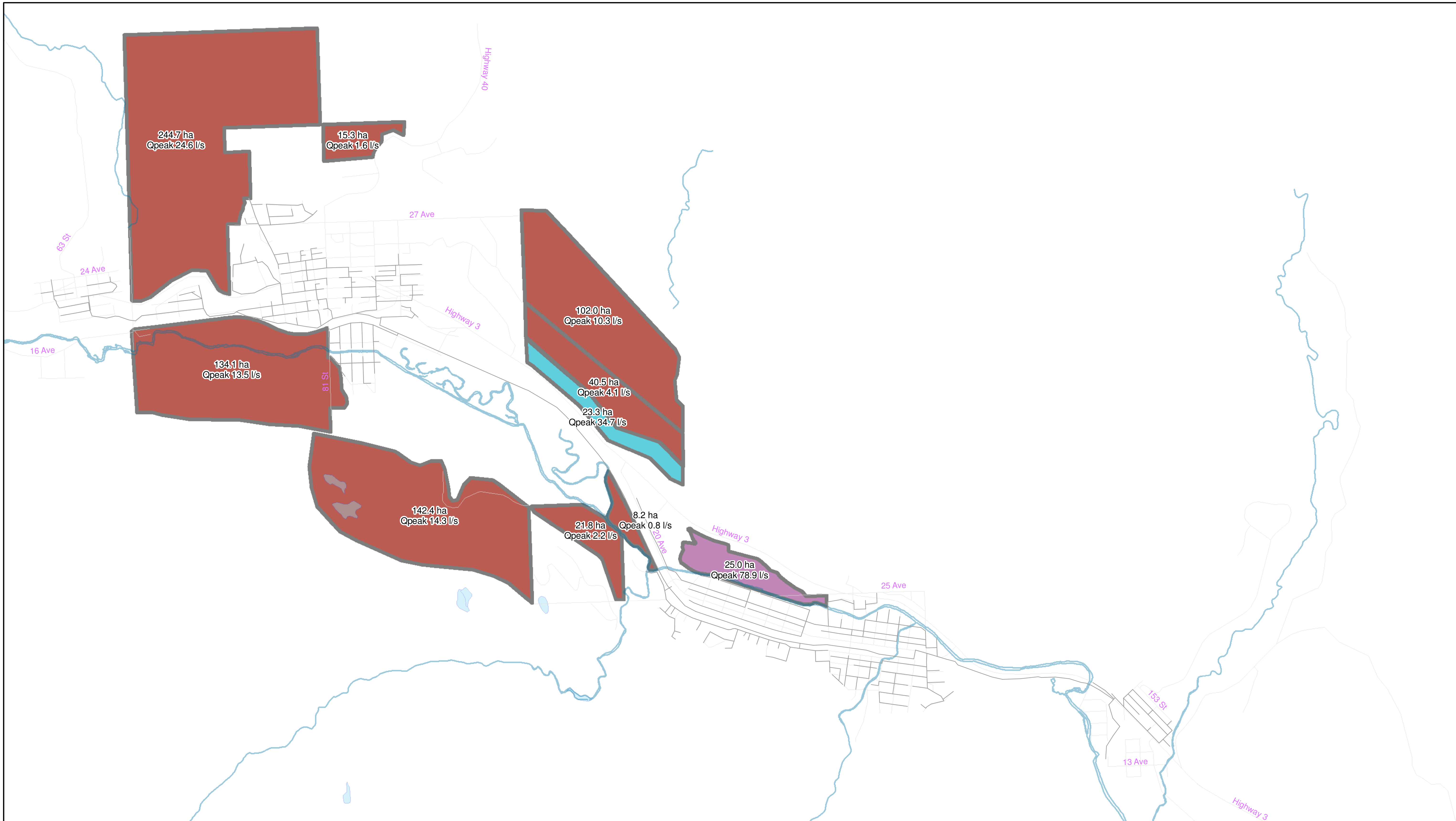
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-2

Title
Future Growth Areas - Sentinel

MUNICIPALITY OF CROWSNEST PASS



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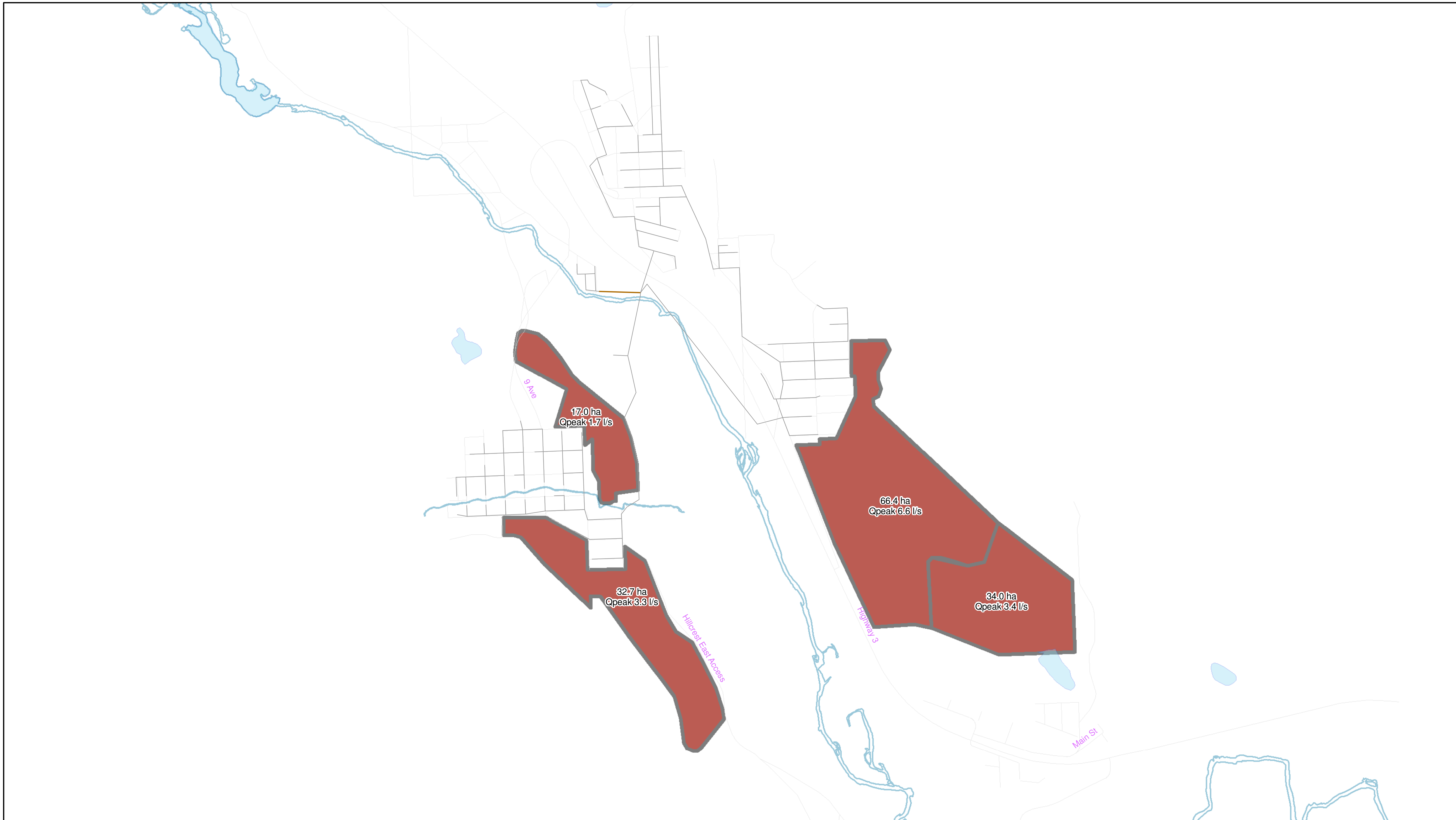
Legend

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-3

Title
Future Growth Areas
Coleman / Blairmore



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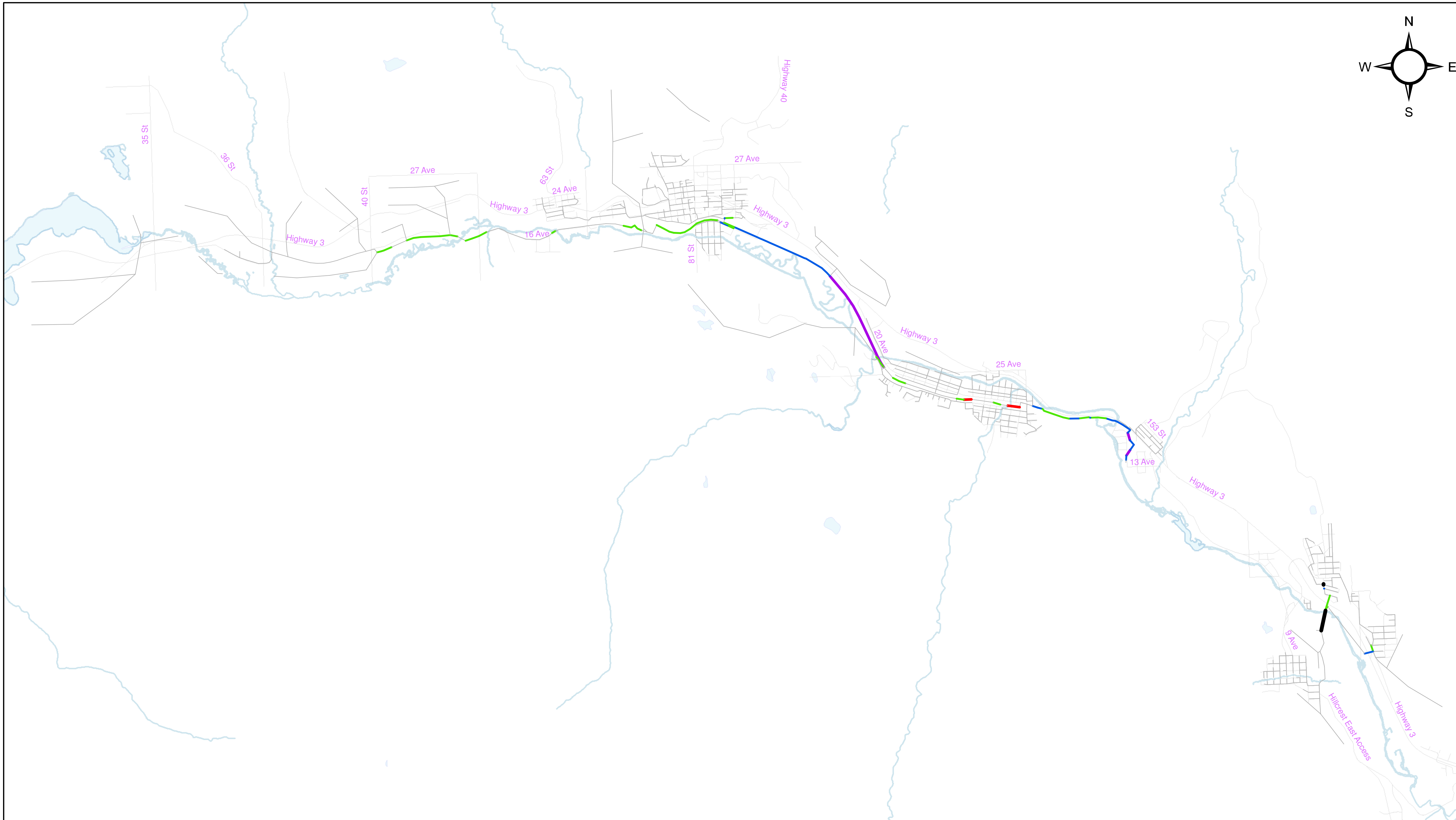
Legend

