# The City of Camrose

# Sanitary Sewer Master Plan

*November 2007*

Associated Engineering

# Executive Summary

The City of Camrose retained Associated Engineering to update its Sanitary Sewer Master Drainage Plan that was developed in 2000. The objectives were to provide more detailed and updated direction to drainage servicing for future development.

## 1 PROJECT SCOPE

The study included:

- Conversion of the previous spreadsheet model of the sanitary trunk sewer system to the MOUSE software platform,
- Updating of the computer model to include new areas that are under development or planned for development in the near future,
- Calibration of the computer model using six years of flow and rainfall data from 1999 to 2004,
- Simulation of the existing sanitary sewer system to determine its capacity for design conditions,
- Assessment of drainage needs for the short, medium, and long-term timeframes in the City,
- Development of an upgrade plan for existing sanitary sewers to accommodate present and future needs,
- Documentation of the results and recommendation in the present report.

## 2 MODEL CALIBRATION

The flow and rainfall data that was collected over the six-year period from 1999 to 2004 were extremely valuable in calibrating the sanitary trunk model and indicated that the model provides a realistic simulation of actual conditions. However, a definitive calibration was not possible due to the lack of a significant storm event during the monitoring program and due to natural rainfall variations over the City area that may not be represented in the rainfall data. Two large storms which occurred in 2007 provided further validation of the model results. The modelling also showed that the system upgrades which the City has recently completed have substantially reduced the risk of basement flooding and system overflows.

## 3 DESIGN CRITERIA

In existing areas of the City, the design flows which were based on the model simulation results are slightly more conservative than were assumed in the 2000 Master Drainage Plan. In future development areas, without weeping tile connections, the proposed design criteria are about 15-27% higher than the City's current design standards.

## 4 EXISTING SYSTEM ASSESSMENT

The sanitary sewer system presently has enough capacity for wet-weather flows from events up to the 1:100 year storm, with the exception of the original trunk main along Camrose Creek and the lateral sewers in the Mohler and North End (54 Avenue) area:

- The Camrose Creek trunk could overflow to the creek in a major storm event, in those areas that remain to be upgraded.
- There is some risk of basement flooding along the 55 Avenue trunk, in part due to backup from the Camrose Creek trunk. This risk will be substantially reduced with the proposed upgrades to the mainline Creek trunk. Flows in the 54th Avenue trunk are sensitive to the assumed wet weather flows from the pipe plants and should be confirmed by monitoring.
- The Mohler laterals are not connected to the new trunk sewer along 44th Avenue. The risk of surcharging in the Mohler Industrial Area could be substantially eliminated or reduced by inter-connecting the new trunk, with the older trunk sewers.

Storage of peak wet-weather flows will be required to facilitate development north of the Ring Road, west of Cornerstone and east of Highway 13, which drain through existing trunk sewers that have limited capacity.

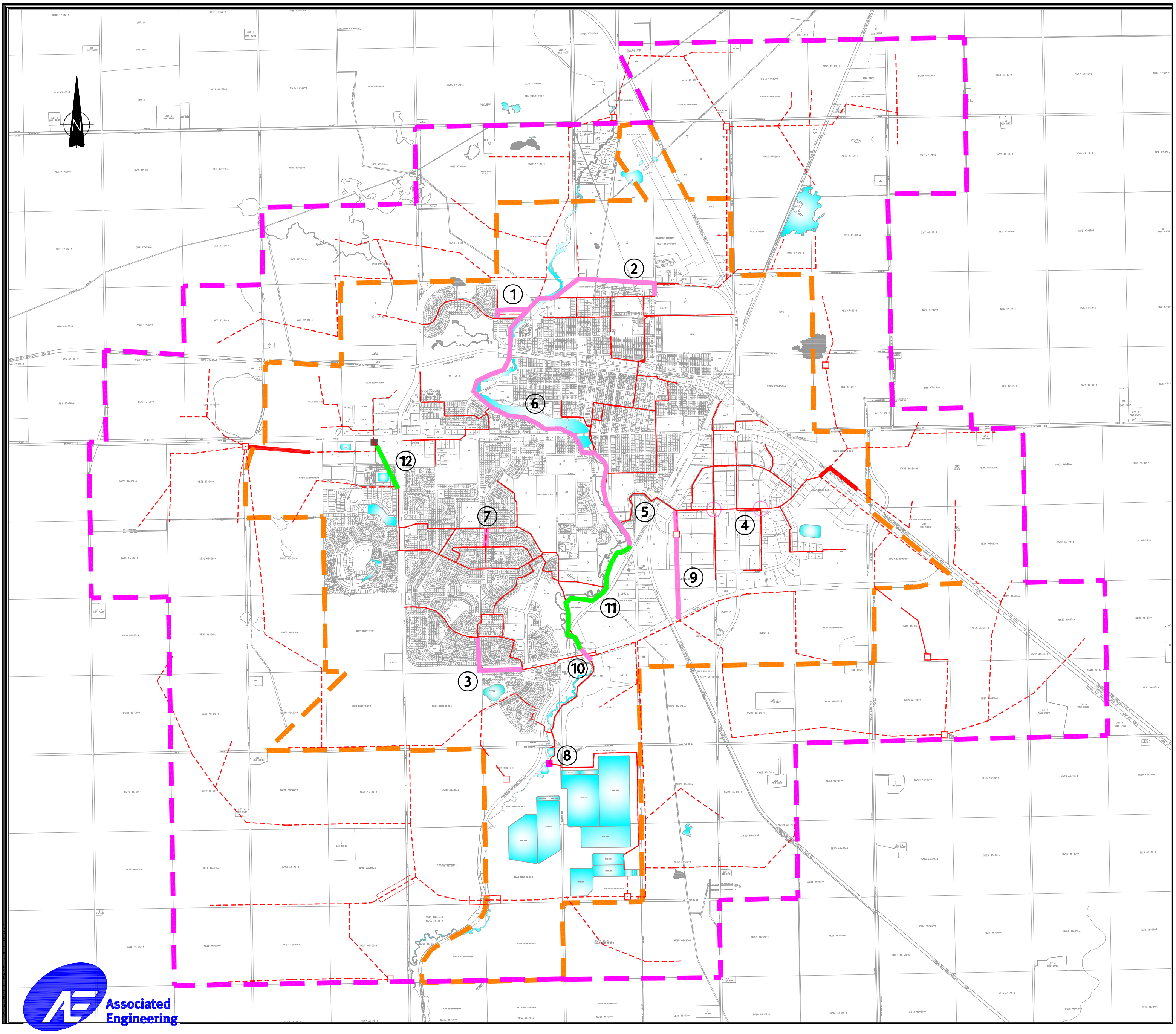
## 5 PROPOSED UPGRADING PLAN

Table 6.1, which follows, provides a summary of the capital improvements required to provide capacity for present and future development needs, and an initial estimate of the costs and implementation schedule of the proposed work, excluding the cost of upgrading the South Lift Station which are subject to further study.

## 6 FUTURE SYSTEM EXPANSION

Initial upgrades, within the next five years, will provide capacity for development up to the present City limits. Further development will require the extension of trunk services and construction of new trunk facilities into the new development area.

As the City grows to the south, new trunk sewer systems will be required to serve these areas and to divert as much flow as possible away from the main creek trunk. Figure 6.1 shows, conceptually, the trunk sewer



Associated Engineering

THE CITY OF CAMROSE

# PROPOSED SANITARY SEWER SYSTEM UPGRADE AND EXPANSION PLAN

| | |
|---|---|
| — | EXISTING TRUNK SEWERS |
| ■ | EXISTING PUMP STATION |
| ━ | PROPOSED UPGRADING FOR PRESENT DEVELOPMENT |
| ━ | PROPOSED UPGRADING FOR FUTURE DEVELOPMENT |
| ① | UPGRADE NUMBER (TABLE 6.1) |
| - - - | FUTURE TRUNK SEWER |
| □ | EXISTING PUMP STATION |
| ▭ | FUTURE PIPE BRIDGE |
| ▬ | FUTURE STORAGE TANK |
| ▬ ▬ | PLAN AREA BOUNDARY |

0 500 1000

SCALE: 1 : 40,000

JANUARY, 2008

FIGURE 6.1

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# Table 6.1
# Camrose Sanitary Sewer Master Plan
## Capital Priorities Plan

| ITEM # | PROPOSED UPGRADE | PURPOSE | SCOPE OF WORK** | APPROXIMATE COST** | WHEN REQUIRED | APPROXIMATE DATE | CAPITAL PRIORITIES PLAN (YEARS) |
|---|---|---|---|---|---|---|---|
| 1 | Design and construct the Creekside trunk (completed in 2007) | Provide capacity for future development west of 68 Street | 250 m of 375 mm sanitary sewer | $ 171,000 | Prior to street construction in Creekside | Completed in 2007 | 5 |
| 2A | Monitor flow rates in the 55 Avenue trunk for one season | Confirm the flows from the pipe plants and review the capacity of the trunk along 55 Avenue | Monitoring contract | $ 15,000 | Immediately | 2008 | 5 |
| 2B | Ring Road Sanitary Trunk | Prevent flooding at 53 Street and provide capacity for future development | 1239 m 1050 mm sanitary trunk | $ 1,500,000 | Prior to Ring Road construction | 2010 | >10 |
| 3 | Intercept the Enevold trunk to Camrose Drive | Provide capacity for Enevold 1/4 section | 800 m of 450 mm sanitary trunk | $ 1,300,000 | Prior to development | 2008 | >10 |
| 4 | Intercept lateral lines at two locations in the Mohler industrial area into the 600 mm diameter trunk | Reduce surcharging of lateral sewers | 2 manholes<br>plus 30 m of 600 mm sanitary sewer | $ 72,000 | Budget year 2008 | 2008 | 5 |
| 5 | Point repair to the Bethany trunk and waterproofing manholes<br>Raise and repair manholes to reduce I/I | Prevent further deterioration and risk of failure | 10 m of 450 mm sanitary trunk<br>Waterproof five manholes | $ 82,000 | Budget year 2008 | 2008 | 5 |
| 6A | Pre-design the mainline upgrades in the Camrose Creek Valley | Select routing and plan for replacement as funds become available | Study | $ 40,000 | Budget year 2008 | 2008 | 5 |
| 6B | Replace Camrose Creek trunk from 55 Avenue to 43 Avenue (limit of 2005 construction) | Reduce surcharge and risk of overflow, reduce surcharge in 55 Avenue trunk, and provide capacity for future development | 3100 m of 1200 mm<br>plus 5500 m of 1350 mm sanitary trunk | $ 10,500,000 | < 250 ha development in north Camrose* | 2026* | >10 |
| 7 | Construct overflow trunk along Mount Pleasant Drive from 42 Avenue to 43 Avenue | Provide additional protection against flooding in the Mount Pleasant area | 200 m of 600 mm storm sewer | $ 150,000 | Budget year 2009 | 2009 | 5 |
| 8A | Develop an upgrade plan for the South Lift Station and force main | Prevent overflows from the lift station and provide capacity for further development | Pre-design | $ 50,000 | Budget year 2009 | 2009 | 5 |
| 8B | Upgrade South Lift Station and Force Main | Prevent overflows from the lift station and provide capacity for further development | Replace pumps and force main | To be determined | With plant upgrades | 2006 | 5 |
| 9 | Pump station and force main in the Mohler area | Divert flows from the Bethany trunk and mainline trunk<br>Provide capacity for further development | Pump station<br>plus 1100 m force main and gravity main | $ 3,000,000 | Prior to 50 ha development in Mohler Basin | 2011 | 10 |
| 10 | Replace 900 mm trunk under Camrose Drive | Provide capacity for future development | 138 m of 1350 mm and 38 m of 1500 mm sanitary trunk (trenchless construction) | $ 500,000 | < 250 ha development in north Camrose* | 2026* | >10 |
| 11 | Twin or replace Camrose Creek Trunk from 43 Avenue to Camrose Drive | Provide capacity for future development | 1,800 m of 1,350 mm sanitary trunk (or twin existing) | $ 3,200,000 | >400 ha development upstream | 2040 | >10 |
| 12A | Upgrade Cornerstone pump station to 93 L/s | Provide capacity for future development | Replace or upgrade pumps to 93 L/s capacity | $ 100,000 | >70 ha cumulative development in Cornerstone Basin | 2010 | 5 |
| 12B | Provide in-line storage in Cornerstone basin | Provide capacity for future development (93 L/s) | 800 m of 1800 mm in-line storage tank c/w RTC | $ 2,000,000 | >130 ha cumulative development in Cornerstone Basin | 2015 | 10 |
| 12C | Upgrade Cornertsone pump station and force main to 145 L/s | Provide capacity for future development (145 L/s) | 700 m of 400 mm HDPE force main | $ 700,000 | >195 ha cumulative development in Cornerstone Basin | 2020 | >10 |
|  | Total Cost |  |  | $ 23,380,000 |  |  |  |
|  | Within 5 years |  |  | $ 680,000 |  |  |  |
|  | 5-10 years |  |  | $ 5,000,000 |  |  |  |
|  | Beyond 10 years |  |  | $ 17,700,000 |  |  |  |

* with in-line storage of wet-weather flows

** 2007 budget level estimates only; subject to pre-design; including construction, contingency (40%), engineering (10%), and GST (6%)

** Subject to confirmation in final design

Note: excludes developer-funded system expansion costs system that will ultimately be required over the next 50 years for the full development of the plan area. These trunks will be developed in a staged fashion:

- The initial servicing will drain to the Camrose Creek trunk and the South Lift Station, with temporary pump stations required at several locations.
- In-line storage will be provided at strategic locations to control the peak flows during storm conditions so as to make optimum use of the system capacity.
- Later, as development extends further south, east, and west, and new trunks are extended to service these developments, large areas will be diverted to these new trunks so as to reduce the flows to the main Camrose Creek trunk and volumes pumped at the South Lift Station.

Details are provided in Section 5 and Appendix C.

The costs of these facilities will be the responsibility of their developers. The estimated costs of these facilities are provided separately in a GIS data base, along with conceptual design information, to aid in the future planning and design of these facilities.