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-4

Title
Future Growth Areas
Bellevue / Hillcrest



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Legend

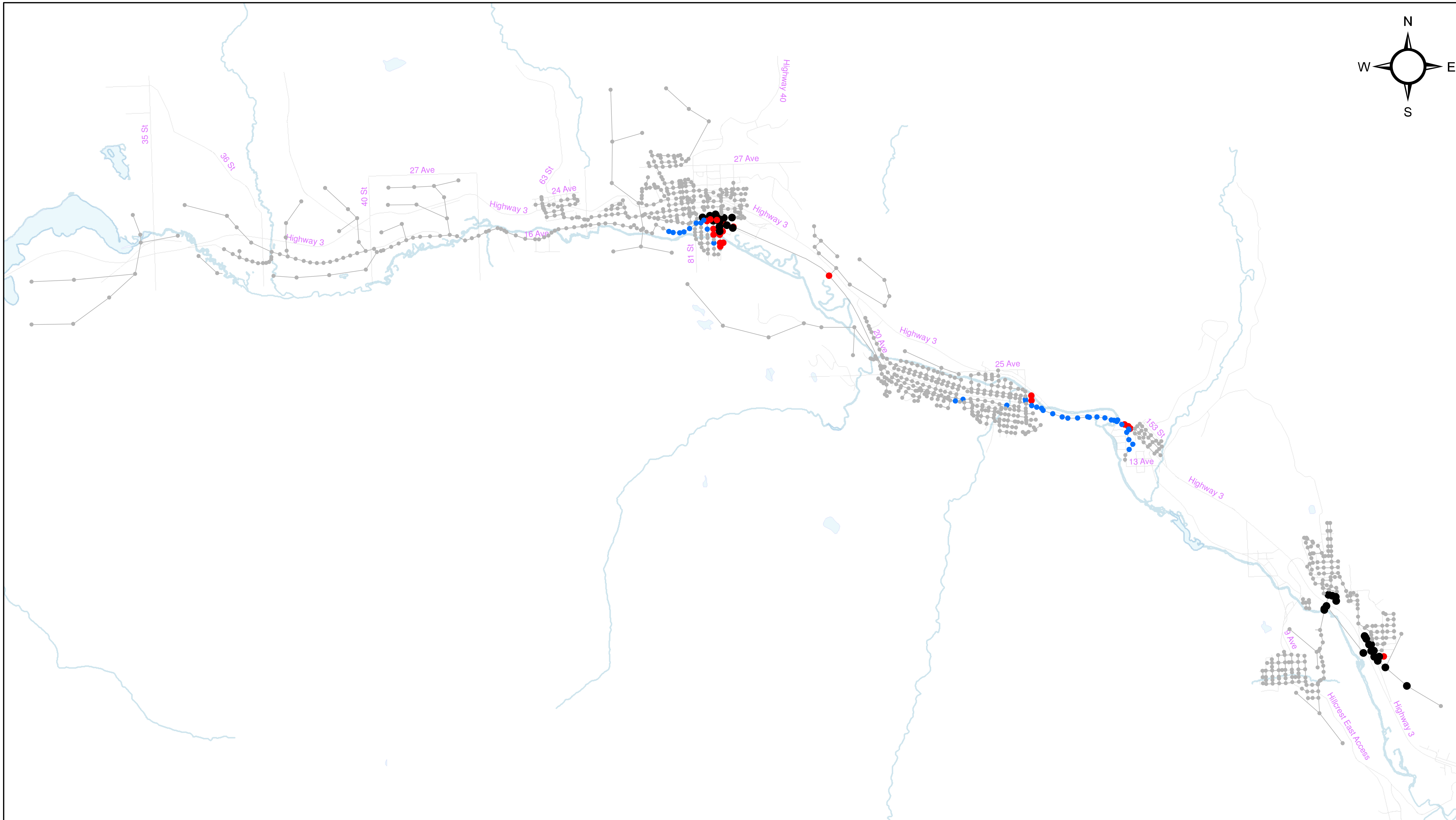
Percent Utilization of Full Pipe Capacity

- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
5-5

Title
Pre-Improvement
Hydraulic Pipe Capacity Rating Factor
Dry Weather Flow



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Legend

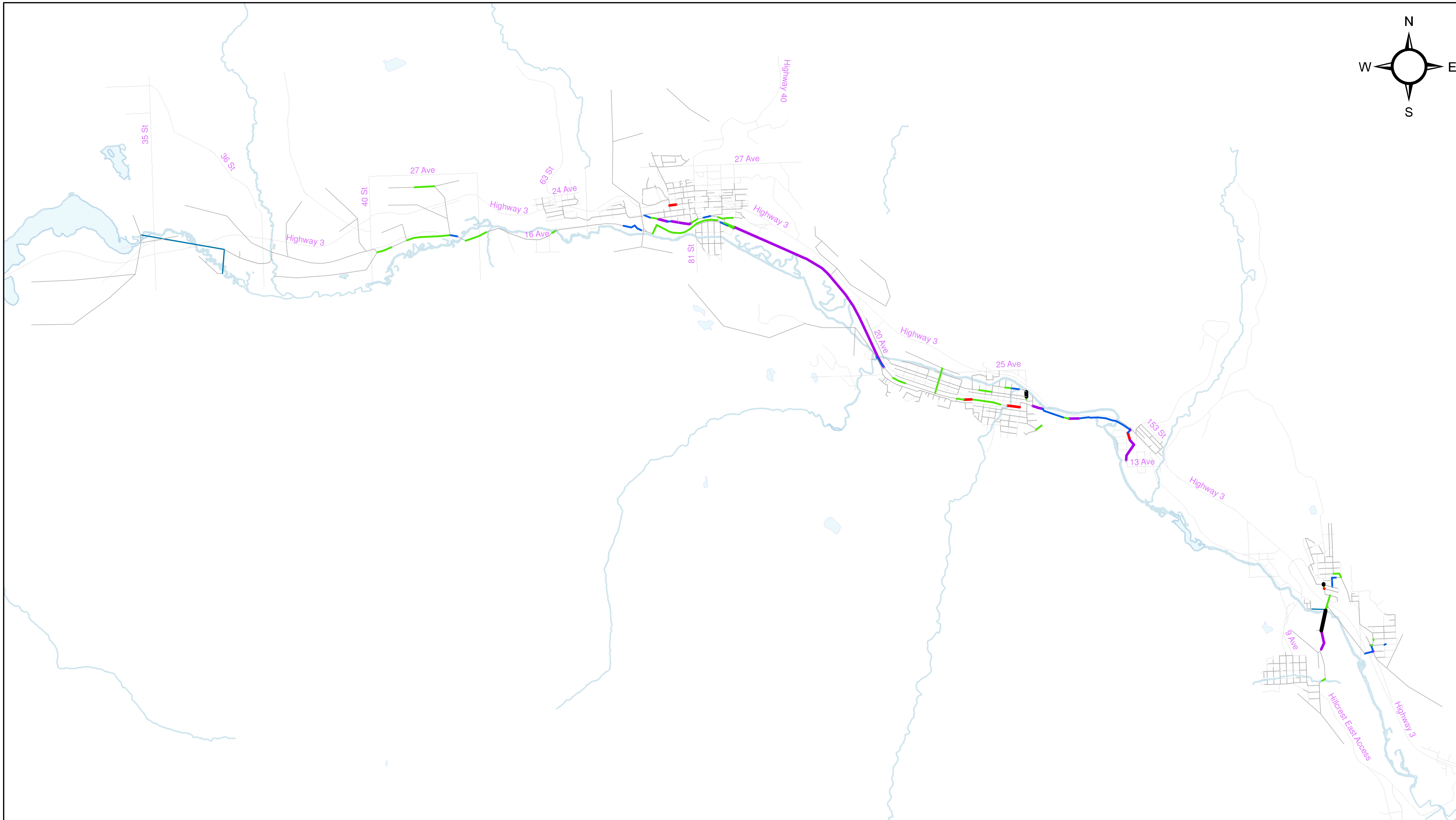
Manhole Surcharging

- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-6

Title
Pre-Improvement
Surcharging Severity
Dry Weather Flow



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Legend

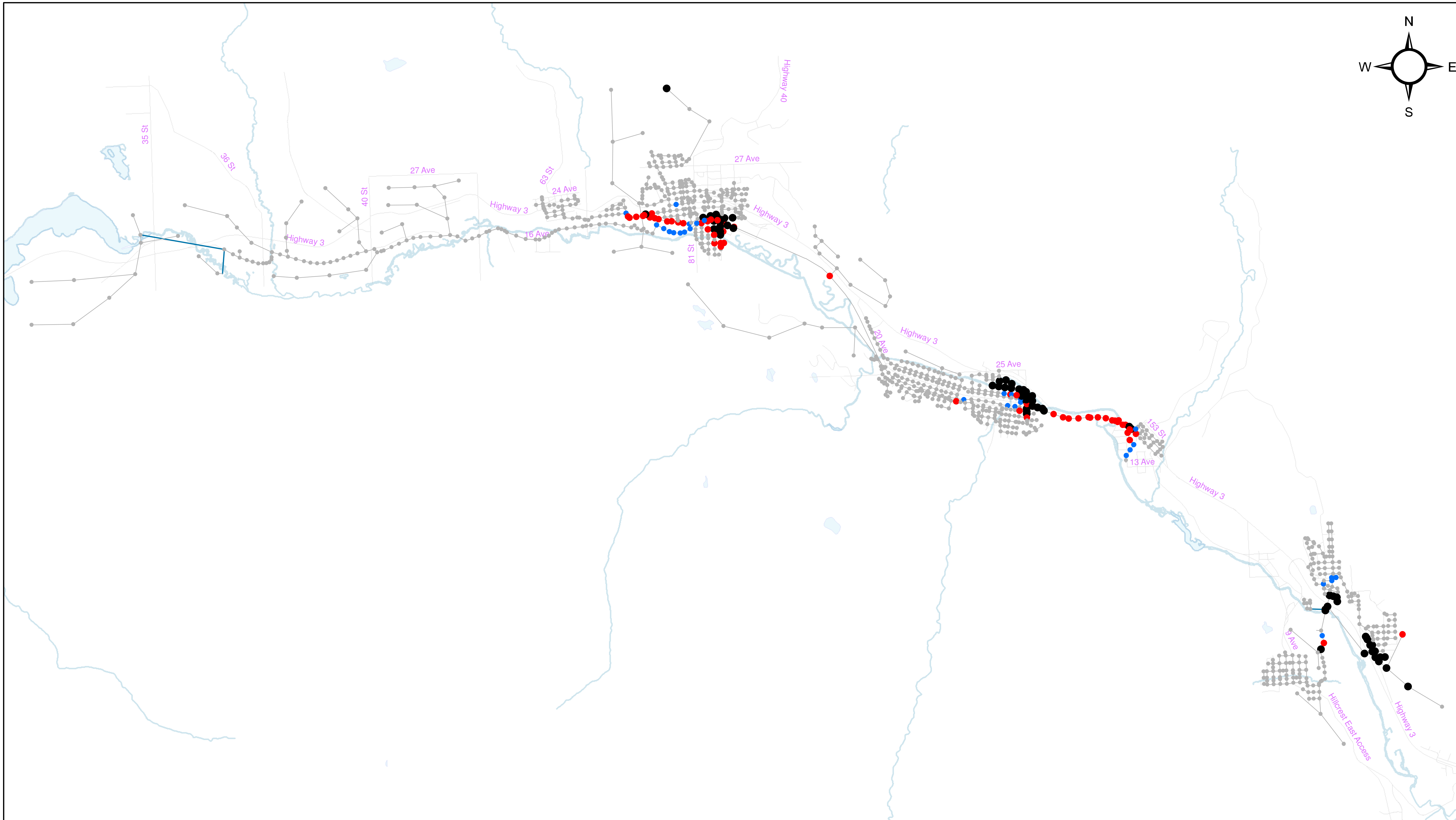
Percent Utilization of Full Pipe Capacity

- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
5-7

Title
Pre-Improvement
Hydraulic Pipe Rating Factor
Wet Weather Flow



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Legend

Manhole Surcharging

- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

Client/Project

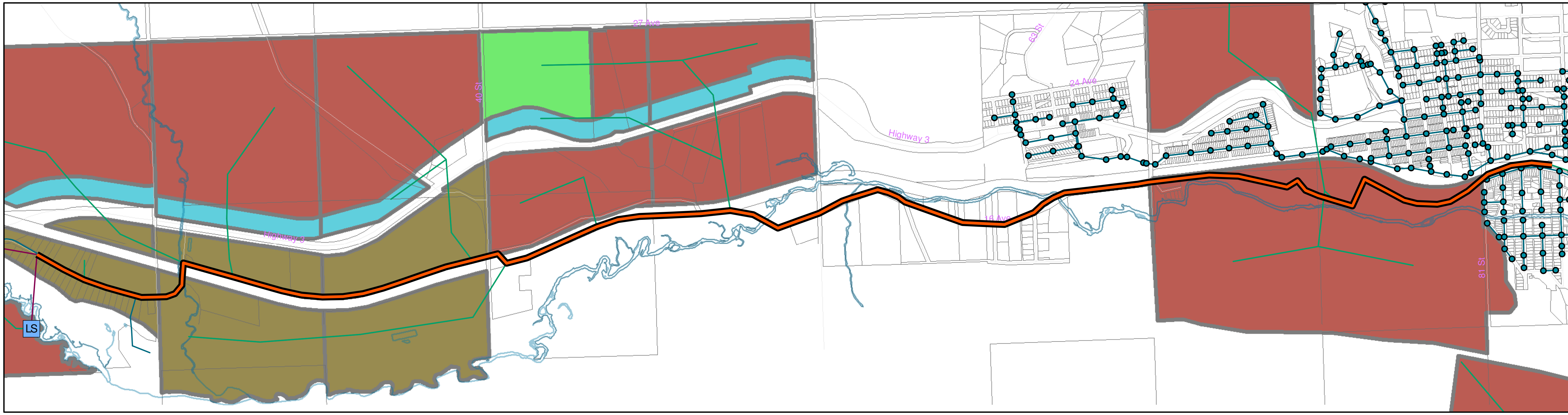
Municipality of Crowsnest Pass
Wastewater Master Plan

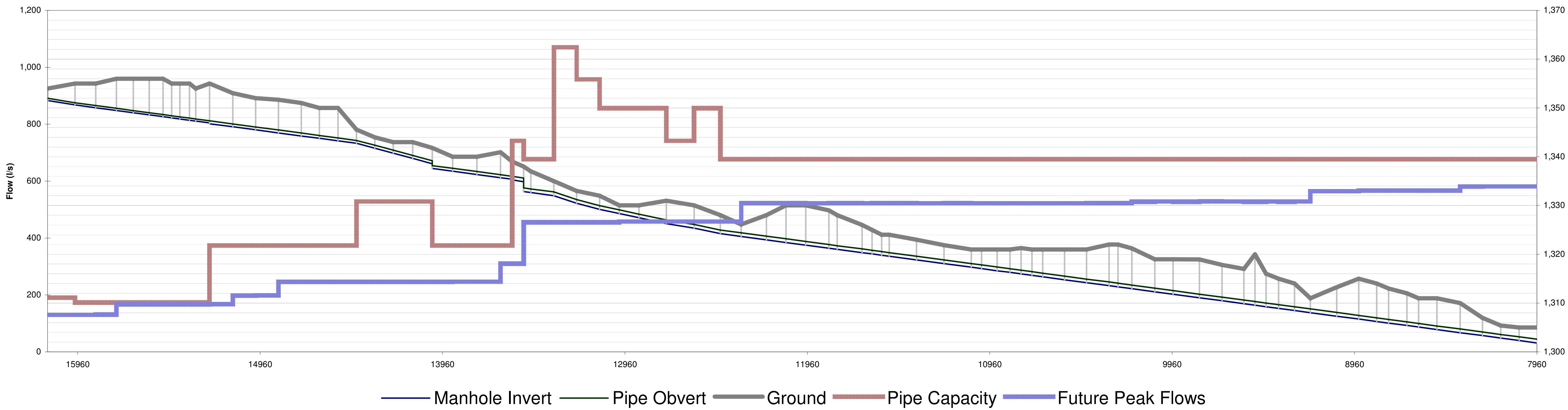
Figure No.

5-8

Title

Pre-Improvement
Manhole Surcharging Severity
Wet Weather Flow





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Legend

- Sentinel Trunk
- WWTP Existing WWTP
- LS Lift Station

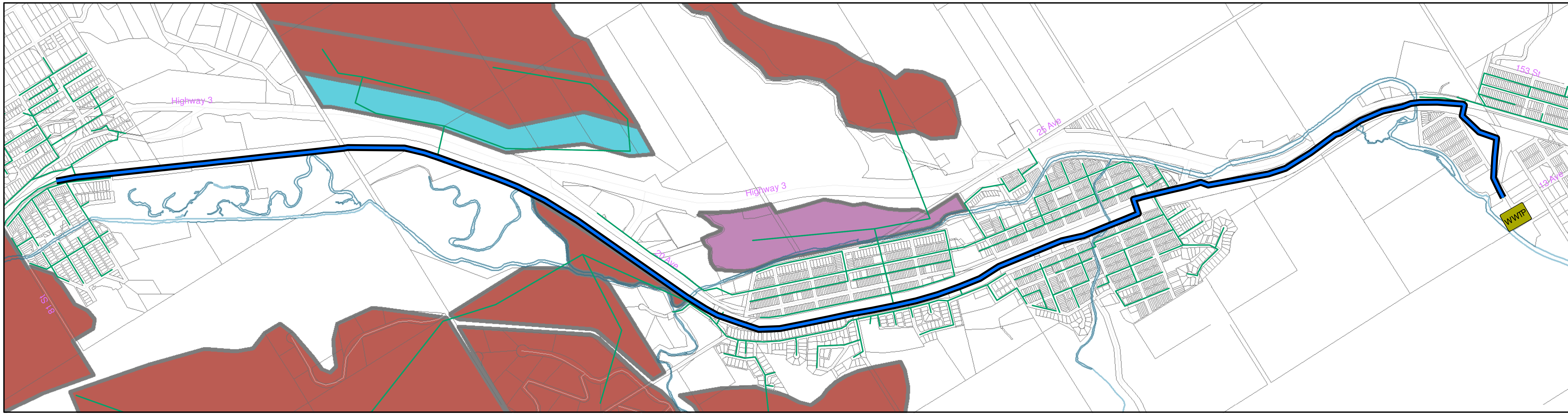
Land Use

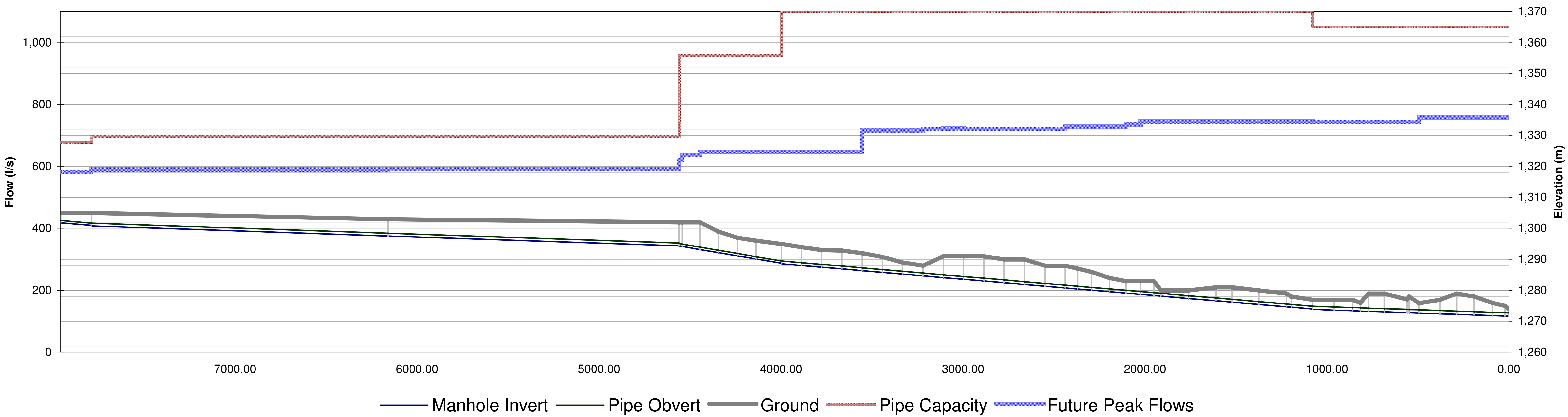
- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-9