## 7 RECOMMENDATIONS

Other recommendations are as follows:

- Review the design and operational aspects of the in-line storage concept, and related provisions of the Master Plan, based on experience gained in the first application,
- Monitor flows in the 55 Avenue Trunk for one season and confirm the capacity of this trunk,
- Collect development levies to fund the replacement of trunk facilities that will be required for future development,
- Revise City development standards for future development areas in accordance with Sections 3.3 and 3.4, and Table 3.6,
- Pre-design the mainline upgrades in the Camrose Creek Valley to assess alignment options and develop cost estimates,
- Undertake a program of Inflow/Infiltration reduction to reduce the peak wet-weather flows in the sewer system,
- Conduct smoke and dye testing in the area contributing to the Enevold Trunk to search for and eliminate the possibility of extraneous inflows,

- Complete point repairs and waterproof manholes in the Mohler ravine,
- Update the development projections and the Master Plan as development conditions change over time.

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# 1 Introduction

## 1.1 BACKGROUND

The City of Camrose requested Associated Engineering to update its Sanitary Sewer Master Drainage Plan.

Associated Engineering prepared the current master plan in the year 1999/2000. The 2000 Master Plan was a strategic planning document that provided an overall concept plan and general guidelines for upgrading and developing the drainage systems.

Since then there have been considerable developments in the City, a number of changes to the drainage system, advances in the modelling software, and collection of flow monitoring data in the sanitary sewer system. The development process has also identified additional drainage options and constraints that need to be considered.

The City now requires an updated document that provides more current direction.

Figure 1.1 shows the principal trunk sewers in the City of Camrose. It also shows the existing areas that are currently under development, and are anticipated to be completed within the near future.

## 1.2 OBJECTIVES

Objectives of the project were to build on the previous Master Drainage Plan and to provide more updated and more detailed information to guide future development. This includes the following:

- Re-confirm the flow modelling using the latest planning information and design criteria,
- Establish system deficiencies and strengths,
- Re-evaluate the 5-year and 10-year capital priorities,
- Confirm design standards and requirements for new and re-development areas,
- Provide clear and specific guidelines for future development areas.

A separate master plan is being prepared for the storm drainage system. Servicing concepts for the storm drainage system will be coordinated with the sanitary drainage system.

## 1.3 SCOPE

General requirements of the Master Drainage Plan are to:

- update the model to include new areas that have developed in Camrose as well as new facilities that are in the planning stage,
- provide more detail for each basin,
- prepare a separate section for each area (neighbour or sub-basin) that is indexed and easy to find, with an index map for the entire City to help locate the sub-area. Each area will include:
  - sub-basin or neighbourhood maps (11x17 inches if possible),
  - identify the connection point and how the area is to be serviced,
  - provide details of constraints, design flows, existing and required capacities, specific upgrade requirements and phasing, development guidelines and limits, and release rates.

Special requirements of the Sanitary Collection System Master Plan Update were to:

- Identify trunks that need to be upgraded or installed to service each sub-area,

- Define an upgrading strategy and schedule for the trunk main. The previous Master Plan identifies hydraulic capacity issues in this line and indicates that it will eventually need to be replaced or upgraded,

- Define an upgrade plan for the Bethany trunk, including a CCTV inspection to determine its structural condition, and search for indications of inflow/infiltration, and modelling to determine its wet-weather flow capacity for present and future developments,

- Confirm the capacity of the 43 Avenue sanitary trunk. The design assumed that weeping tiles in future development areas would not be drained to the sanitary sewers. Although weeping tiles connections have not been permitted since 1994, the City estimates that only 50% compliance has been achieved. This could affect the design flows and the capacity available in this line for future development. A third pipe (foundation drain collector) has been used for sump pump discharges since 2003,

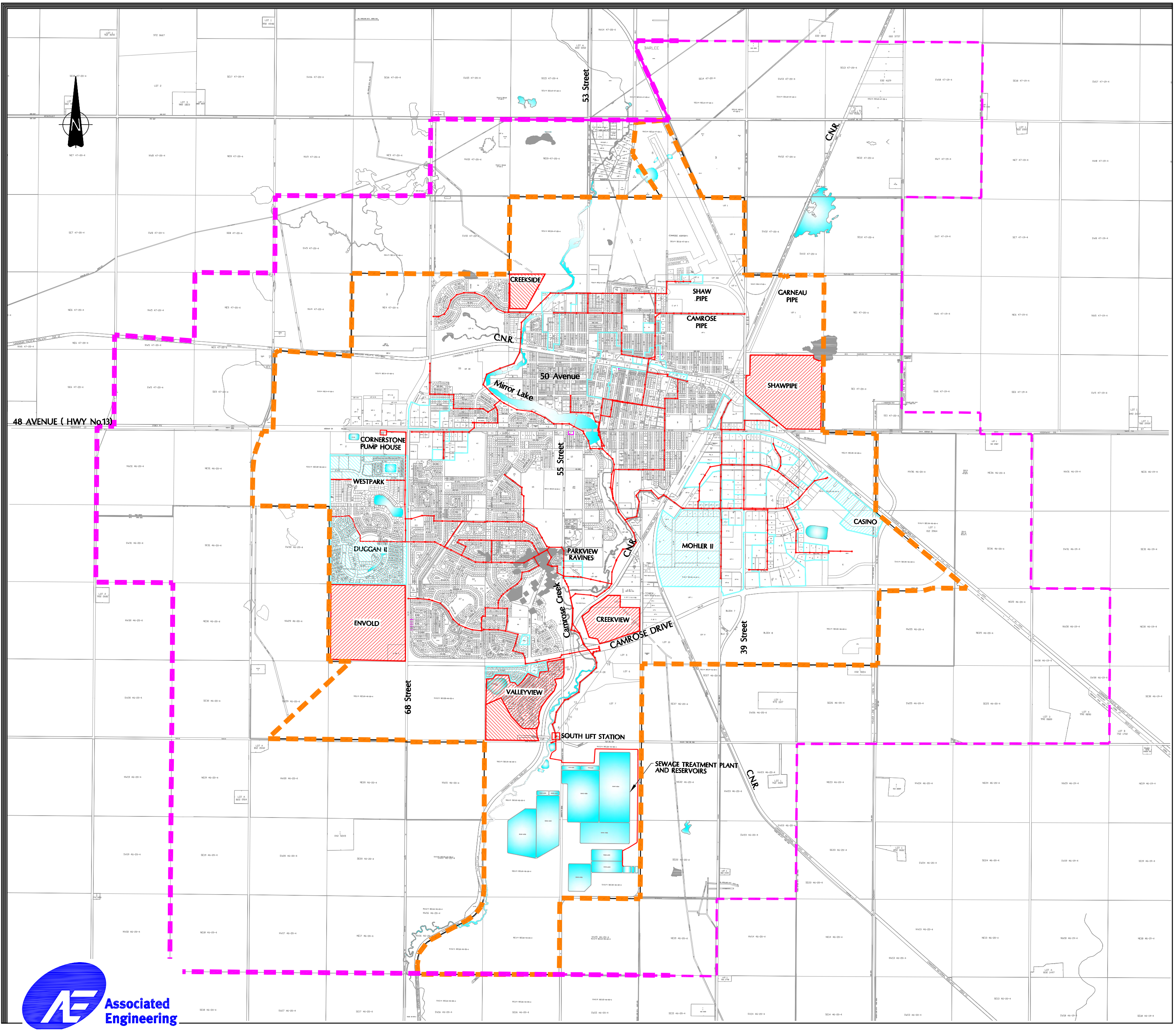
- Define system deficiencies and upgrading strategies for the existing system and to service future development areas.

Two Technical Memoranda (TM's) were submitted as working documents during the course of the study to document the analysis and to provide interim results. TM1 described the model development and calibration in some detail. TM2 described the simulation of the design storms for existing development conditions. The present report contains a summary of the analysis and the principal findings of the two updated TM's.

## 1.4 STUDY DATA

Principal system data used in the study included the following:

- Updated GIS information (pipe sizes, elevations, ground elevations),
- As-built record plans or design drawings for recent development areas,
- Updated cadastral plans, contour maps, and air photos,
- Present and proposed land use plans,
- DEM ground elevation data from AltaLis to prepare ground elevation contours for areas not mapped by the city,
- Sewer system monitor data collected by Associated Engineering on behalf of the City of Camrose from 1999 to 2004,
- Sewage flow data for the South Lift Station provided by the City of Camrose,
- Rainfall data from the two rain gauges operating within the City, at the Airport and in south Camrose,
- Water supply and consumption data for various sub-catchments to compare with sewage flow data.



**THE CITY OF CAMROSE**

# EXISTING SANITARY SEWER COLLECTION SYSTEM

**LEGEND:**

| | |
|---|---|
| ▬ ▬ | CITY BOUNDARY |
| ▨ | PARTIALLY DEVELOPED |
| ▨ | INTERIM DEVELOPMENT (< 5 Years) |
| — | SANITARY TRUNK SEWER |
| ▬ ▬ | PLAN AREA BOUNDARY |

0 500 1000

SCALE: 1 : 40,000

JANUARY, 2008

FIGURE 1.1

Associated Engineering

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EXpipes
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# 2 Computer Model Development and Calibration

## 2.1 MODEL DEVELOPMENT

Previously the sanitary trunks were modelled using a steady-state spreadsheet model. Subsequently, flows in the sanitary sewer system have been monitored over the past six years to collect data on system flows and to provide data for model calibration.

The model calibration required the use of a dynamic model capable of simulating both dry-weather and wet-weather flow hydrographs. Associated Engineering converted the trunk spreadsheet model to MOUSE and updated the model to include development which has occurred over the past five years. MOUSE is ideally suited to the simulation of dry-weather and wet weather flows in sanitary sewers and to the calibration of recorded storm runoff hydrographs.

Associated Engineering calibrated the model using the flow and rainfall data for selected storm events to ensure that it accurately represents the dry-weather and wet-weather flows in the pipe system.

The modelling involved the following steps:

- Convert the spreadsheet model to MOUSE,
- Confirm pipe and catchment data from the City's Geographic Information System,
- Update the model using recent record plans, allowing for partial weeping tile connection from 1994 to 2002,
- Review flow and rainfall data and select storm events for calibration,
- Calibrate the model parameters for dry-weather and wet-weather flow conditions during selected events.

The model development and calibration yielded a calibrated MOUSE model for the analysis of existing and future system capacities.

Technical memorandum No. 1 provided details of the model development and calibration. Following is a summary of the salient points.

## 2.2 FLOW MONITORING DATA BASE

On behalf of the City of Camrose, Associated Engineering conducted a flow monitoring program in Camrose from 1999 to 2004.

Rocky Mountain Instruments Inc conducted the field operations, data collection, and processing from 1999 to 2002. These activities were then taken over by SFE Global Inc in 2003 and 2004. Associated Engineering managed the program, selected the monitoring sites, and conducted the final data analysis.

Figure 2.1 shows the locations of the flow monitoring sites, superimposed on a schematic map of the City's sanitary trunk sewer system. Table 2.1 provides a summary of the flow monitoring program, manhole locations, and principal sub-catchment land use characteristics.

Flow monitors were installed at 5 locations during the summer of 1999 (Gauges 1-5 in Figure 2.1), during the development of the original Master Plan. Two gauge sites (5 and 6) were abandoned with the construction of the 43rd Avenue Interceptor in 1999 and were replaced with Gauges 6 and 7 in 2000. The flow monitoring program was then continued at five sites for five additional years, until 2004. Gauge 2 was re-located in 2001 and 2002 to find a better gauging site and was abandoned in 2004 when the trunk was relocated during the construction of the Mohler storm pond.

Gauge sites 1, 2, 4, 5 and 6 were chosen in order to measure flows from discrete land uses. Gauges 3 and 7 measure the main trunk flows. Flows are also recorded at the South Lift Station; this data represents the total sewage flow and gives another calibration point.

The City also provided hourly data on treated-water flows supplied from the water treatment plant and metered water consumption data in 2004, for all catchments, for use in the sewage flow calibration.

The City also provided rainfall data for wet-weather model calibration from two continuous-recording rain gauges, one located at the airport and one in south-central Camrose as shown on the location map in Figure 2.1.

## 2.3 MODEL CALIBRATION

### 2.3.1 Dry-Weather Flows

The model was initially calibrated for dry-weather flow conditions. The calibration process involved the following steps:

- Average daily sanitary flow generation rates were estimated for different land use classes from water consumption data and sewage flow data during periods with no rain,
- Diurnal curves that depict the variation of sewage flows during the day were developed from the monitored sewage flow data,
- Sewage flow were then simulated during periods of no rain and were compared with the recorded flows at the flow monitoring sites,
- The flow generation rates and diurnal curves were adjusted until an acceptable match was achieved between the simulated and monitored flows.

## Table 2.1

## Flow Monitoring Program Summary

| Gauge | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Pipe Diameter (mm) | Basin | Land Use |
|---|---|---|---|---|---|---|---|---|---|
| 1 | T7_121.00 | T7_121.00 | T7_121.00 | T7_120.00 | T7_120.00 | T7_120.00 | 375 | Central | Downtown commercial, residential and a small amount of industrial |
| 2 | 9_001.00 | 9_001.00 | 9_017.00 | 9_013.00<br>9_016.00 | 9_013.00 | 9_013.00 | 450 | Mohler Olstead | Industrial and highway commercial |
| 2W | - | - | - | 9_001.00 | - | - | 450 | Mohler Olstead | Industrial and Augustana College |
| 3 | T7_106.00 | T7_106.00 | T7_106.00 | T7_106.00 | T7_106.00 | T7_106.00 | 600 | Main Trunk | Mixed Land Use (Main Trunk) |
| 3a | - | - | - | - | T7_105A.00 | - | 600 | Main Trunk | Mixed Land Use |
| 3b | - | - | - | - | T7_105.00 | - | 600 | Main Trunk | Mixed Land Use |
| 4 | 7_900.03 | - | - | - | - | - | 375 | Marler | Residential |
| 5 | 8_001.39 | - | - | - | - | - | 450 | Mt. Pleasant | Residential |
| 6 | - | 8_001.25 | 8_001.25 | 8_001.25 | 8_001.25 | 8_001.25 | 750 | Marler/ Mt. Pleasant | Residential |
| 7 | - | T7_205.00 | T7_205.00 | T7_205.00 | T7_205.00 | T7_205.00 | 600 | Main Trunk | Mixed Land Use (North Camrose) |

Dry-weather flows from the pipe plants in northeast Camrose were estimated from the following:

- the three existing pipe plants in Camrose (Shaw, Camrose, and Garneau) consume a total volume of water of 125 $m^3$/day, according to recent water consumption data,
- all the flow was assumed to return to the sanitary sewer system,
- dry-weather flows from the new Shaw Pipe plant expansion were estimated on a unit area basis from the measured flows.