Title
Future Upgrades - Sentinel Trunk





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Legend

Upgrade Existing Trunk
WWTP Existing WWTP
LS Lift Station

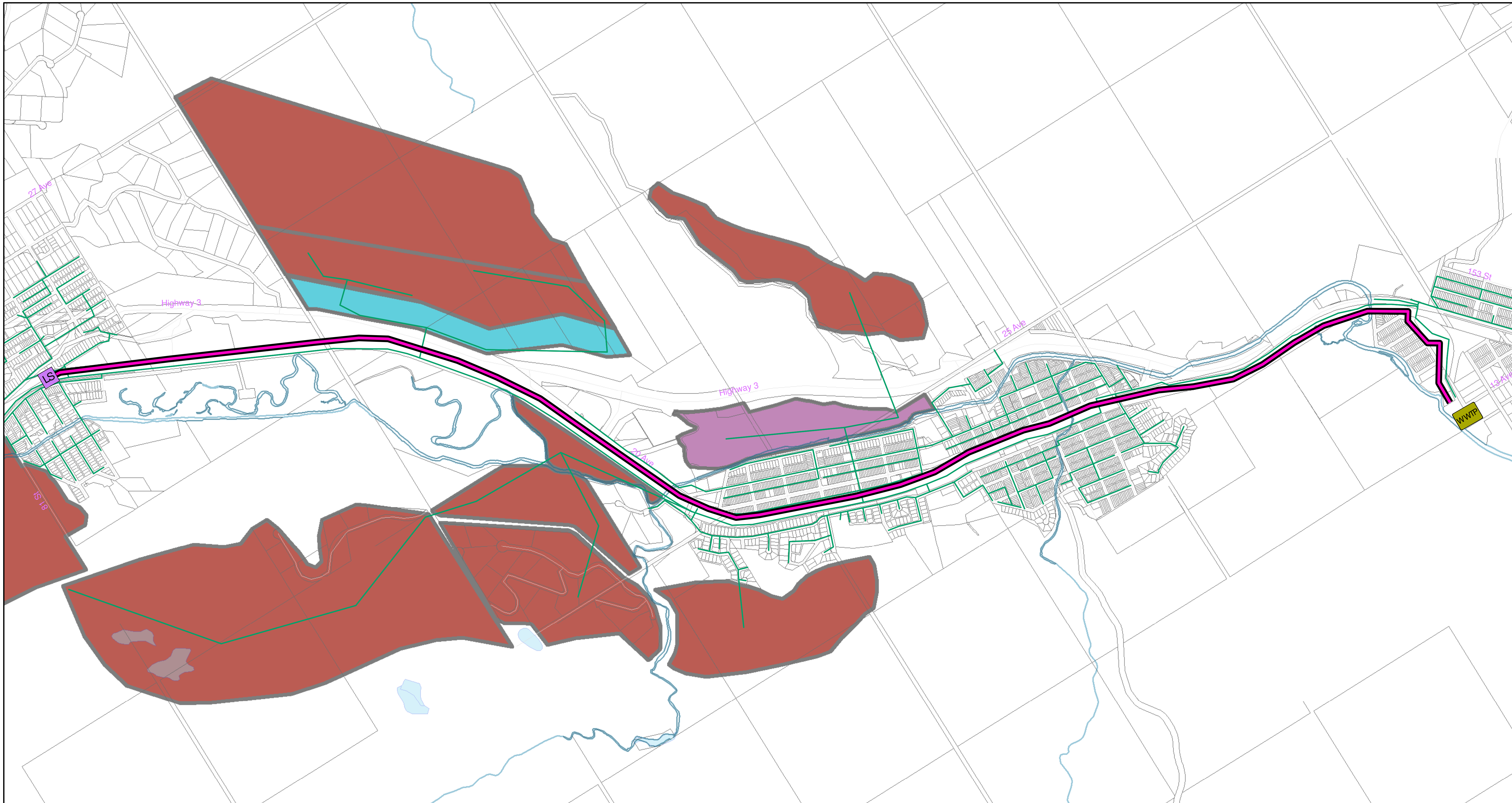
Land Use

Bridgegate Resort
Commercial
Crowsnest Resort
Industrial
Residential
River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-10