Figure 2.2 shows the diurnal curves that were developed for residential, commercial, and industrial areas in the City of Camrose. The commercial diurnal curves were also used for institutional complexes. The diurnal curves show the variation of flows over a typical weekend day and a typical work day.

Flow records at the South Lift Station showed an average sanitary sewer flow rate of 68 L/s in 2004, which was 23% higher than the corresponding flow rate developed from water supply data. This difference in flows was attributed to the base infiltration from Camrose Creek and inflow/infiltration during storm events. A base infiltration rate of 8 L/s, divided into seven point inflows, was added to the model.

Figure 2.3 shows the comparison of recorded and simulated dry-weather flows at the South Lift Station for a one-week period.

### 2.3.2 Wet-Weather Flows

Wet-weather flow in a sanitary sewer system consists of the normal sanitary flow generated by household and commercial/industrial activities (the dry-weather flow) plus inflow and infiltration (I/I) generated by storm rainfall. I/I enters the sewer system from house weeping tiles, which were connected to the sanitary sewers prior to 1999, and through vent holes in manholes, through pipe joints, and from other miscellaneous sources.

Wet-weather flows are simulated with the I/I component of the MOUSE computer model software. It contains various algorithms and parameters that simulate the fast-responding components of rainfall-induced runoff into sanitary sewers (from manhole inflows), the medium-responding components (principally weeping tiles), and the slow-responding components (groundwater infiltration). These parameters were adjusted until the recorded and simulated flows agreed.

Table 2.2 provides a summary of the largest storm events that occurred during the monitoring period (1999 – 2004) and were used in the calibration. These storm events were relatively small, each less than a 1:2 year storm.

Figure 2.4 provides a comparison of the simulated and recorded flows at the South Lift Station for the 2004 summer season, the last year for which monitor flows were available. The results show a good overall agreement.

## Table 2.2
## Calibration Storm Events

| | Airport Gauge | | | 39 Ave Gauge | | |
|---|---|---|---|---|---|---|
| Date | Depth of Rainfall (mm) | Duration (hrs) | Return Period (years) | Depth of Rainfall (mm) | Duration (hrs) | Return Period (years) |
| **July 14, 1999*** | 40.4 | 26 | <1:2 | - | - | - |
| **August 16, 1999*** | 23.6 | 16 | <1:2 | - | - | - |
| **September 2-3, 2000** | 49 | 42 | <1:2 | 38.4 | 39 | <1:2 |
| **July 29, 2001** | 42.2 | 22.5 | <1:2 | 33.8 | 22.5 | <1:2 |
| **July 3, 2004** | 39.2 | 38 | <1:2 | 33.6 | 32 | <1:2 |
| **July 8, 2004** | 33.2 | 42 | <1:2 | 18.4 | 19 | <1:2 |
| **August 4, 2004** | 18 | 5.5 | <1:2 | 28.5 | 7 | 1:2 |
| **June 26, 1998** | 30 | 5 | 1:2 | 90** | 5 | >1:100 |
| **July 11, 1998** | 48 | 19 | 1:2 | 100** | 19 | 1:35 |

*Only Airport Rainfall is available for 1999.

**Estimated

The 1998 flood event was also used for model calibration. Over 75 homes were flooded by backup of the sanitary sewer system on June 26 and July 11. To simulate these conditions, a special version of the model was created which represented the development conditions that existed in 1998, and this model was then used to simulate the July 1998 storm events.

The bottom two rows in Table 2.2 provide the summary statistics for the two storms. As noted in this table the June 26, 1998 storm had a return period in excess of 1:100 years, and the July 11, 1998 storm had a return period of 1:35 years. Flow data was not available for these two events, but flood reports were compared with model results to provide a qualitative check on the model's ability to simulate extreme flood conditions.

Figure 2.5 shows the simulated peak surcharge levels in the 1998 storm, with the manholes colour-coded to represent the depth of surcharge below ground surface. The red dots represent manholes where the simulated surcharge levels reached ground surface and the blue dots show those manholes where the surcharge levels were within basement elevation (typically 1.5 m below street level). The model results show that basement flooding would occur in the southwest residential area where flooding actually occurred in 1998.

Figure 2.5 also shows that the trunk sewers surcharged to grade along the creek valley, where the trunk sewer is very shallow, and in the Mohler Industrial area on the east side of the City. However, as there are no basements in these areas, no flooding was reported to have occurred.

The model results appear to give a reasonable simulation of flood conditions.

After the 1998 flood, the City constructed the 43rd Avenue Interceptor to provide flood relief in the area. Figure 2.6 shows the resulting surcharge levels in the 1:100 year storm. These surcharge levels were simulated with the model of present development conditions with the interceptor in place. It confirms that the 43 Avenue Interceptor has significantly reduced the flood risk in the area. There is still some surcharge and some potential for flooding at one node, which could be reduced with minor upgrades as will be discussed later.

### 2.3.3 Recent Storm Events

Three large storm events occurred in May and June, 2007, during the final production of this report, which provided further validation of the computer model.

In the first event, between 50 and 80 mm of rain fell in Camrose over the two-day period May 3-4, 2007. This event was unusual in that it involved a large amount of rainfall so soon after snow melt. According to Environment Canada data, more rain fell over the two-day period than normally occurs in the entire month of May. Saturated soil conditions and frozen ground contributed to higher runoff than would have otherwise occurred (high frost levels were observed within some manholes, to within about 0.3 m of the ground surface at one location).

This event surcharged portions of the sanitary trunk sewers and overloaded the South Lift Station, filling Anaerobic Cell A which provides storage of wet-weather flows, and causing a small spill to Camrose Creek. All three pumps at the South Lift Station were operated at full capacity, about 300-315 L/s, for about 20 hours. City crews observed surcharging at several locations in the main trunk along Camrose Creek.

Subsequently, on May 8, 2007, after the storm had passed, Associated Engineering, assisted by field staff from SFE Global, conducted a site inspection to collect information from Public Works staff and to inspect key manholes for signs of water levels that had occurred during the storm. Principal findings are shown in the trunk sewer profiles in Figure 2.7 (main trunk sewer in the Camrose Creek valley), Figure 2.8 (the Marler/Mount Pleasant area), and Figure 2.9 (Mohler Industrial area), which confirm that the trunk sewers had surcharged during the storm event. Observed water levels were similar to those simulated in the 1:100 year storm in Section 4 of this report.

In the second storm event, on June 5, 2007, about 40-45 mm of rain fell over a six-hour period (approximately a 1:5 year event), which again overloaded the South Lift Station and caused an overflow to the storage cell for a short period of time. There were no reports of basement flooding in this event, nor surcharging of the sanitary trunks other than at the South Lift Station. These conditions were similar to those indicated by the model for the 1:5 year design storm.

In the third event, on June 25, 2007, another 47 mm of rain and hail were reported in south Camrose, following 50 mm of rainfall on June 22-23, 2007. Large flows occurred on the streets. Water levels and flows in the sanitary sewers were even higher than in the May storm:

- The South Lift Station was overloaded and consequently overflowed to Anaerobic Cell A which filled to capacity and then spilled to Camrose Creek.
- The main trunk in Camrose Creek surcharged to grade, causing three houses to flood on 53 Street at 55 Avenue, and overflowing from at least two manholes in the valley.
- The Enevold trunk was surcharged to higher levels than were indicated by the model in the 1:100 year storm. This suggests that inflows to the sanitary sewer system may be higher than expected in this portion of the system, possibly due to connection of weeping tiles in this area.

Previously, the pump station had operated at capacity for short periods of time in several other storm events in 2005 and 2006, but there was no overflow to storage or to the creek.

These findings confirm that:

- The trunk sewers are surcharged in some locations in a severe storm as indicated by the computer model,

- The model provides a reasonable depiction of flow conditions in the trunk sewers and a suitable basis for planning upgrades and expansion, since peak water levels were similar to those indicated by the computer model,
- The recent upgrades that the City has completed have helped to prevent basement backup. As of May 8/07 about 50 residents had reported water in their basements due to seepage, which indicates that weeping tiles were overloaded, but there were no reports of basement flooding due to sewer back up.
- The South Lift Station is operating at capacity in a major storm event and will need to be upgraded in the near future.
- The rapid response of sewer flows to storm rainfall indicates that there is a fairly large source of direct inflow, which could be reduced through sealing of manhole vent holes.
- Sewer flows may be higher than expected in the Century Meadows area.

At one manhole, T_221.00 at the north end of the creek trunk, visible inflows were observed from the creek, into the bottom of the manhole. Several manholes were observed with their rims at the creek floodplain elevation where they could become submerged during high creek flows. These manholes should be flood-proofed to reduce the extraneous inflow of stormwater.

## 2.4 SUMMARY COMMENTS

In practice, a perfect agreement between simulated and recorded flows in real storm events is rarely possible, and the present instance is no exception, due to the spatial variability of rainfall and the lack of a major storm event during the monitoring period. The calibration results confirm that the model reasonably simulates the flows and surcharge levels in the pipe system, and could be used for the analysis of system capacity. The recent storm events suggest that inflows may be under-estimated in the Century Meadows area.

The calibrated computer model was used to evaluate system capacity for design storm conditions in Section 4 of this report and to evaluate the future sewer system requirements in Section 6.

Standard - 2005Model-1998.PRF

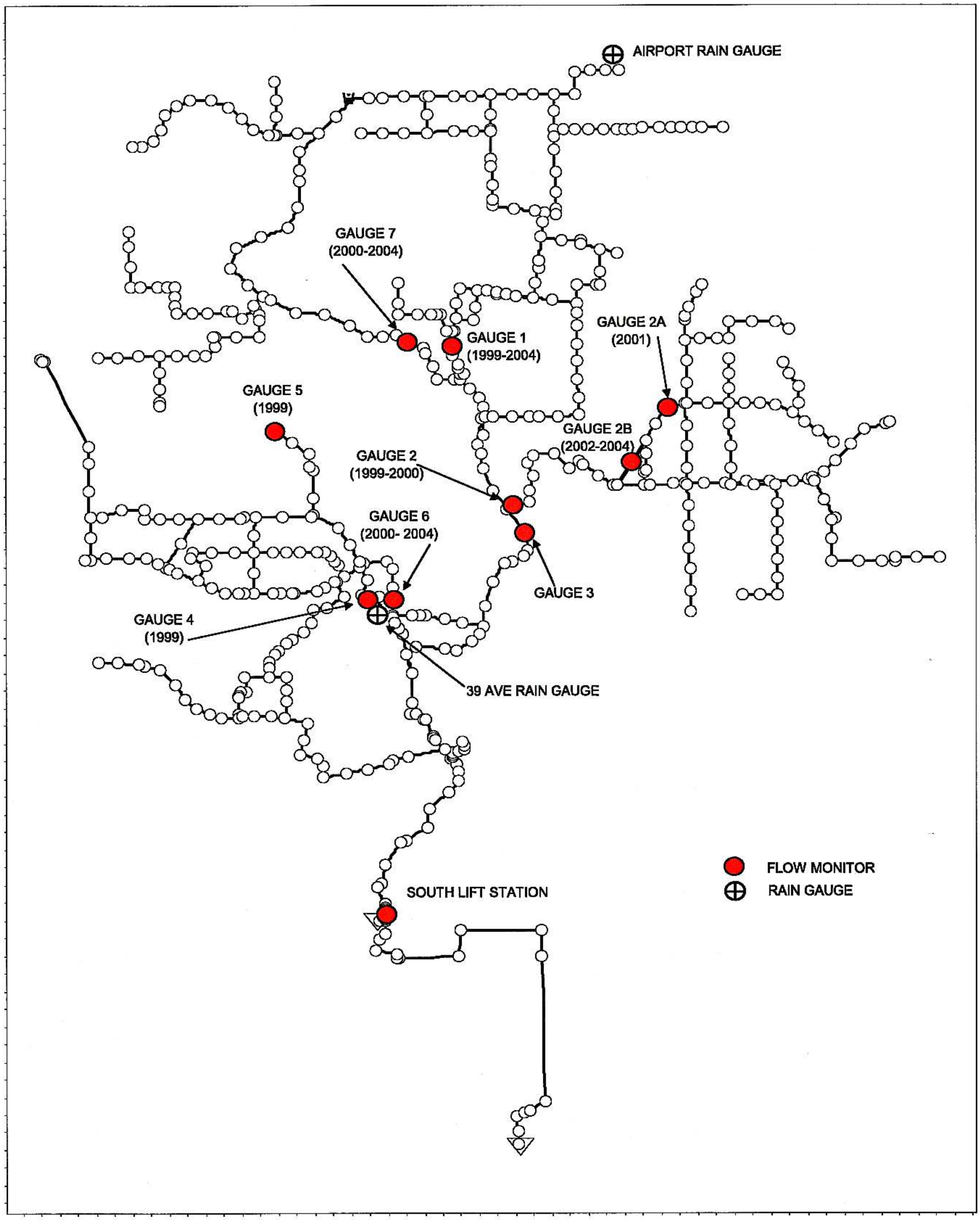


FIGURE 2.1
MONITOR LOCATIONS

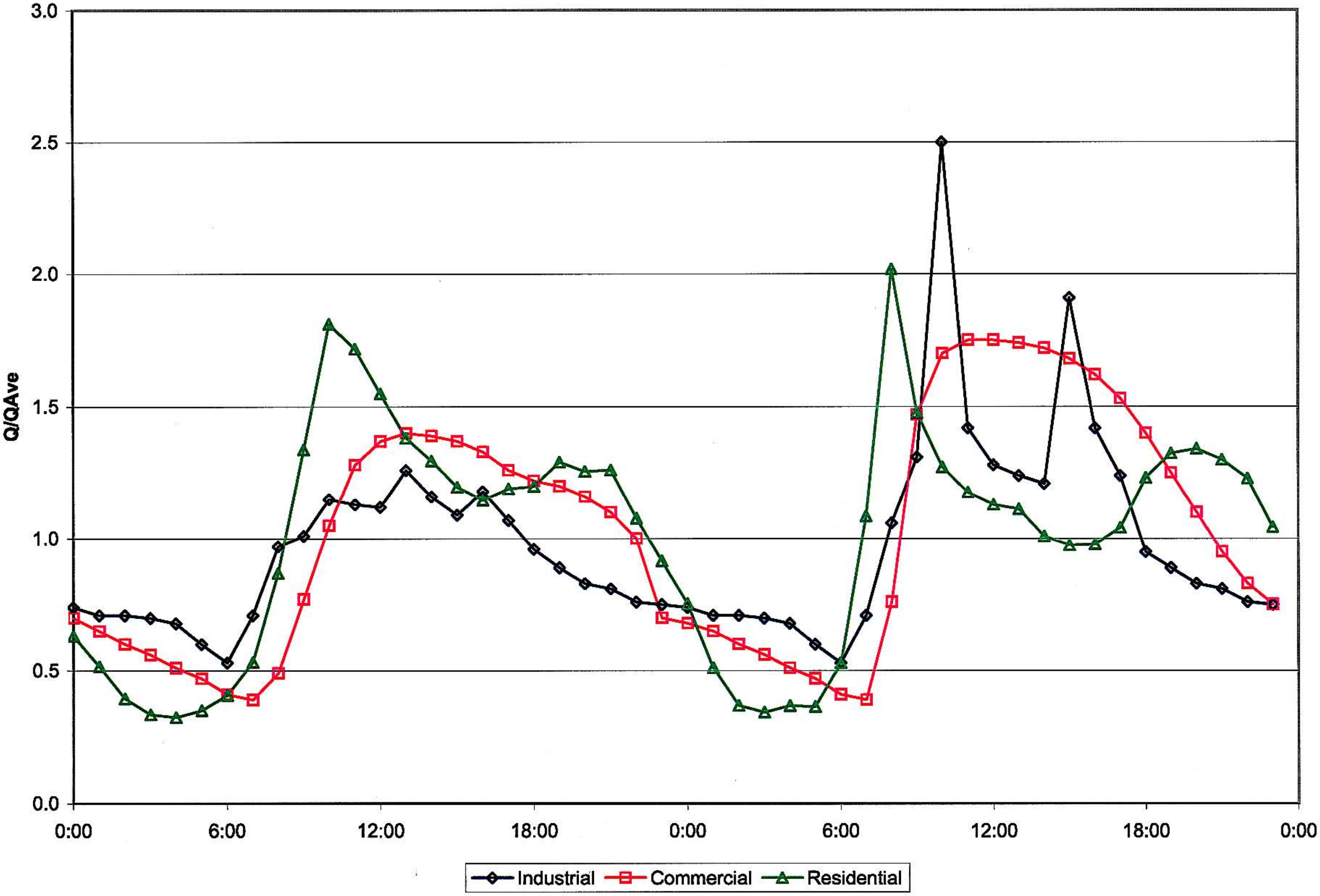


FIGURE 2.2
DIMENSIONLESS DIURNAL CURVES FOR DRY- WEATHER FLOW

## Average Dry Weather Wastewater Treatment Plant Flows

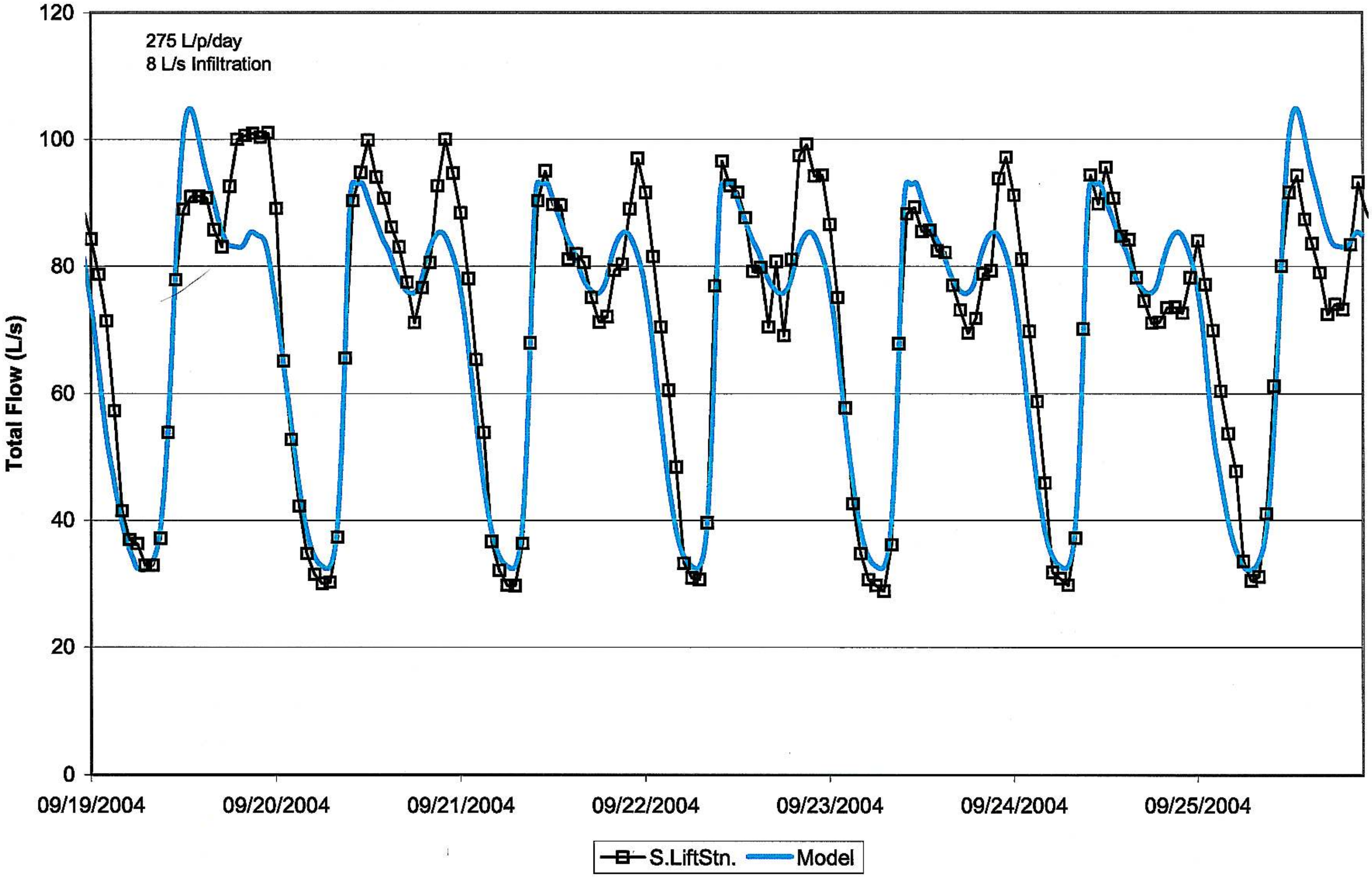


FIGURE 2.3:
DRY- WEATHER VERIFICATION - SOUTH LIFT STATION

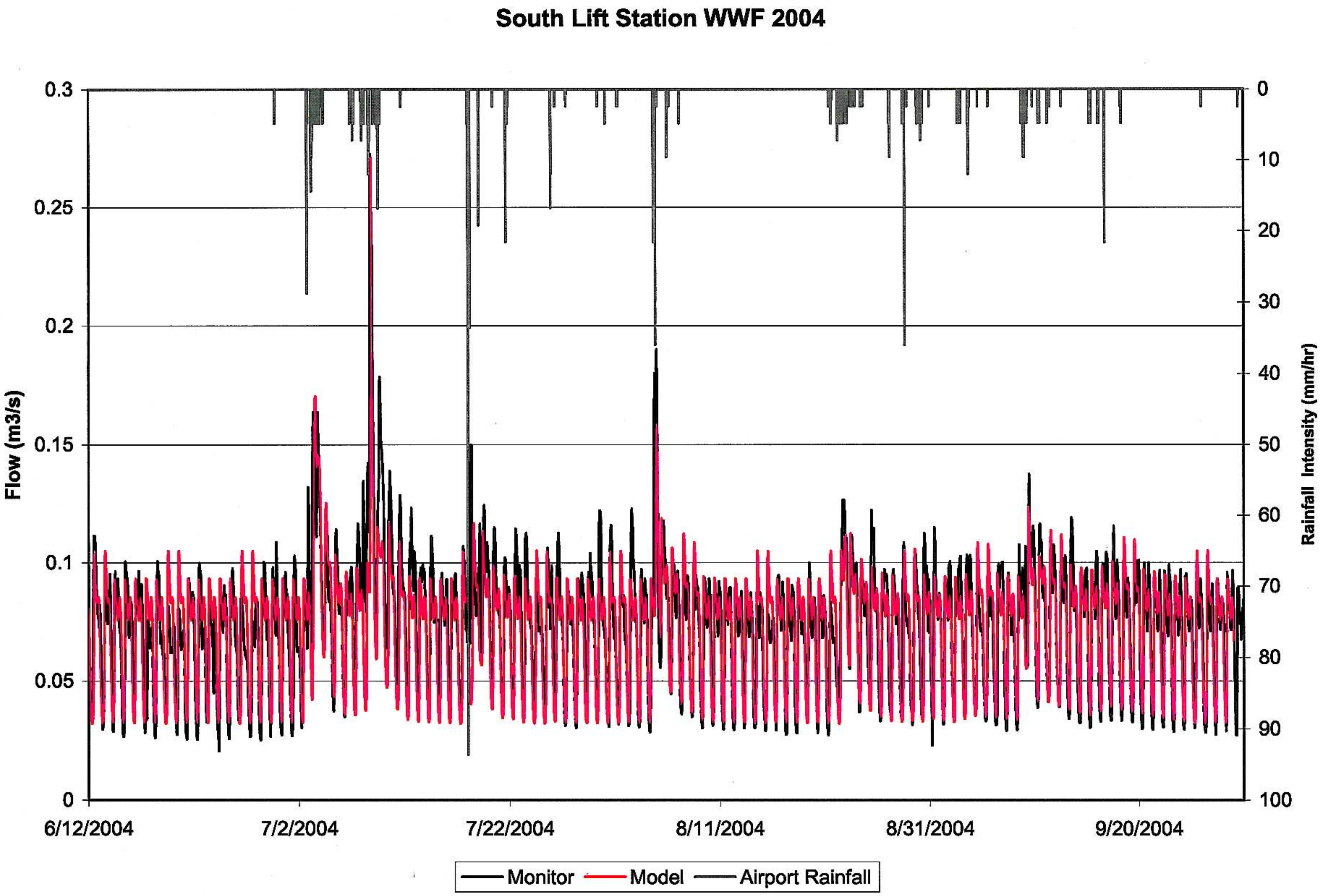
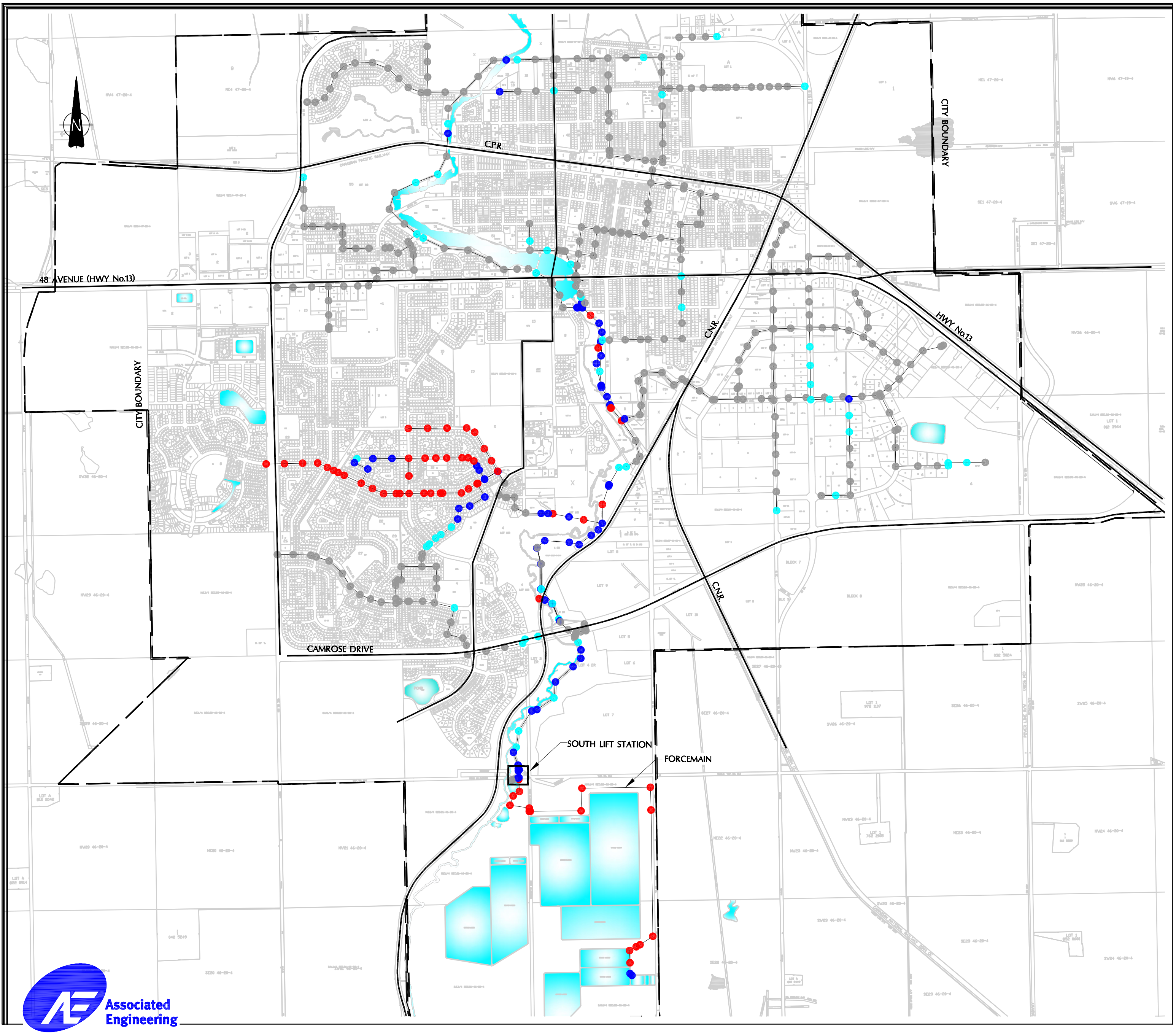