Title
Future Upgrades - Upgrade Existing 600 mm Main



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Legend

- Forcemain
- WWTP Existing WWTP
- LS Lift Station
- LS Liftstation

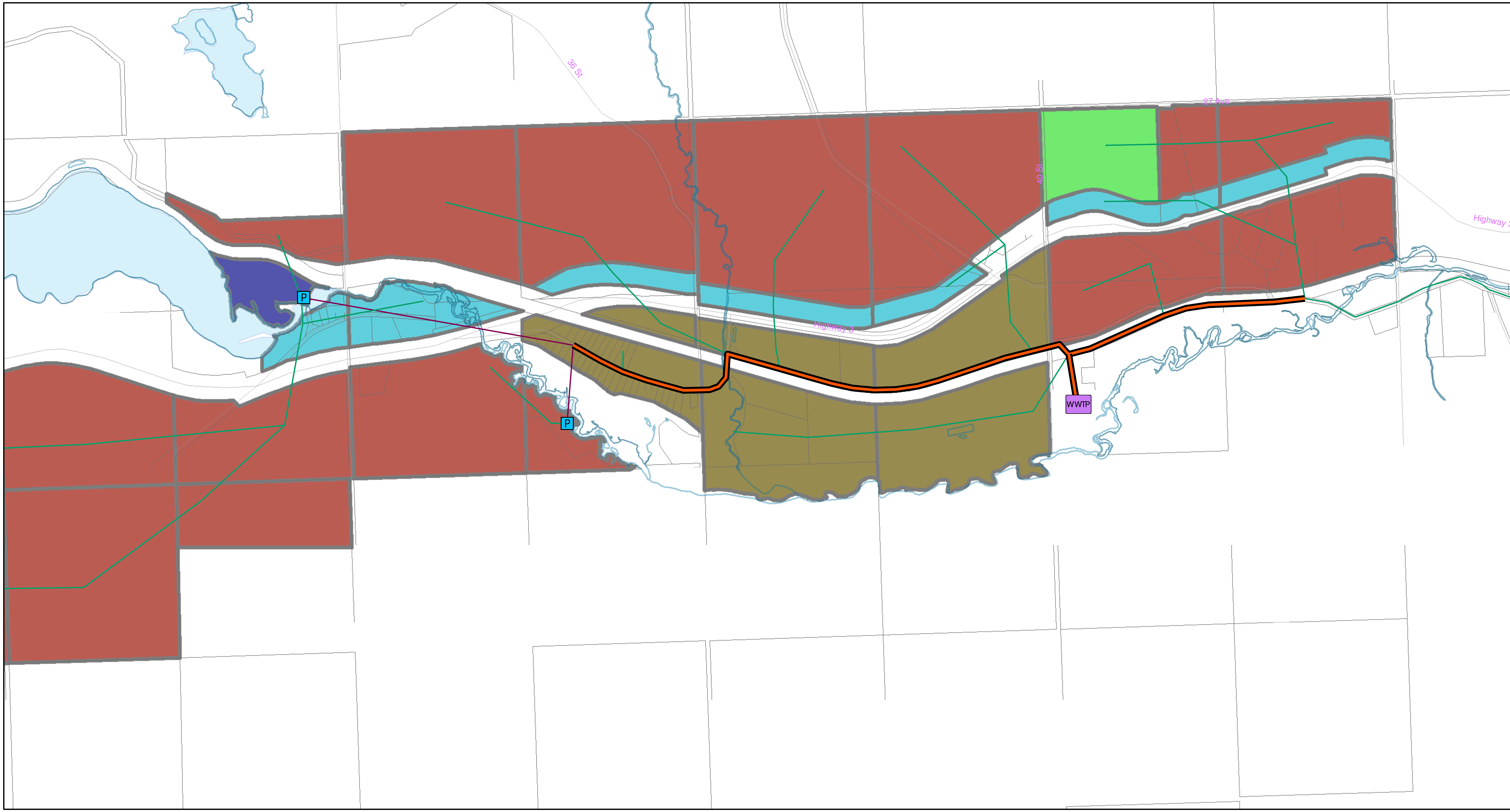
Land Use

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-11

Title
Future Upgrades
Liftstation and Forcemain



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Legend

- Adjusted Sentinel Trunk
- WWTP New WWTP
- P LS

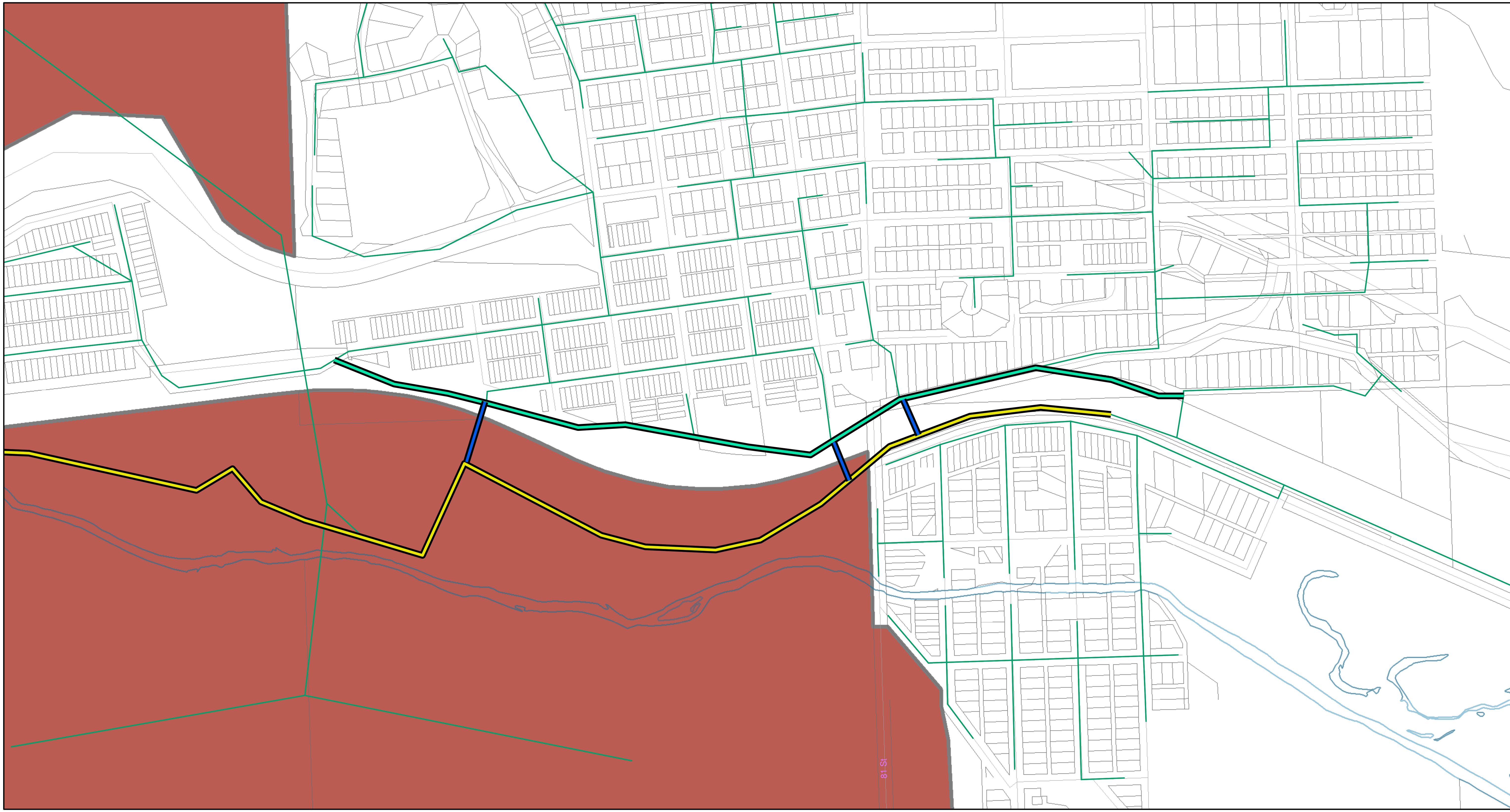
Land Use

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-12

Title
Future Upgrades
New Wastewater Treatment Plant



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Legend

- Sentinel Trunk
- Coleman Trunk Upgrade
- Coleman Interconnection

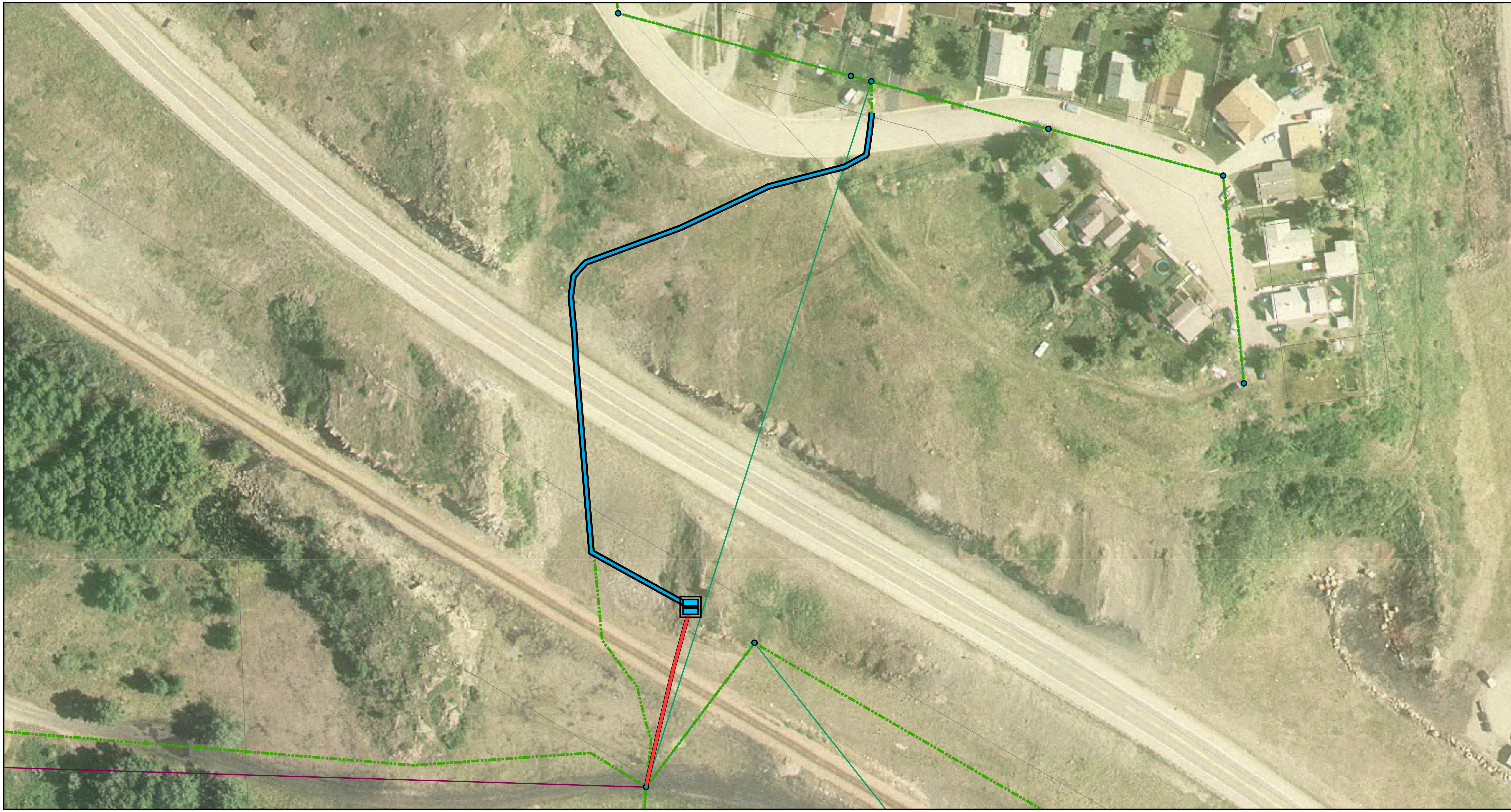
Future Land Use

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-13

Title
Future Upgrades
Coleman Trunk Upgrades



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Legend

newmain

Name

- Siphon Extension to Inlet Chamber
- North Bellevue Siphon Inlet Upgrade
- Inverted Siphon Inlet Chamber

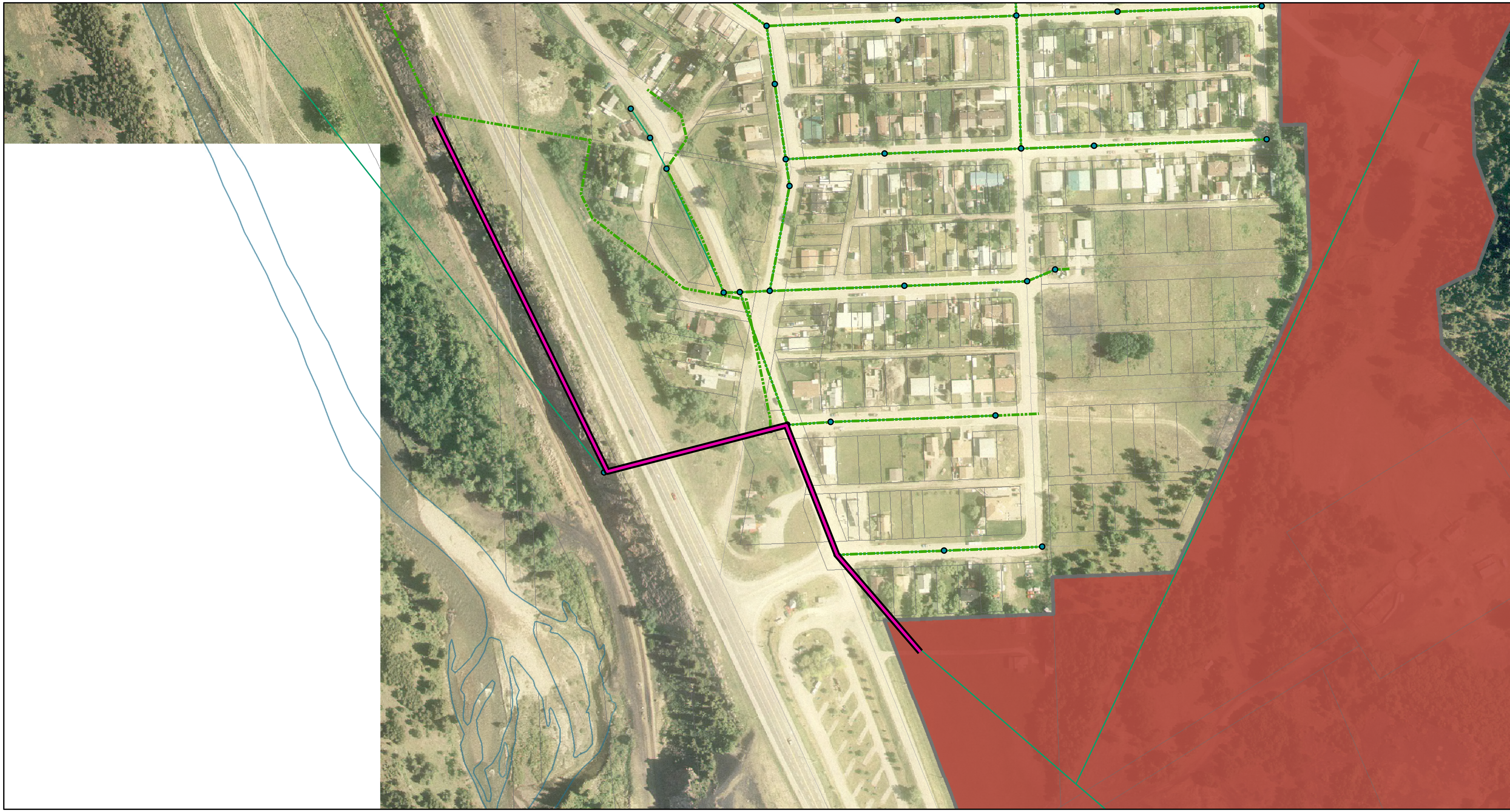
Future Land Use

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-14

Title
Future Upgrades
Bellevue Inverted Siphon Upgrades



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Legend

- Bellevue South Trunk Upgrade

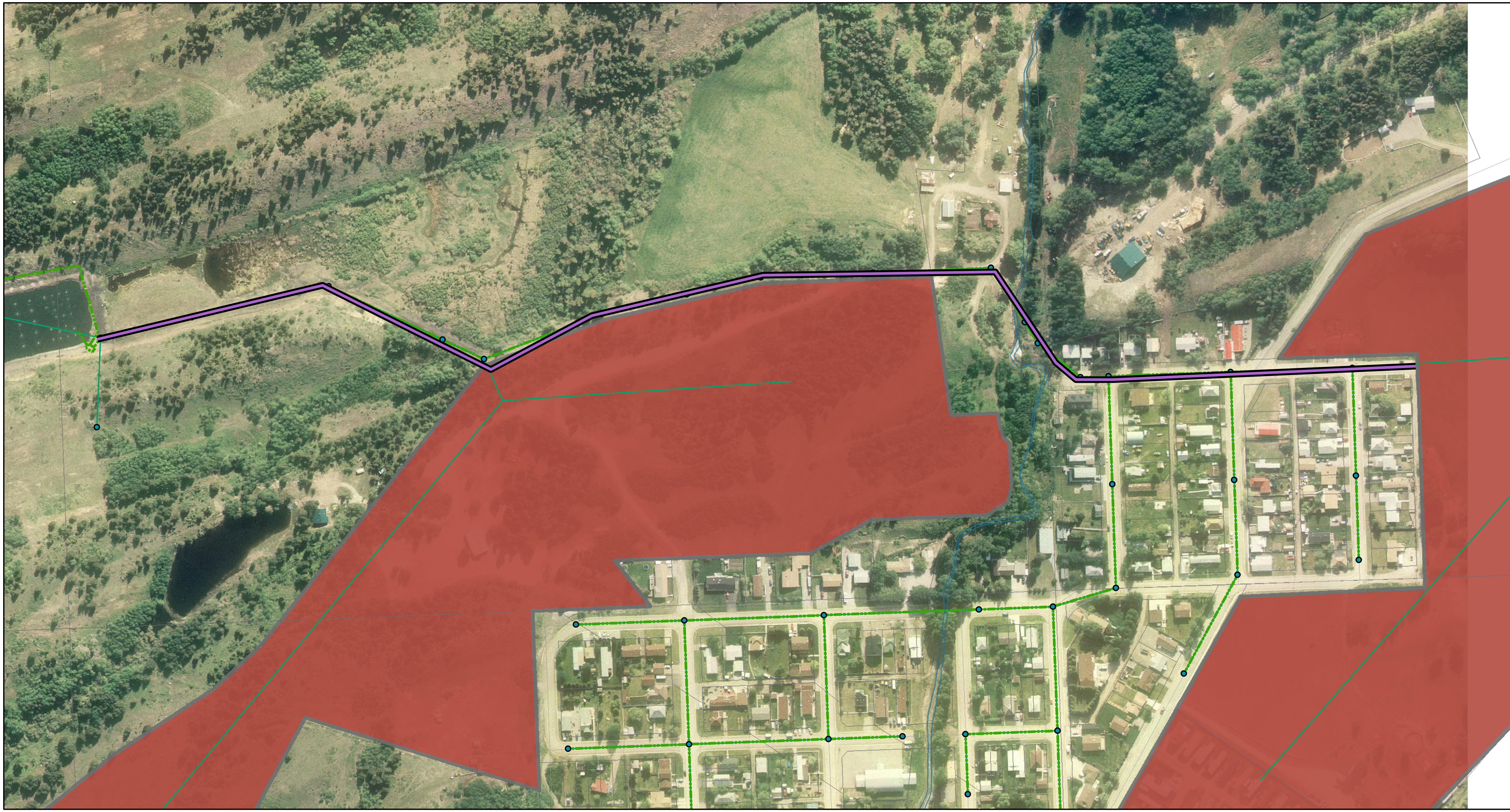
Future Land Use

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-15

Title
Future Upgrades
Bellevue Trunk Upgrades



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Legend

- Hillcrest Trunk Upgrade
- Inverted Siphon Inlet Chamber

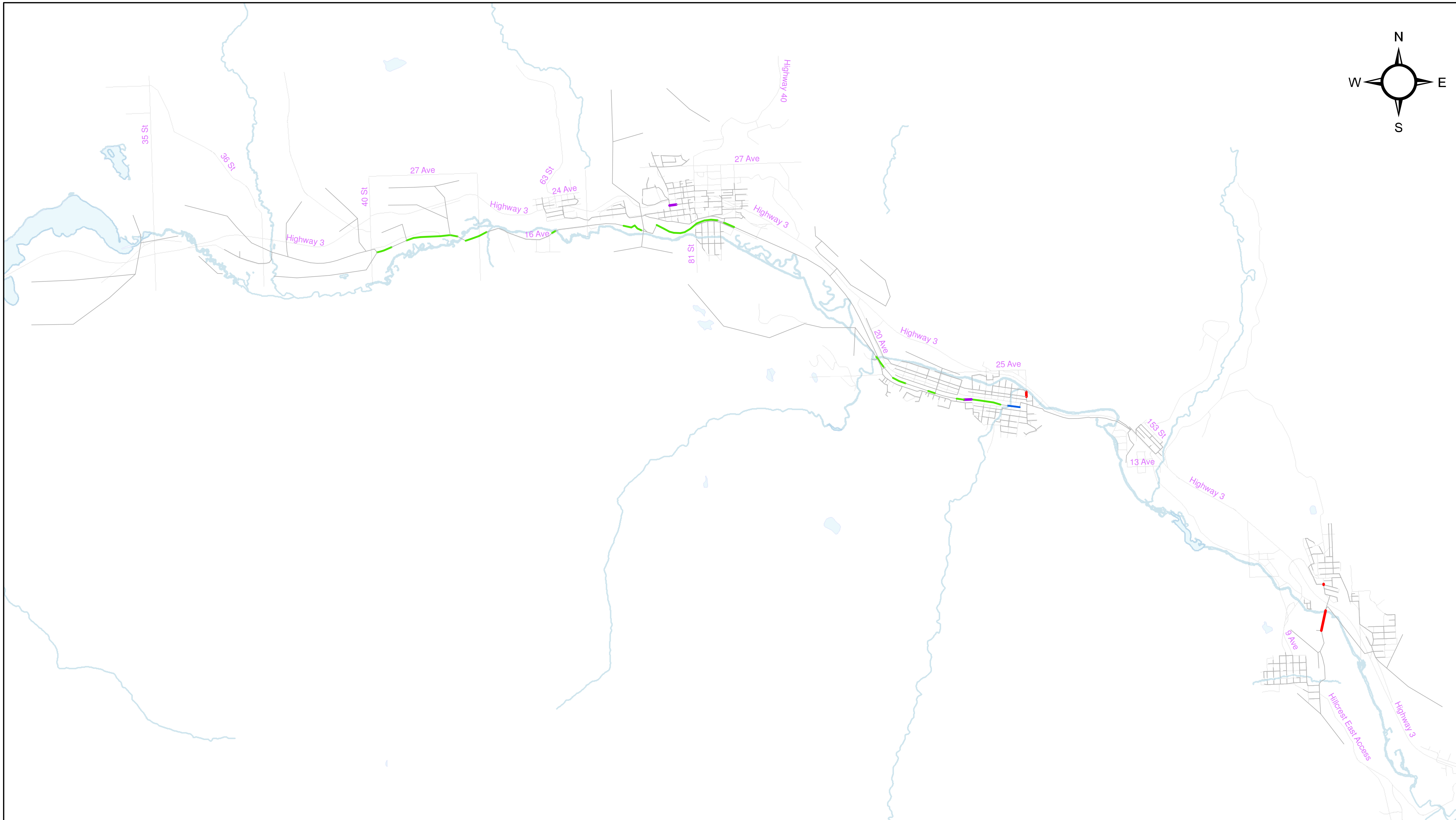
Future Land Use

- Bridgegate Resort
- Commercial
- Crowsnest Resort
- Industrial
- Residential
- River Run

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-16

Title
Future Upgrades
Hillcrest Trunk Upgrade



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Legend

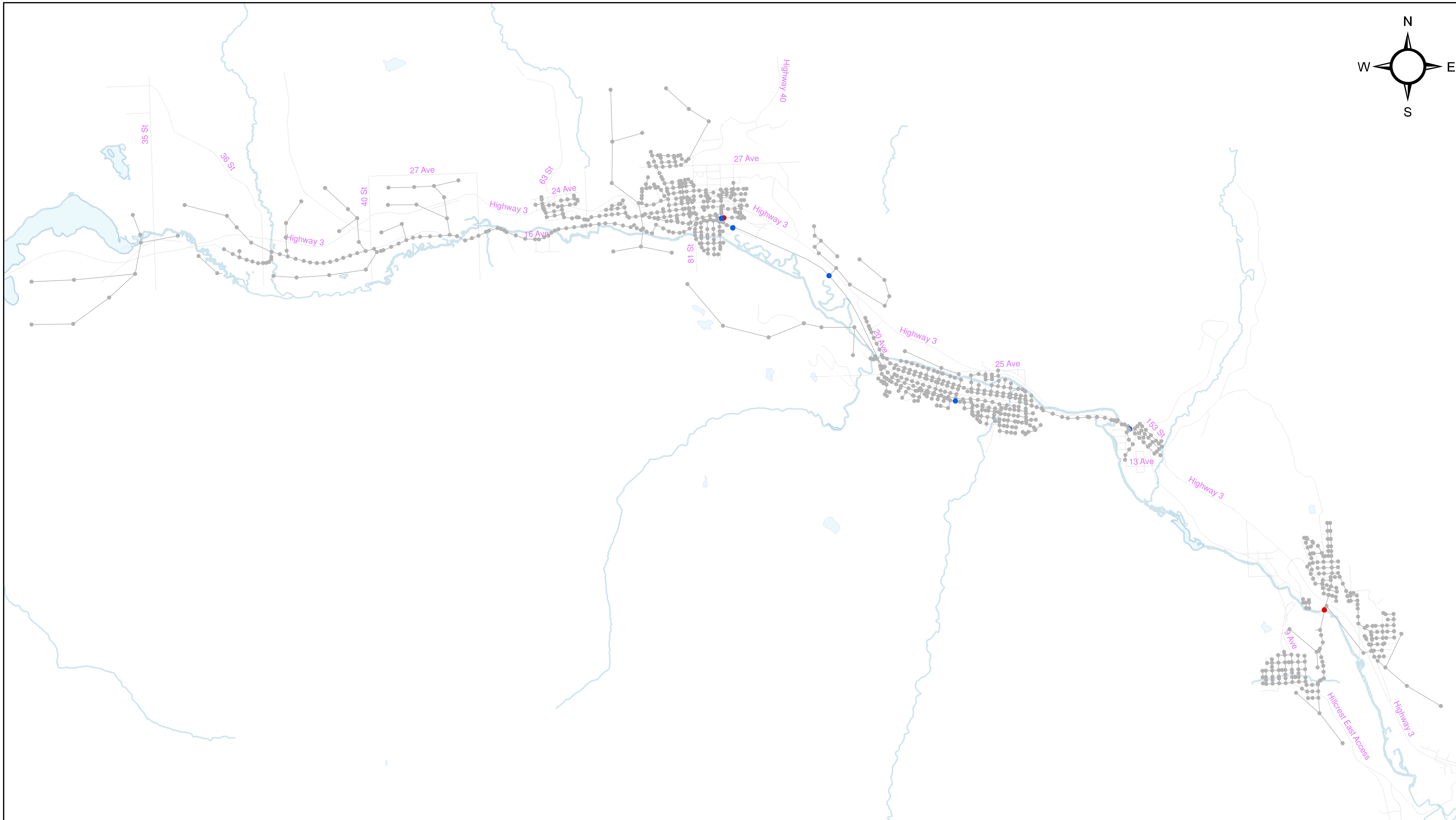
Percent Utilization of Full Pipe Capacity

- Less than 80%
- 80% to 100%
- 100% to 125%
- 125% to 150%
- 150% to 250%
- Greater than 250%