FIGURE 2.4
SIMULATED AND RECORDED FLOWS AT THE SOUTH LIFT STATION IN 2004

Time: 2:10pm
Date: Jan 15, 2008
File: Q:\053804\Report\Final Report\3804-fg_2.5.DWG by BW
Xrefs: 1998
3804-RT-01_TITLE
road-outline
3804-RP01_BASE_2005_nad27



Associated Engineering

**THE CITY OF**
**CAMROSE**

## SIMULATED SURCHARGE LEVELS FOR THE 1998 STORM WITH 1998 CONDITIONS

LEGEND:

DEPTH BELOW GROUND SURFACE

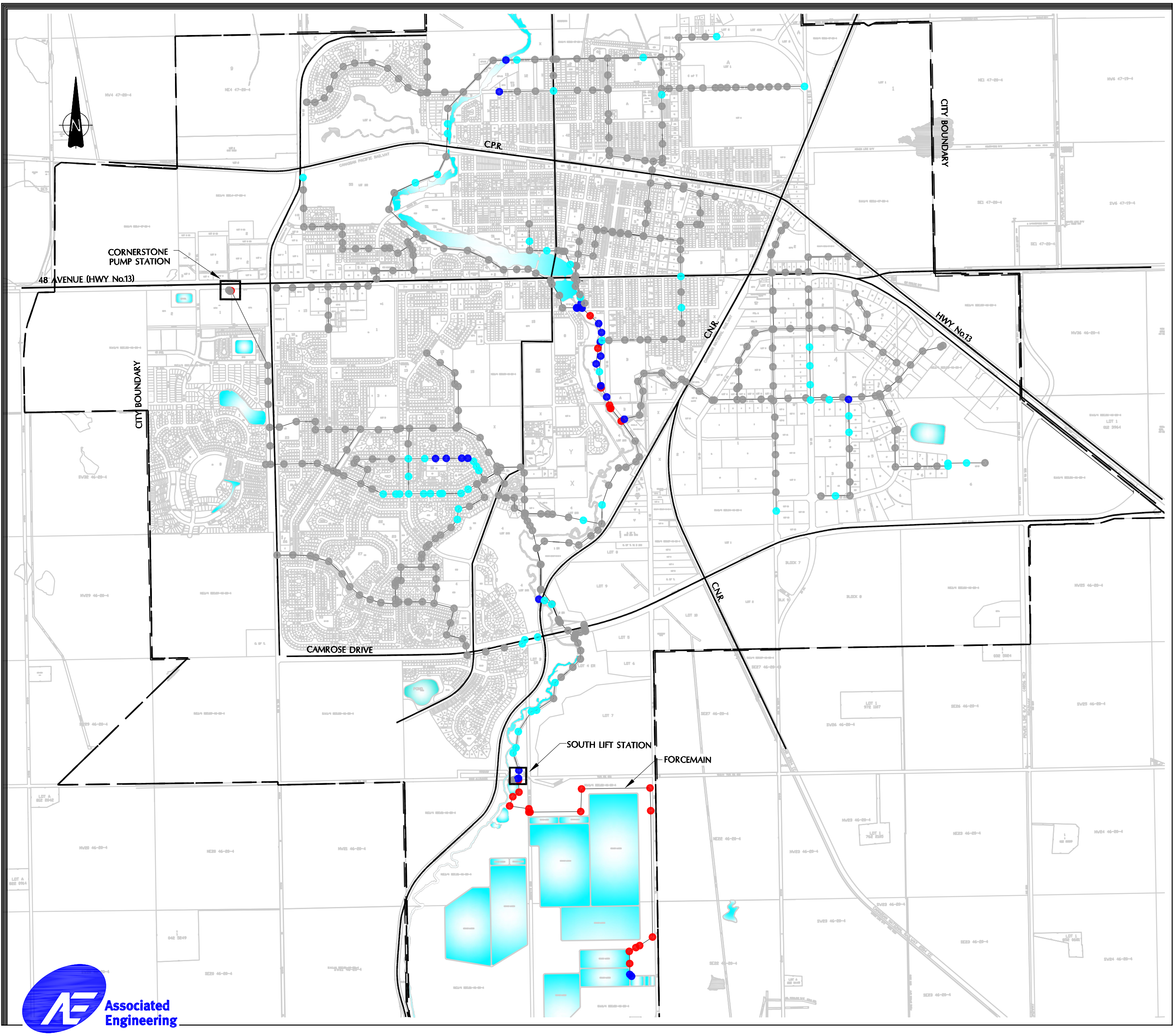
| | |
|---|---|
| ● | 0.00 < |
| ● | -1.50 to 0.00 |
| ● | -2.50 to -1.50 |
| ● | < -2.50 |
| ☐ | LIFT STATION |

0 500 1000

SCALE: 1 : 25,000

JANUARY, 2008

FIGURE 2.5



**THE CITY OF**
**CAMROSE**

## SIMULATED SURCHARGE LEVELS FOR THE 1998 STORM WITH EXISTING CONDITIONS

LEGEND:

DEPTH BELOW GROUND SURFACE

🟥 0.00 <
🟦 -1.50 to 0.00
● -2.50 to -1.50
● < -2.50
☐ LIFT STATION

0 500 1000

SCALE: 1 : 25,000

JANUARY, 2008

FIGURE 2.6

**Associated Engineering**

Time: 2:11pm
Date: Jan 15, 2008
File: Q:\053804\Report\Final Report\3804-fg_2.6.DWG by BW
Xrefs: 3804-RT-01_TITLE
road-outline
3804-RP01_BASE_2005_nad27
2005