Client/Project
Municipality of Crowsnest Pass
Proposed Developments

Figure No.
5-17

Title
Post Improvement
Hydraulic Pipe Rating Factor
Dry Weather Flow



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Legend

Manhole Surcharging

- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

Client/Project

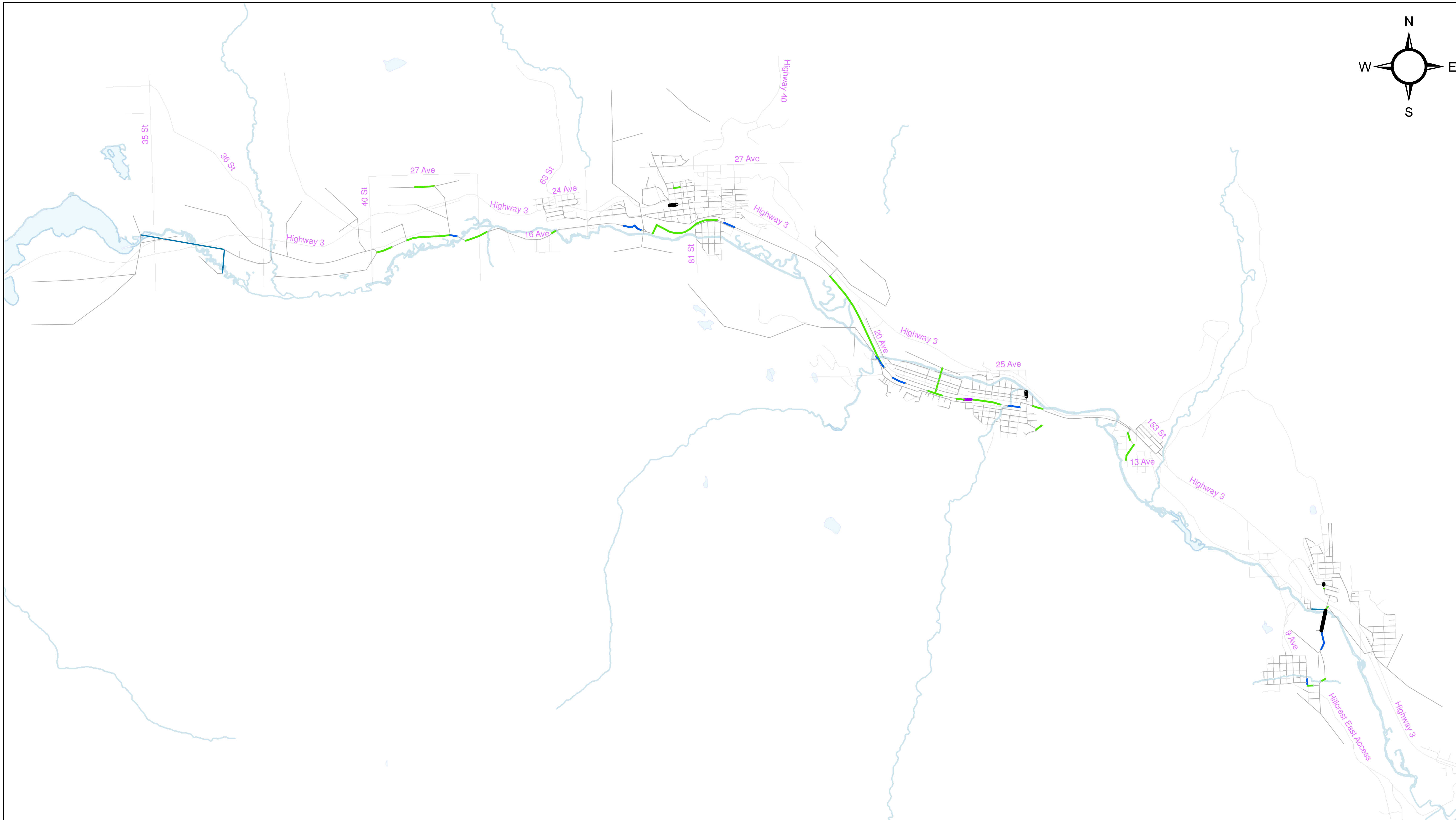
Municipality of Crowsnest Pass
Proposed Developments

Figure No.

5-18

Title

Post Improvement
Surcharging Severity
Dry Weather Flow



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Legend

Percent Utilization of Full Pipe Capacity

- Less than 80%
- 80% - 100%
- 100% - 125%
- 125% - 150%
- 150% - 250%
- Greater than 250%

Client/Project

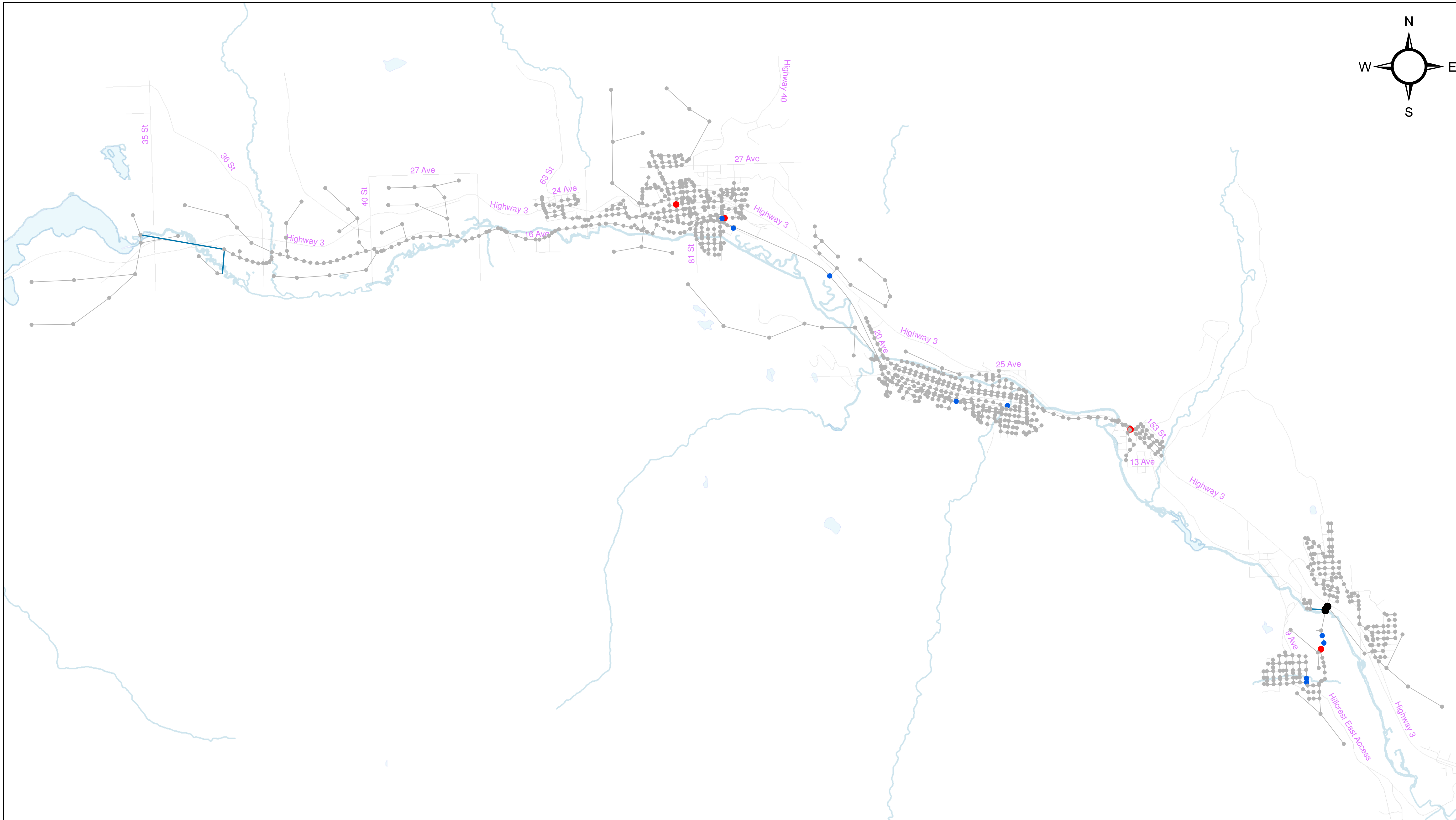
Municipality of Crowsnest Pass
Proposed Developments

Figure No.

5-19

Title

Post Improvement
Hydraulic Pipe Rating Factor
Wet Weather Flow



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Legend

Manhole Surcharging

- No Surcharging
- Minor Surcharging
- Moderate Surcharging
- Severe Surcharging

Client/Project
Municipality of Crowsnest Pass
Wastewater Master Plan

Figure No.
5-20

Title
Post Improvement
Surcharging Severity
Wet Weather Flow

6.0 Capital Improvement Plan

6.1 OPINION OF PROBABLE COSTS

This section presents **"conceptual"** cost estimates (± 50%) for capital costs associated with the construction of the infrastructure required for the development of the lands described in the previous sections. Due to the conceptual nature of this study and understanding that there exist unknown variables beyond the scope of this study, the cost estimates presented herein include a contingency allowance of 30% and an engineering allowance of 10% of the total estimated capital costs.

These factored level capital cost estimates should be considered realistic, but conceptual at this point and intended to give an order of magnitude opinion of estimated costs for planning and internal budgeting purposes only.

No detailed specifications, geotechnical requirements, process flow diagrams, site development or construction drawings have been developed or assessed to obtain "preliminary design level" cost estimates.

Stantec Consulting Ltd. does not guarantee the accuracy of this opinion of probable cost. The actual final cost of the project will be determined through the bidding and construction process.

The costs for each improvement alternative are listed in **Table 6-1.**

Table 6-1 Improvement Alternatives - Opinion of Probable Cost

		Projected Capital Cost	Improvement Trigger
Coleman Sub-Trunk Upgrade			
Option 1	Upgrade Existing 250mm Trunk	**$ 950,000**	Existing Deficiency
Option 2	Bypass to New Trunk[1]	**$ 1,450,000**	
Bellevue Siphon Upgrade			
	Upgrade Existing Siphons	**$ 1,200,000**	Existing Deficiency
Riverbottom Lift Station Upgrade			
	Upgrade Existing Forcemain and Pumps	**$ 310,000**	Existing Deficiency
Sentinel Trunk			
	New Trunk Construction	**$ 10,790,000**	Development in Sentinel Growth Area
Blairmore-Coleman Trunk Main[2]			
Option 1a	Twin Existing Trunk	**$ 10,160,000**	Additional Development Area
Option 1b	New Trunk Construction	**$ 11,880,000**	
Option 2	Lift Station	**$ 13,090,000**	
Option 3	WWTP	**$ 57,300,000**	
Bellevue Inverted Siphon Upgrades			
	Construct new 250mm Siphon	**$ 1,200,000**	Additional Development Area
Bellevue Trunk Upgrades			
	Upgrade Existing Trunk	**$ 660,000**	Additional Development Area
Hillcrest Trunk Upgrades			
	Upgrade Existing Trunk	**$ 770,000**	Additional Development Area

[1] Option 2 for the Coleman Trunk Improvements requires the installation of the Sentinel Trunk Main
[2] The Blairmore Coleman Interconnection may be completed in phases based on the location and size of the proposed development.

In addition to the costs for trunk mains and upgrades to the existing system there are costs related to construction of mains to service lands within the growth areas. **Table 6-2** provides a list of costs related to the infrastructure within the proposed development areas.

Table 6-2 Growth Area Pipe Network - Opinion of Probable Cost

		Projected Capital Cost
Sentinel Growth Area		
A	Pipe Network	**$ 9,200,000**
B	Lift Station 1	**$ 2,500,000**
C	Lift Station 2	**$ 500,000**
Coleman Blairmore Growth Area		
A	Pipe Network	**$ 9,600,000**
Bellevue Growth Area		
A	Pipe Network	**$ 1,100,000**
Hillcrest Growth Area		
A	Pipe Network	**$ 1,300,000**

The final improvement that will be required is an upgrade to the Frank Wastewater Treatment Plant. The plant capacity will not be sufficient to meet the flow requirements from the proposed development areas. The treatment plant was not part of the scope of this master planning study. For the purposes of this analysis an improvement value of $35,000,000 has been used.

6.2 CAPITAL IMPROVEMENT PLAN

The wastewater master plan has defined two groups of improvements for the Municipality of Crowsnest Pass wastewater system. Existing system and future system improvements are ranked and discussed in the following sections.

6.2.1 Existing System Capital Improvement Ranking

Table 6-3 lists the ranking of the two proposed capital improvements for the existing system. The Bellevue Siphon upgrade ranks as the most important due to the severity of surcharging that is apparent in the manhole upstream of the existing siphons. The Coleman Trunk improvement requires additional investigation to validate the findings of the hydraulic model.

Table 6-3 Existing System Capital Improvement Rankings

Improvement Rank	Description of Capital Improvement		
1	**Bellevue Inverted Siphon Upgrade**		
		Upgrade Existing Siphons	
2	**Riverbottom Lift Station**		
		Upgrade Forcemain and Lift Station	
3	**Coleman Trunk Improvements**		
	Option 1	Upgrade Existing Trunk	Preferred Option
	Option 2	*Bypass to New Trunk*[2]	

6.2.2 Future System Capital Improvement Ranking

Table 6-4 lists the rankings of the infrastructure projects required to service the growth areas described in this report. Each project is not given a specific ranking as they are dependent on the actual progression of development within the Municipality.

Each improvement alternative is ranked based on cost and subjective criteria such as constructability, technical feasibility, operating costs, and regulatory requirements.

Table 6-4 Future System Capital Improvement Rankings

Improvement Alternative Ranking	Improvement		Notes
	Sentinel Trunk		
		New Trunk Construction	Required as development proceeds
	Blairmore Coleman Interconnection[1]		
1	Option 1a	Twin Existing Trunk	Preferred Option based on capital cost, operating costs, and other required approvals.
2	Option 1b	New Trunk Construction	May still be considered if constructability becomes and issued for Option 1.
3	Option 2	Lift Station	High Operating Costs
4	Option 3	WWTP	Regulatory Approval will not be granted
	Bellevue Trunk Upgrades		Required as development proceeds
		Upgrade Existing Trunk	
	Hillcrest Trunk Upgrades		Required as development proceeds
		Upgrade Existing Trunk	

6.3 DEVELOPMENT COSTS

Four individual development cost scenarios were developed for the infrastructure servicing requirements for the Municipality of Crowsnest Pass.

Table 6-5 lists the area based development costs neglecting the additional cost of upgrading the Frank wastewater treatment plant. Area based costs are calculating by dividing the cost of infrastructure required for a specific area by the developable area in question. This gives a measure of the relative cost to service different areas in different each community.

Table 6-5 Scenario 1 – Growth Area Based Development Costs (WWTP Upgrades Not Included)

	Projected Capital Cost	Area (ha)	Development Cost (per Hectare)
Sentinel Growth Area			
Pipe Network	$9,200,000		
Lift Station 1	$2,500,000		
Lift Station 2	$500,000		
Sentinel Trunk	$10,790,000		
Blairmore Coleman Interconnection (75% Share)	$7,620,000		
Total	**$30,610,000**	**854**	**$36,000 / ha**
Coleman Blairmore Growth Area			
Pipe Network	$9,600,000		
Blairmore Coleman Interconnection (25% Share)	$2,540,000		
Total	**$12,140,000**	**757**	**$16,000 / ha**
Bellevue Growth Area			
Pipe Network	$1,100,000		
Bellevue Trunk Upgrade	$660,000		
Total	**$1,760,000**	**100**	**$18,000 / ha**
Hillcrest Growth Area			
Pipe Network	$1,300,000		
Hillcrest Trunk Upgrade	$770,000		
Total	**$2,070,000**	**50**	**$32,000 / ha**
Grand Total (not including WWTP Upgrade)	**$46,580,000**	**1,761**	**$26,500 / ha**

Table 6-6 lists the area based development costs including the additional cost of upgrading the Frank wastewater treatment plant. Area based costs are calculating by dividing the cost of infrastructure required for a specific area by the developable area in question. This gives a measure of the relative cost to service different areas in different each community.

Table 6-6 Scenario 2 – Growth Area Based Development Costs (WWTP Upgrades Included)

		Projected Capital Cost	Area (ha)	Development Cost (per Hectare)
Sentinel Growth Area				
	Pipe Network	$9,200,000		
	Lift Station 1	$2,500,000		
	Lift Station 2	$500,000		
	Sentinel Trunk	$10,790,000		
	Blairmore Coleman Interconnection (75% Share)	$7,620,000		
	Share of WWTP Upgrade (75%)	$26,250,000		
	Total	**$56,860,000**	**854**	**$67,000 / ha**
Coleman Blairmore Growth Area				
F	Pipe Network	$9,600,000		
G	Blairmore Coleman Interconnection (25% Share)	$2,540,000		
	Share of WWTP Upgrade (25%)	$8,750,000		
	Total	**$20,890,000**	**757**	**$28,000 / ha**
Bellevue Growth Area				
H	Pipe Network	$1,100,000		
I	Bellevue Trunk Upgrade	$660,000		
	Total	**$1,760,000**	**100**	**$18,000 / ha**
Hillcrest Growth Area				
J	Pipe Network	$1,300,000		
K	Hillcrest Trunk Upgrade	$770,000		
	Total	**$2,070,000**	**50**	**$32,000 / ha**
Grand Total (including WWTP Upgrade)		**$81,580,000**	**1,761**	**$46,000 ha**

7.0 Summary of Recommendations

7.1 EXISTING SYSTEM RECOMMENDATIONS

7.1.1 Collection System Data Collection

A comprehensive survey of the wastewater collection system should be carried out to complete the database for the wastewater collection system. This will also verify the connectivity of the collection system network and the associated pipe slopes and capacities. This data should be used to update the wastewater collection system model and associated databases. Costs to complete surveys are unknown at this time.

Flow monitoring should be continued throughout the Municipality on an annual basis to confirm sewage generation rates and wet weather flow contributions in each community. Verified flow monitoring data should be used to update the wastewater collection system model in order to further refine proposed upgrades and improve operational performance of the wastewater system. Approximately $20,000 per year should be allocated to flow monitoring and data retrieval and analysis efforts.

7.1.2 Coleman Sub-Trunk Improvement

The existing 250mm main should be upgraded to provide enough capacity for existing system flows plus the added flows from future development areas in Coleman. The upgrade consists of installation of approximately 1,250 m of 375 mm pipe and related work.

A thorough review of the problem area should be completed prior to advancing the design of this improvement. The estimated cost for this improvement is $950,000 if the existing trunk is upgraded (Option 1), or $1,450,000 if the flows are diverted to a new sentinel trunk (Option 2).

7.1.3 Bellevue Inverted Siphon Improvement

An upgrade of the existing 150mm main from the top of the hill to discharge by gravity into a new siphon inlet chamber.

The new siphon inlet chamber should be constructed on the north side of the Crowsnest River. This new chamber will provide a hydraulic grade that will accommodate future flows through the existing inverted siphon to the Bellevue Lagoons.

The upgrade consists of approximately 250 m of 300 mm pipe to replace the 150 mm siphon inlet line from north Bellevue. A new siphon inlet chamber will also be required at the upstream end of the inverted siphons. The estimated cost to construct this upgrade is $1,200,000.

7.1.4 Riverbottom Lift Station

Upgrade the existing 100mm force main by diverting it to the upstream end of the siphon system or constructing a new 150mm forcemain from the Riverbottom lift station to the inlet to the lagoons. The existing pumps will also require upgrading to meet he required head and pumping capacity. The estimated cost to construct this upgrade is $310,000.

7.1.5 Service Related Deficiencies

Operational programs should be considered that will address these operating issues in the collections system. Programs should include:

- *CCTV Inspection Program:* The program should attempt to capture condition data from the entire collection system on a regular interval based on the criticality of the specific pipe in the system. For pipes smaller than 300mm the interval should be 5 to15 years depending on the current state of the infrastructure. For pipes 300mm and larger the interval should be 2 to10 years depending on the current state of the infrastructure.

- *Collection System Cleaning Program:* Pipes in the collection system should be cleaned on a 2-3 year rotation. Mains that experience regular debris buildup should be cleaned either annually or biannually.

- *Inflow and Infiltration Reduction:* Programs should be implemented to reduce the amount of extraneous flow in the collection system. Known problem areas should be targeted to determine the most effective control measures.

  Control measures may include cross connection identification and disconnection, smoke testing, CCTV inspections, additional flow monitoring or infrastructure replacement.

  New development should be constructed in a manner that minimizes the potential for inflow and infiltration. Newly constructed sanitary sewers may require exfiltration testing to verify water-tight installation of new services.

- *Surcharging Problem Area Identification:* Areas prone to surcharging should be monitored periodically to collect additional data to verify the success of programs implemented to increase the collection system reliability.

7.2 FUTURE SYSTEM RECOMMENDATIONS

7.2.1 Sentinel Trunk

A new trunk main is required to service the Sentinel Growth areas. The peak flow capacity required is 560 l/s. The new trunk will require approximately 8,100 m of 750 mm pipe and related work. The estimated cost to construct this upgrade is $10,760,000.

7.2.2 Coleman-Blairmore Trunk Main

A full trunk upgrade would be completed to provide the full capacity of the projected existing and future flows. The existing trunk should be twinned to create additional capacity. The upgrade consists of approximately 8,100 m of 750 mm pipe and related work. The estimated cost to construct this upgrade is $10,160,000.

7.2.3 Bellevue Trunk Improvements

The new growth areas added to the southeast of Bellevue stress the capacity of the trunk that extends through the southernmost portion of Bellevue to the Inverted Siphons. The capacity of the main will require upgrade to accommodate the addition of future flows. The upgrade consists of approximately 325 m of 300 mm pipe as well as related manholes and associated work. The estimated cost to construct this upgrade is $660,000.

7.2.4 Hillcrest Trunk Main

The new growth areas added to the Hillcrest Trunk stress the capacity of the trunk that extends to the through the southernmost portion of Bellevue to the Inverted Siphons. The capacity of the main will require upgrade to accommodate the addition of future flows. The upgrade consists of approximately 1,150 m of 250 mm pipe as well as related manholes and associated work. The estimated cost to construct this upgrade is $770,000.

7.3 SYSTEM IMPROVEMENT COSTS

The total projected cost to construct infrastructure to support the development of the proposed 1,800 ha of developable area within the Municipality of Crowsnest Pass is $46,580,000. This equates to approximately $26,500 per hectare of developable land as tabulated in Table 6-5.

The flows that result from the development of the proposed lands will exceed the capacity of the Existing Frank Waste Water Treatment Plant. If the upgrades to the existing plant are included in the overall development costs, the cost per hectare of developable land increases to $46,000 per hectare as tabulated in Table 6-6.

8.0 Corporate Authorization

This document entitled "Municipality of Crowsnest Pass Wastewater Master Plan" was prepared by Stantec Consulting Ltd. for the Municipality of Crowsnest Pass. The material in it reflects Stantec Consulting Ltd.'s best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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