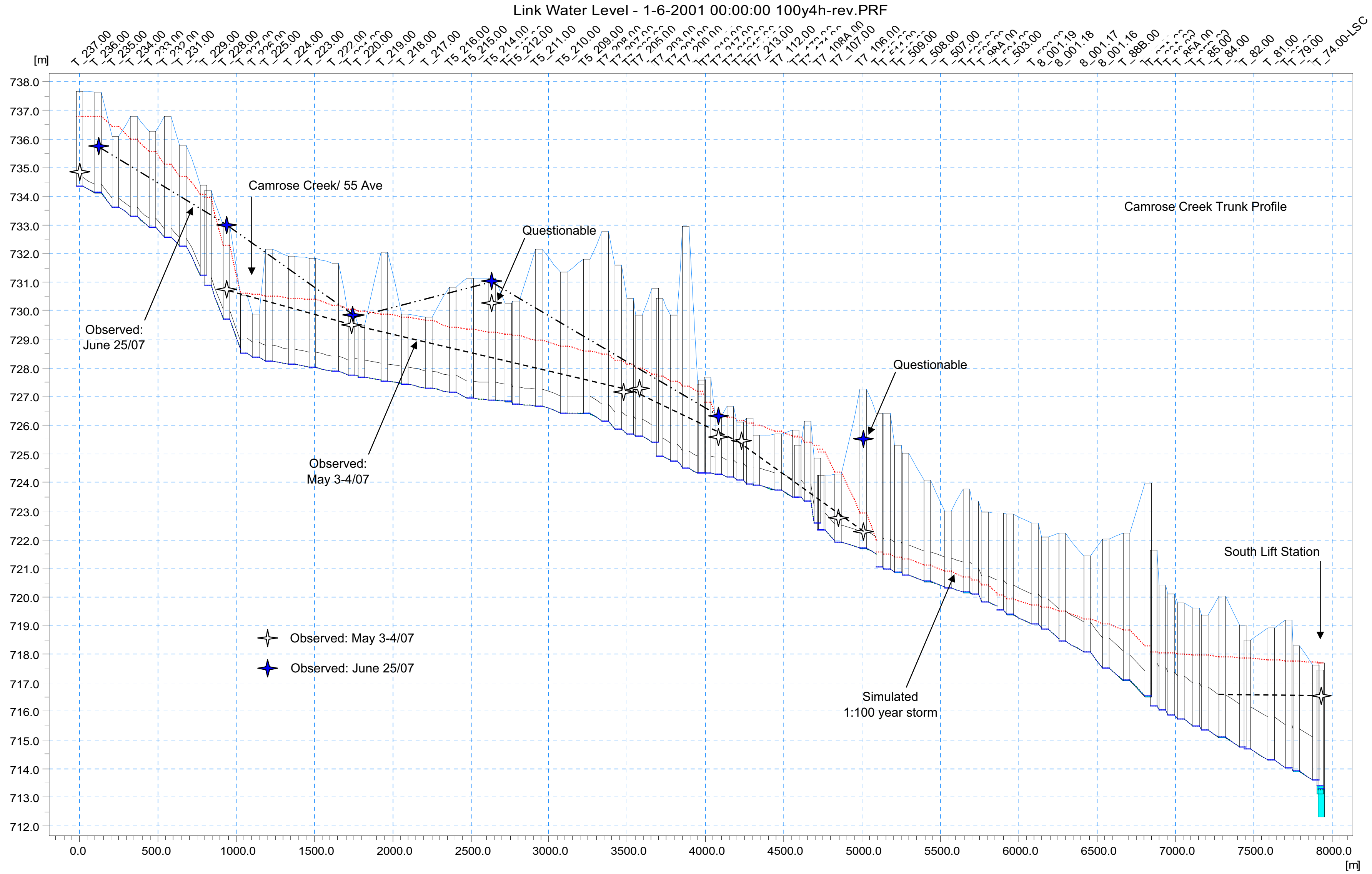


FIGURE 2.7
MAIN TRUNK PROFILE

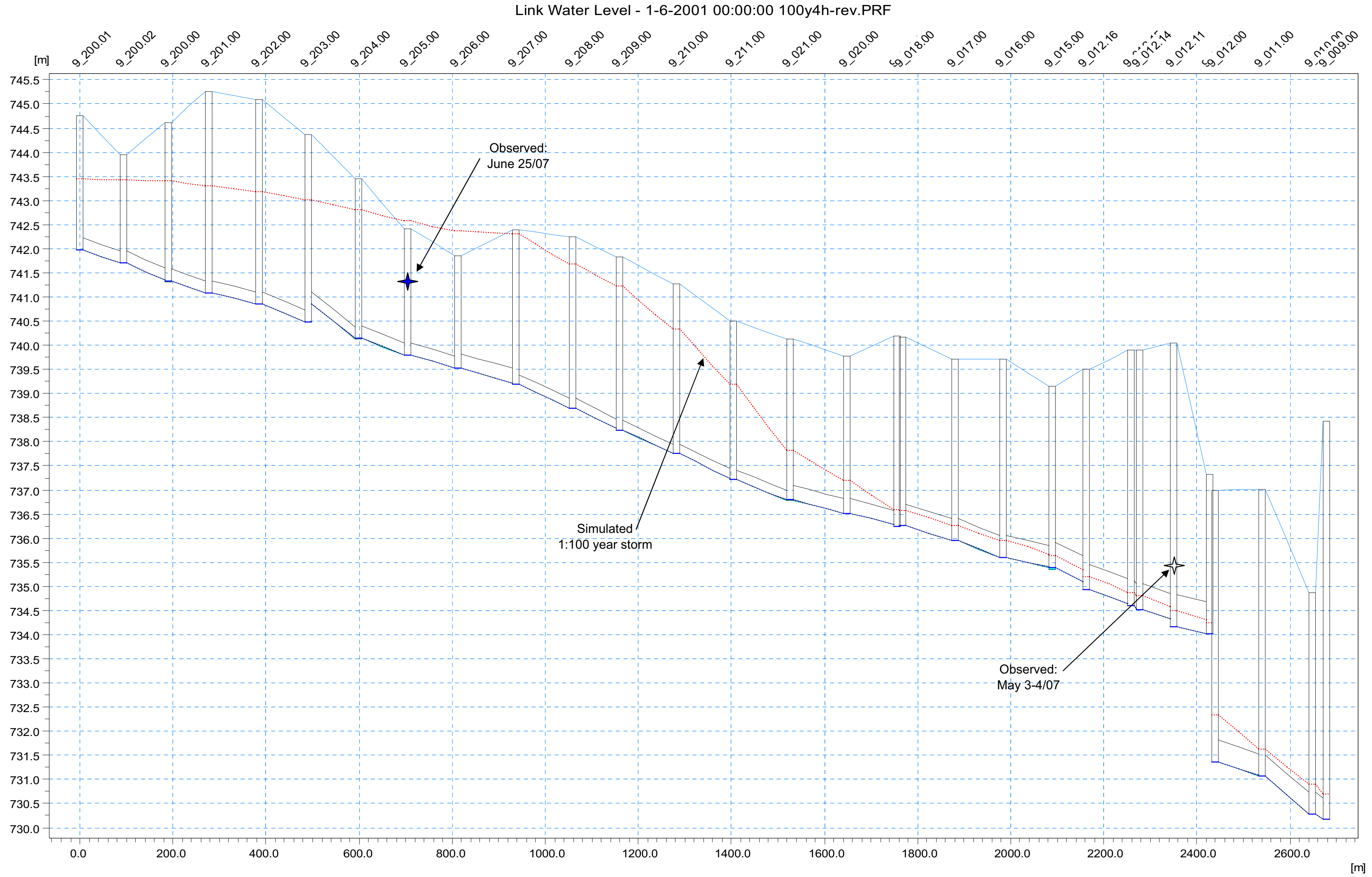


FIGURE 2.7
MAIN TRUNK PROFILE

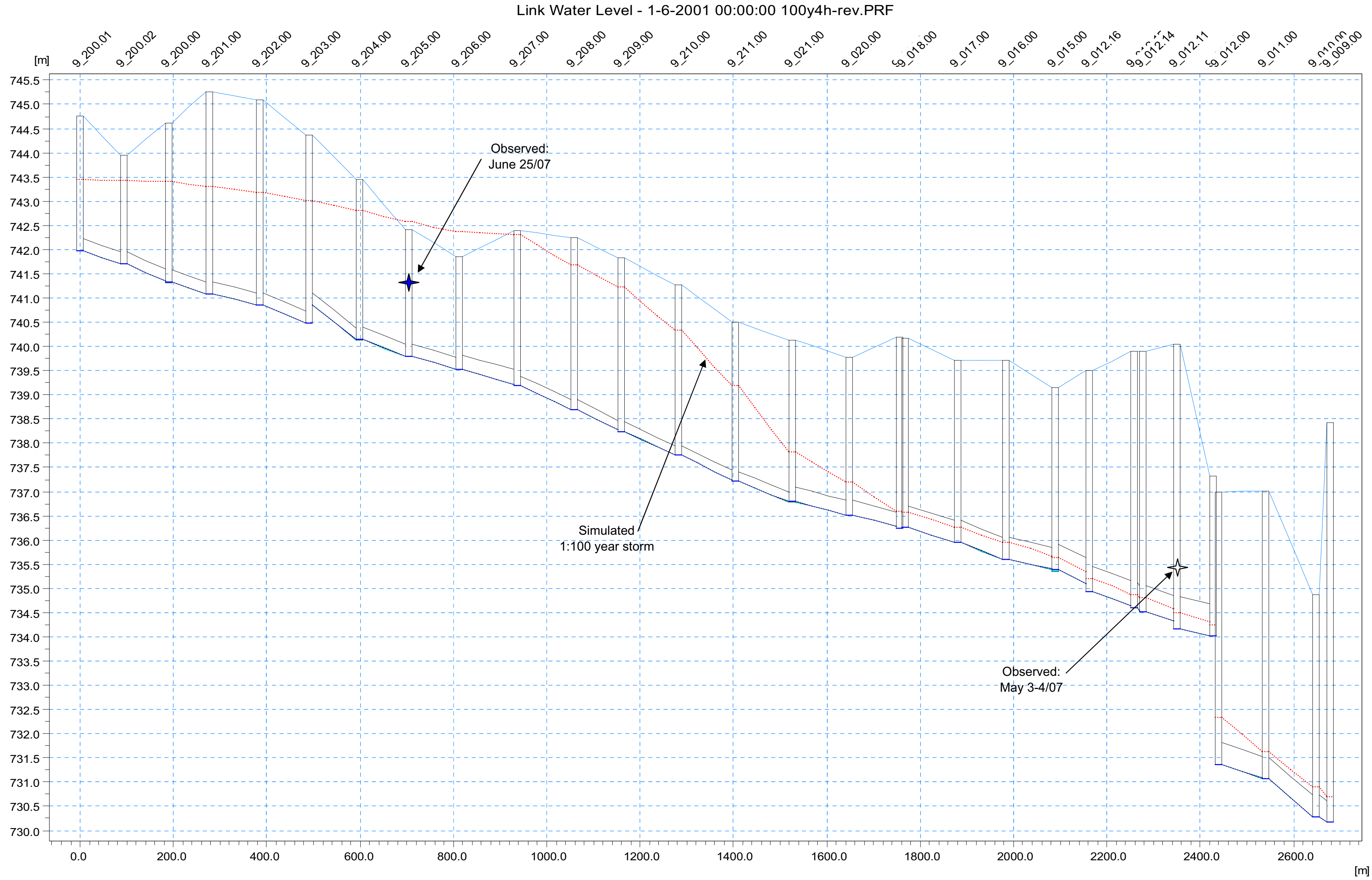


FIGURE 2.8
MOHLER TRUNK PROFILE

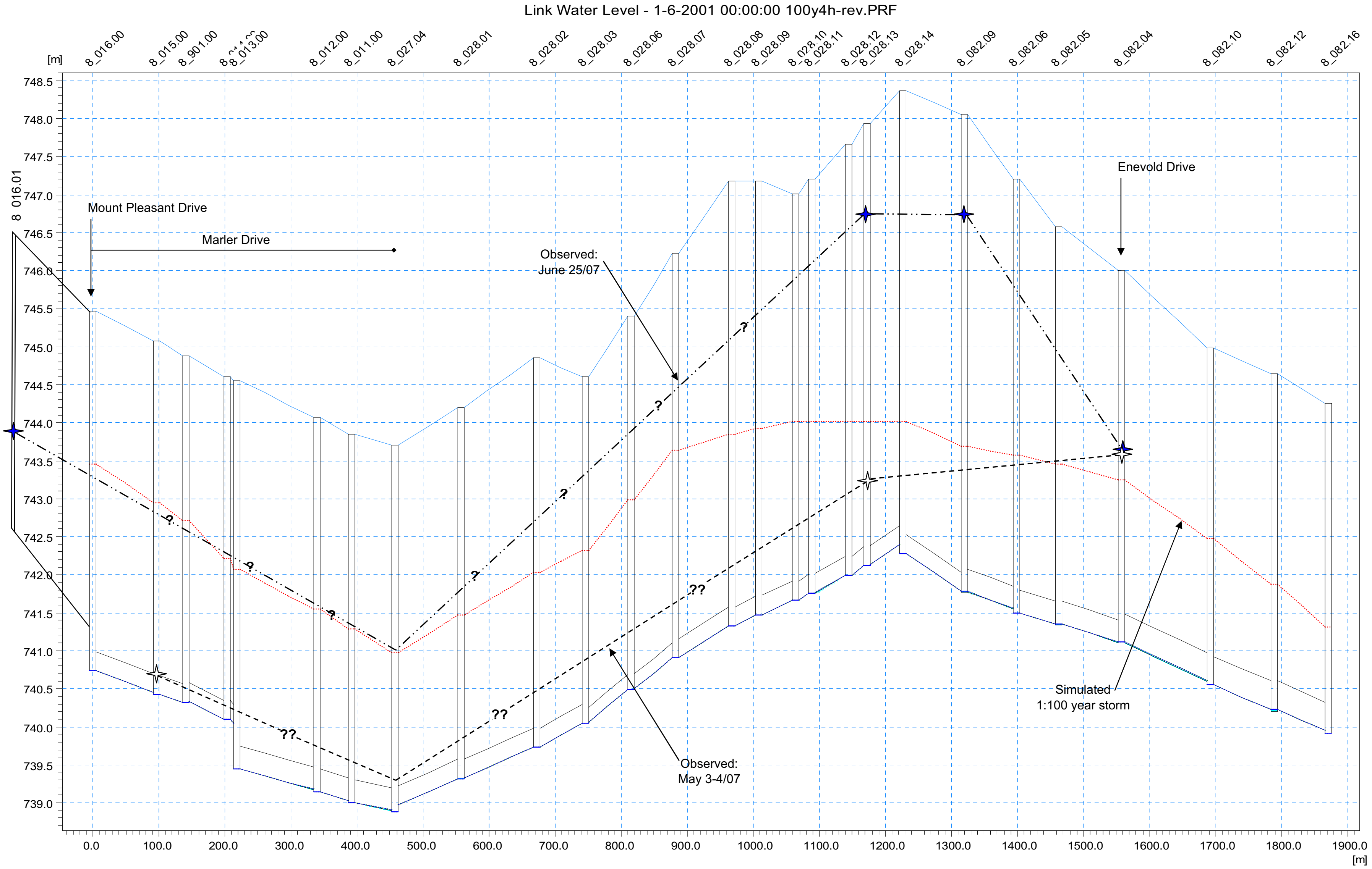


FIGURE 2.9
MARLER/CENTURY MEADOWS PROFILE

# 3 Design Criteria

## 3.1 EXISTING DEVELOPMENT CONDITIONS

Design parameters for the existing development areas were developed from the model calibration results that are documented in the previous section.

Table 3.1 provides a summary of the calibrated dry-weather flow generation values for different land uses and compares them with the design values used in the 2000 Master Plan, the standard values for the Cities of Camrose and Edmonton, and with water consumption data. The adopted values are shown in the right-most column; these values are slightly higher than were calibrated, to allow for the possibility of higher peak flows than were measured.

The calibration indicated an average dry-weather flow generation rate of 275 Litres per person per day (L/p/day) for residential areas, which suggests that the City's design standard of 350 L/p/day may be overly conservative.

Table 3.2 provides data on the site-specific flow generation values for the larger individual water users. These values were provided by the City based on actual meter data, except where noted.

The diurnal variation of dry-weather flows was modelled after the diurnal curves in Figure 2.2. Peaking factors (ratio of peak to average daily dry-weather flow), for simulation of trunk flows, vary with land use as shown in Table 3.3. These values are somewhat lower than would be computed with the Harmon Equation, which has traditionally been used for sanitary sewer design (the Harmon Equation is known to be conservative for dry-weather flow and does not represent wet-weather flow particularly well).

Table 3.4 provides a summary of the model parameters that were adopted for wet-weather flows in the existing development areas. Note that the RDI (Rainfall-Dependent Inflow/Infiltration) parameter, which represents the percentage of rainfall that enters the sanitary sewers in a storm event, varies from 1% in the Heavy Industrial land use area (pipe plants) in the Northeast, to 10% in the Marler/Mount Pleasant residential area, where foundation drains (weeping tiles) are connected to the sanitary sewer system.

## Table 3.1
## Design Dry-Weather Flow Generation Rates for Existing Development

| Land Use | Units | 2000 Master Plan | Camrose Standards | Edmonton Standards | Water Consumption Data | Calibrated Existing | Proposed for Design |
|---|---|---|---|---|---|---|---|
| **Residential** | L/person/day | 320 | 350 | 300 | 212 to 360 | 275 | 300 |
| **Light Industrial** | L/s/ha | 0.20 | 0.23 | 0.66 | 0.011 | 0.011 | 0.2 |
| **Medium Industrial** | L/s/ha | 0.20 | 0.23 | 0.56 | 0.010 | 0.010 | 0.2 |
| **Heavy Industrial** | L/s/ha | 0.20 | 0.23 | 0.50 | 0.005 | 0.005 | 0.2 |
| **Central Commercial** | L/s/ha | 0.25 | 0.46 | 0.74 | 0.081 | 0.243 | 0.46 |
| **Fringe Commercial** | L/s/ha | 0.25 | 0.46 | 1.00 | 0.035 | 0.108 | 0.25 |
| **Highway Commercial** | L/s/ha | 0.25 | 0.46 | 0.79 | 0.062 | 0.062 | 0.25 |
| **Institutional** | L/s/ha | | | 2.80 | Varies | Varies | |
| **Neighborhod Commercial** | L/s/ha | 0.25 | 0.46 | 0.81 | | 0.035 | 0.25 |
| **Entertainment/Recreation** | L/s/ha | | | 2.30 | (Race track) - 0 | 0.023 | |

## Table 3.2
## Site-Specific Dry-Weather Flows for Large Water Users

| Catchment Zone | Facility Name | Facility Type | Flow Generation (L/s/ha) |
|---|---|---|---|
| **8_001.39** | Camrose Composite High School | School | 0.272 |
| **8_001C.42** | Chester Ronning | School | 0.031 |
| **T7_208.00** | Our Lady Mount Pleasant | School | 0.153 |
| **8_001.28** | Bethany Meadows/Deer Meadows | Health Facility | 0.099 |
| **9_002.00** | Augustana | School | 0.070 |
| **11_040.00** | Sifton School | School | 0.065 |
| **3_120.07** | Charlie Killiam | School | 0.009 |
| **3_224.00** | Canadian Lutheran Bible Institute | School | 0.345 |
| **2_230.00** | Sparling School | School | 0.164 |
| **8_028.10** | Jack Stuart School | School | 0.0722 |
| **2_600.00** | Camrose Pipe | Industrial | 0.0095 |
| **2_570.00** | Shaw Pipe | Industrial | 0.0092 |
| **2_650.00** | Garneau Pipe | Industrial | 0.0095 |
| **4_021.04** | Golf Course | Recreation | 0.002 |
| **8_001.65** | Cornerstone | Commercial | 0.036 |
| **9_200.00** |  | Industrial | 0.053 |
| **9_200.13** | CRE | Jamboree | 3.1 L/s (Total Flow) |
| **T7_109.00** | Garner College | School | 0.033* |
| **T7_109.00** | Shepard House (Bethany) | Health Facility | 0.029 |
| **T7_109.00** | Rosehaven (Bethany) | Health Facility | 0.66* |
| **T7_109.00** | St. Mary's Hospital | Health Facility | 0.350 |
| **T7_109.00** | RoseAlta Lodge | Health Facility | 0.212 |
| **T7_109.00** | Stoney Creek Lodge | Health Facility | 0.229 |
| **T7_109.00** | Rec Complex | Recreational | 0.104 |

*Estimated

## Table 3.3
## Comparison of Peaking Factors for Various Land Uses

| Land Use | Peaking Factors | |
|---|---|---|
| | Adopted for Trunk Sewers | City of Camrose Standard |
| Residential | 2.0 | 2.0 |
| Commercial | 2.5 | 2.0 |
| Industrial | 1.75 | 2.0 |

## Table 3.4

## Model Parameters for Inflow/Infiltration in Presently Developed Areas

| **RDI Parameters** | **Description** | **Trial 8 Values (Adopted)** |
|---|---|---|
| **Main Parameters** | | |
| $U_{max}$ | Surface storage interception | **10 mm** |
| $L_{max}$ | Soil zone storage | **20 mm** |
| $CQ_{of}$ | Runoff distribution coefficient | **0.9** |
| CK | Overland flow coefficient (fast response) | **3 hours** |
| $CK_{if}$ | Interflow recession (slow response) | **100 hours** |
| $CK_{bf}$ | Base flow recession | **36 hours** |
| **Threshold Parameters** | | |
| $T_{of}$ | Threshold of overland flow | **0** |
| $T_{if}$ | Threshold of interflow | **0** |
| $T_g$ | Threshold of groundwater flow | **0** |
| **Area of City** | **Existing Development** | |
| | **Imperviousness** | **RDI** |
| Northeast Industrial | **0%** | **1%** |
| Mohler Industrial | **0%** | **3%** |
| North End | **0%** | **5%** |
| Downtown | **0%** | **2%** |
| College/ Bethany | **0%** | **5%** |
| West Residential | **0%** | **5%** |
| Golf Course | **0%** | **10%** |
| Highway Commercial | **0%** | **1%** |
| Marler/ Mt. Pleasant | **0%** | **10%** |
| South Century Meadows | **0%** | **2%** |

Weeping tiles were connected to sanitary sewers prior to 1994. Starting in 1994, sump pumps have been used for weeping tile drainage, but between 1994 and 2003, some weeping tiles were apparently connected to the sanitary sewers. Slightly higher RDI values (2%) have been used in those areas.

Table 3.5 provides a summary of the corresponding peak rainfall Inflow/Infiltration rates that were simulated in existing and future development areas, for various land uses and various storm events;

- For existing development areas, the I/I rates (in the 1:100 year 4 hour storm) vary from approximately 0.5 L/s/ha in commercial areas to 2.7 L/s/ha in residential areas that have weeping tile connections.
- Note that these I/I rates are higher than had been assumed in the 2000 Master Plan and considerably higher than the values used in areas currently being developed with better materials and techniques.
- In future development areas the I/I rates are comparable with the previous study and City Standards, and with values generally adopted in the region.

## 3.2 DESIGN STORM

The 12 hour duration storm generates peak flows that are about 30% higher than the 4-hour storm. However, the higher flow rates appeared to be overly conservative when compared with design standards and recent experience in other municipalities in the Edmonton region. Furthermore, they are based on model parameters that were calibrated to relatively small storm events, and there is considerable uncertainty whether they apply to larger storms. Therefore, the 4-hour duration storm results were adopted as the basis for the design. As will be described below, a safety factor of 20% will be provided in the design of upgrades and new pipe systems to allow for these and other sources of uncertainty.

The 1:100 year design storm is derived from the analysis of historical rainfall data from the past 80 years in the City of Edmonton. Future rainfall patterns may not necessarily be the same as historic rainfall, due to global warming and other factors that cannot be quantified at this time.

## Table 3.5

## Simulated Inflow/Infiltration Rates

| | | Computed Peak Flow Rates (L/s/ha) | | | | | | 2000 Master Plan Design Values (L/s/ha) |
|---|---|---|---|---|---|---|---|---|
| | RDI | 1:25 | July 1998 | 1:100 | | | | |
| **Existing Development:** | (%) | 4 hour | | 1 hour | 4 hour* | 12 hour | 24 hour | |
| Residential with weeping tiles | 10 | 1.63 | 3.17 | 1.06 | 2.69 | 3.48 | 3.19 | 1.88 |
| Residential w/o weeping tiles | 5 | 0.81 | 1.00 | 0.53 | 1.35 | 1.74 | 1.59 | 0.88 |
| Downtown Commercial | 2 | 0.33 | 0.40 | 0.21 | 0.54 | 0.70 | 0.64 | 0.48 |
| Mohler Industrial | 3 | 0.49 | 0.60 | 0.32 | 0.81 | 1.05 | 0.96 | 0.58 |
| Recent Residential (Since 2000) | 2 | 0.32 | 0.63 | 0.21 | 0.54 | 0.70 | 0.64 | 0.28 |
| **Future Development:** | | | | | | | | |
| Residential (without foundation drainage) | 1.5 | 0.25 | 0.30 | 0.16 | 0.41 | 0.53 | 0.48 | 0.28 |
| Commercial/ Industrial | 1 | 0.16 | 0.20 | 0.11 | 0.27 | 0.35 | 0.32 | 0.28 |

* Adopted for the Sanitary Sewer Master Plan (see Section 3.3)

## 3.3 FUTURE DEVELOPMENT AREAS

### 3.3.1 Dry-Weather Flows

The following design parameters were adopted for modelling of dry-weather flows in future development areas:

- Average population density: 40 people per gross hectare, based on an average of 15 units/ha and 2.8 people per unit

- The average daily dry-weather flow varies with land use as follows:

| | |
|---|---|
| Residential: | 300 L/person/day |
| Industrial: | 0.20 L/s/ha |
| Highway commercial: | 0.25 L/s/ha |

- Peak dry-weather flows are simulated with the diurnal curves that were provided in Figure 2.2, corresponding to the following peaking factors (ratio of peak to average daily dry-weather flow):

| | |
|---|---|
| Residential: | 2.0 |
| Commercial: | 2.5 |
| Industrial: | 1.75 |

### 3.3.2 Inflow/Infiltration Rates

Future development areas are being designed to reduce stormwater inflow/infiltration, by eliminating weeping tile connections, providing better street grading, reducing manhole inflows, and using more water-tight sewer pipes. However, limited monitoring data is actually available for areas developed according to these standards. Therefore, RDI percentages for future residential areas were estimated from calibration results for existing areas and previous experience in the Edmonton area.

The following RDI percentages are estimated for computing the wet-weather flow rates in future development areas:

| | |
|---|---|
| Residential: | 1.5% |
| Commercial/industrial: | 1.0% |
| Heavy industrial (pipe plants): | 0.5% |

The bottom portion of Table 3.5 provides a summary of the simulated I/I rates for future development areas and for various storm events using these model parameters. For the 1:100 year design storm, the simulated peak I/I rates are 0.41 L/s/ha for residential areas and 0.27 L/s/ha for commercial and industrial areas. These are significantly lower than in areas that were previously developed with weeping tiles draining to sanitary sewers.

Current design standards in the Edmonton region typically call for Inflow/Infiltration rates of 0.20 to 0.28 L/s/ha for areas without weeping tiles, regardless of land use, plus additional allowances for sag manholes where these are present. This is equivalent to a combined rate of approximately 0.4 L/s/ha as proposed above. These values are generally consistent with the proposed values for the 1:100 year 4 hour storm in Table 3.5.

The City of Camrose currently requires a third pipe, in addition to storm and sanitary sewers, to collect the discharges from sump pumps and carry them to storm sewers. Design values for inflow/infiltration would be the same as above as they assume no contribution from house weeping tiles.

The City currently allows a gravity overflow from the weeping tile drainage system to the floor drain to guard against the possibility of pump failure or power outage. This practice reduces the risk of flooding from weeping tile drainage, but it increases the risk of higher sewer flows and localized backup into house basements in a severe storm event. **Sump pumps should be equipped with a high-level alarm to warn the homeowners if their sump pumps are not operating properly and need to be repaired.**

## 3.4 PIPE SYSTEM CAPACITY

Pipe capacity is assessed according to the following criteria:

- Pipefull capacity is based on Manning's Equation with a roughness value of 0.013.
- In existing areas, sanitary sewers can be allowed to surcharge provided that the maximum hydraulic grade line is at least 2.5 m below ground level, or approximately 1.0 m below basement levels. Surcharge to ground surface may be tolerated in industrial areas, in severe storm conditions, if there are no basements.
- For new areas and design of system upgrades, include a safety factor of 20%, to ensure that the pipe is flowing part-full and to allow a factor of safety for uncertainties and unknowns.

## 3.5 COMPARISON WITH CAMROSE DEVELOPMENT STANDARDS

Table 3.6 provides an overall summary of the flow rates for future development areas that would occur with the proposed design criteria, compared with the design values that had been used previously in the 2000 Master Plan and the City of Camrose development standards. The comparison indicates that the design (pipefull) capacity ranges from 0.89 L/s/ha for future residential areas to 0.96 L/s/ha for industrial areas with the proposed standards (including a pipefull safety factor of 1.2), which are about 15-27% higher than are currently specified in the City's current design standards.

**It is recommended that the City's Development Standards for future development areas be revised to reflect the values cited in Sections 3.3 and 3.4.**

## Table 3.6

## Sanitary Trunk Sewer Design Standards

## For Future Development Areas

| | | Proposed | | | 2000 Master Plan | | | 1994 Development Standards with 1998 update | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Flow Component** | **Units** | **Residential** | **Commercial** | **Industrial** | **Residential** | **Commercial** | **Industrial** | **Residential** | **Commercial** | **Industrial** |
| Dry-Weather Flow | L/c/d | 300 | - | - | 320 | - | - | 320 | - | - |
| Population | persons/ha | 40 | - | - | 28 | - | - | 40 | - | - |
| Average Dry-Weater Flow | L/s/ha | 0.15 | 0.25 | 0.20 | 0.10 | 0.25 | 0.20 | 0.15 | 0.25 | 0.25 |
| Peak Factor | | 2.0 | 1.8 | 2.5 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 2.0 |
| Peak Dry-Weather Flow | L/s/ha | 0.30 | 0.45 | 0.50 | 0.21 | 0.50 | 0.60 | 0.30 | 0.50 | 0.50 |
| RDI | % | 1.5% | 1.0% | 1.0% | - | - | - | - | - | - |
| Stormwater Inflow/Infiltration | L/s/ha | 0.41 | 0.27 | 0.27 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| Sag Manholes | L/s/sag | included above | | | | | | 0.4 | - | - |
| Total Design Flow | L/s/ha (approx L/s/ha) | 0.71 | 0.72 | 0.77 | 0.49 | 0.78 | 0.88 | 0.70 | 0.78 | 0.78 |
| Pipefull Safety Factor | Ratio of Pipefull Capacity to Design Flow | 1.2% | 1.2% | 1.2% | - | - | - | - | - | - |
| Design Pipefull Capacity | L/s/ha | 0.89 | 0.90 | 0.96 | 0.49 | 0.78 | 0.88 | 0.70 | 0.78 | 0.78 |
| **Ratio of Proposed/Previous** | | | | | **1.8** | **1.2** | **1.1** | **1.3** | **1.2** | **1.2** |

# 4 Existing System Assessment

Associated Engineering used the (calibrated) model to assess the system capacity and to define the required upgrading for present development conditions, including those developments that are on-going and will be completed within the next 2 to 5 years.

This task involved the following steps:

- Simulate design conditions for the existing system to define system flows and hydraulic grade lines,
- Define any capacity constraints and upgrade requirements for present development conditions,
- Model the proposed upgrades to determine their design capacities and confirm their effectiveness.

The system was initially modelled for the 1:2, 1:5, 1:25, and 1:100 year design storms as well as the 1998 storm event, with development conditions that existed during the monitoring period, to help define the design standards. Results were reported in Technical Memorandum No 1 and were used to develop the design criteria in the previous section of this report. Then the model was updated to reflect the developments that are anticipated within the next 2 to 5 years, in order to assess the capacity of the existing system for present and short-term development conditions. Results were reported in Technical Memorandum No. 2. The present section includes a summary of the salient findings.

Figure 1.1, in Section 1, shows the interim development areas. These include the following:

| **Residential development areas:** | |
|---|---|
| Creekside | 9.5 ha residential development which is planned on the north side of the City adjacent to Camrose Creek |
| West Park | 42.7 ha residential area on the west side of the City, south of 48 Avenue |
| Duggan Park II | 34.5ha residential development southwest of the existing Duggan Park, which is undergoing development in stages and drains to the 43 Avenue Interceptor |
| Enevold Residential | 64.5 ha residential area, west of Camrose Drive, that is likely to be developed in the near future and is planned to be serviced through the Enevold Trunk |
| Parkview Ravines | 1.5 ha residential development that is planned for the south-central area of Camrose, draining to the 43 Avenue Interceptor |
| Creekview | 21.0 ha of residential development which is planned for the south side of the City, east of Camrose Creek |
| Valleyview | 28.8 ha of residential development in the south of the City |

| **Commercial/Industrial development areas:** | |
|---|---|
| Shaw Pipe Plant Expansion | 56.5 ha (Heavy Industrial) area currently being developed in the northeast of the City |
| Mohler II Industrial | 53.5 ha of Light Industrial east of the CNR, which is currently being developed in the Mohler Industrial basin |
| Camrose East Industrial/Commercial | currently undergoing development on the east side of the City adjacent to Highway 13, east of the Mohler Industrial area |

## 4.1 SIMULATION RESULTS (1:100 YEAR 4 HOUR STORM)

Figures 4.1 and 4.2 show the principal model results for the existing system with interim development conditions for the design storm event (1:100 year return period, 4 hours duration):

- Figure 4.1 shows the simulated flow loading, defined as the ratio of peak flow to the pipe's capacity. The blue lines show those pipes that are carrying flows between 1.0 and 2.0 times their design capacity, and the red lines show those pipes that carry flows more than 2.0 times their design capacity.

- Figure 4.2 shows the hydraulic grade line or surcharge levels. The coloured dots show the relative distance from ground surface to the peak water level in the manhole during the storm event simulation, coded as follows;

    - The red dots show those manholes where the hydraulic grade line reaches ground surface and where water would probably spill out of the manhole to the ground.

    - The dark blue dots show those manholes where basement flooding may occur (water level within 1.5 m of ground surface, the typical basement depth).

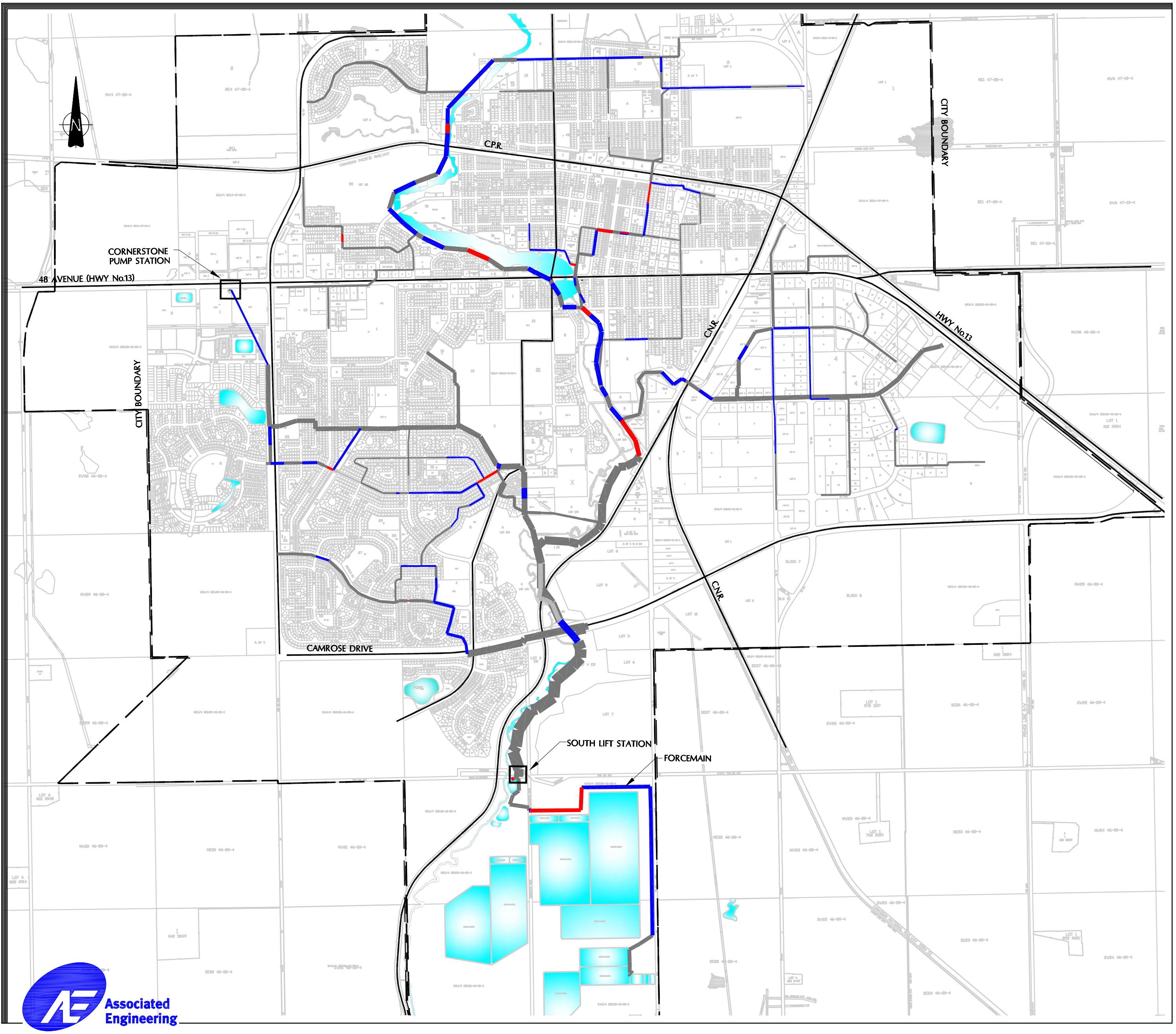
    - The lighter blue dots show those manholes where the water level is within 1.0 m below the typical basement level, or 1.5 to 2.5 m below street level.

    - The grey dots shown the manholes where the water level is more than 2.5 m below the ground, i.e. well below basement level.

## 4.2 SYSTEM CAPACITY AND CONSTRAINTS

The simulation results in Figures 4.1 and 4.2 show that system capacity would be exceeded in several areas during peak wet-weather conditions. Potential areas of concern are as follows:

- Local surcharge to basement level occurs in the north end along 55 Avenue, in the residential area west of Downtown, and in the southwest (Marler/Mount Pleasant, and Century Meadows).
- Surcharge levels reach ground surface in some potions of the main trunk along Camrose Creek and could result in spillage out of the tops of the low-lying manholes along the creek.
- Surcharge levels also reach street surface in the Mohler Industrial area.
- A short section of pipe on Marten Drive, from 57 Street to 43 Avenue, was twinned in 1984. The model results show that both the original pipe and the twin pipe are overloaded to twice their capacity, but surcharge levels are below the basement elevations.



**Associated Engineering**

Time: 2:12pm
Date: Jan 15, 2008
File: Q:\053804\Report\Final Report\3804-fg_4.1.DWG by BW
Xrefs: 3804-RT-01_TITLE
road-outline
3804-RP01_BASE_2005_nad27

**THE CITY OF**
**CAMROSE**

## SIMULATED PEAK FLOW FOR THE 1:100 YEAR 4 HOUR STORM WITH EXISTING CONDITIONS

LEGEND:

🟥 2.0 < Qp/Qcap
🟦 Qp/Qcap = 1.0-2.0
▬ Qp/Qcap < 1.0
☐ LIFT STATION

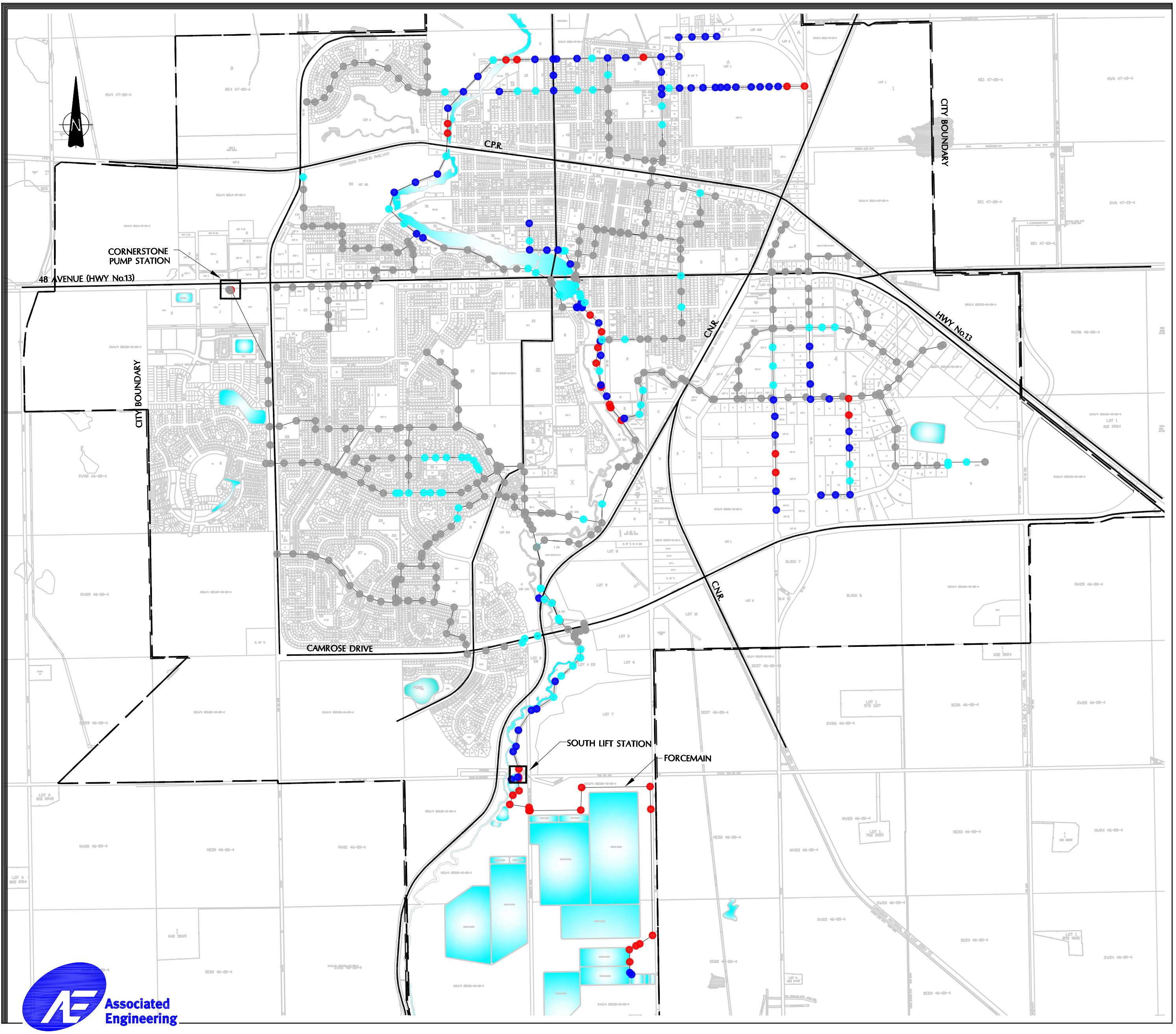
NOTE:
LINE WIDTHS ARE SCALED ACCORDING TO PIPE DIAMETER

0 500 1000

SCALE: 1 : 25,000

JANUARY, 2008

FIGURE 4.1



**THE CITY OF**
**CAMROSE**

# SIMULATED SURCHARGE LEVELS FOR THE 1:100 YEAR 4 HOUR STORM WITH EXISTING CONDITIONS

LEGEND:

DEPTH BELOW GROUND SURFACE

| | |
|---|---|
| 🔴 | 0.00 < |
| 🔵 | -1.50 to 0.00 |
| ● | -2.50 to -1.50 |
| ● | < -2.50 |
| ☐ | LIFT STATION |

0 500 1000

SCALE: 1 : 25,000

JANUARY, 2008

FIGURE 4.2

Time: 2:12pm
Date: Jan 15, 2008
File: Q:\053804\Report\Final Report\3804-fg_4.2.DWG by BW
Xrefs: 3804-RT-01_TITLE
road-outline
3804-RP01_BASE_2005_nad27
2005

# 5 Future Development Needs

Associated Engineering expanded the model to include the future development plans and drainage concepts developed in the previous Master Plan, to assess the system capacity and upgrading required to serve future development.

This task included the following steps:

- expand the model to include future development areas and trunks,
- simulate design conditions to define system flows and hydraulic grade lines,
- define any capacity constraints and upgrade requirements for interim and ultimate development,
- model the proposed upgrades to determine their design capacities and confirm their effectiveness,
- define upgrade and expansion requirements, their phasing, and cost estimates,
- define development constraints and guidelines (design flows, weeping tile drainage, upgrade requirements, development limits).

## 5.1 ASSUMED DEVELOPMENT PLAN

Figure 5.1 shows the growth pattern assumed for the sanitary master plan. It is similar to the one developed by Brown and Associates in the 2003 Growth Study Report and updated in the 2006 Growth Study Update, but includes additional areas beyond the 50-year planning horizon to ensure that the sanitary servicing plan provides for the long-term growth potential of the City.

Figure 5.1 shows that:

- Approximately 250 hectares are currently being developed or are planned for development in the short term (less than 5 years),

- Another 750 ha remain to be developed within the present City boundary over the next 5-20 years,

- Approximately 1,300 ha that lie outside the City boundary are assumed to be annexed within the next 5 to 10 years and developed within the medium term (say 10-30 years),

- 1,850 additional hectares are assumed to be developed over the longer term (30-50 year) time frame, and,

- Potential residential areas in the southwest (600 ha) may be developed beyond the 50 year time frame.

Development rates are difficult to forecast with any accuracy. The Brown and Associates study estimated that the population of Camrose will double over the next 30 years, from approximately 16,000 people in

2006 to 35,000 people in 2036, followed by an additional 23,000 people in the following 20 years. They also estimated that approximately 3,500 ha of land will be developed over that 50-year time frame (compared with 4,200 ha in the estimates above), initially at a rate of about 50 ha/yr then increasing to 100 ha/yr in later years.

The actual development will depend on various socio-economic and market forces, and therefore the time frames may vary from those assumed in Figure 5.1. The general sequence of development is more important for servicing as it will drive the provision of services into those areas. Generally the development growth is assumed to occur in concentric rings outward from the existing development areas. This will facilitate the orderly extension of services with a minimum of leap-frogging and over-sizing.

Figure 5.2 shows the assumed land use in the plan area. Generally it consists of:

- Residential development in the southwest and northwest,
- Large-lot industrial development in the northeast,
- Industrial land uses in the southeast,
- Commercial land uses in the highway corridor along Highway 13 on the east and west sides of the City.
- Multi-family residential on the north and south sides of the Highway Commercial, on the west side of the City.

The land uses shown on Figure 5.2 are the predominant land uses assumed for the plan area. The single family residential areas will likely include some multi-family sites as the City intends to incorporate a mix of single family and multi-family in future residential developments. The average density of 40 people per hectare was assumed for these neighbourhoods.

The multi-family sites on the north and south sides of the highway commercial were assumed to be predominantly multi-family, therefore, higher densities were used in these areas compared to the values used for single family areas.

## 5.2 PROPOSED EXPANSION PLAN

Associated Engineering prepared a drainage concept plan for the future development areas based on the following:

- Existing topography,
- System capacity and constraints,
- The likely sequence of development,
- The need for orderly drainage development of drainage systems from downstream to upstream in order to minimize leap-frogging and over-extension of services,
- Coordination with the storm sewer servicing plan.

A number of variations were modeled with the MOUSE model described earlier in this report, expanded to include the future development areas. The model results were used to identify system deficiencies and preliminary pipe sizes and capacities. These concepts were reviewed with the City and refined to prepare the proposed sanitary servicing concept plan.

The proposed drainage concept plan is shown conceptually in Figure 5.3. This map shows the following:

- Boundaries of the sub-catchments and the general direction of drainage,
- Connection points to the existing main trunk sewers,
- Upgrades required of existing trunk sewers to accommodate the future development.

Because the full development of the area will take place over many years, the drainage concept plan provides for staged implementation, in order to optimize the use of system capacity and minimize the front-end costs of major trunks. This involves the use of interim facilities (trunks or pump stations) that may be abandoned or re-routed in subsequent stages. In general, the intention is to minimize the trunk construction required for initial stages of development and to provide a permanent gravity connection in subsequent stages. The long term goal is divert as much flow as practical from the South Lift Station as other alternatives (large regional trunks) become available.

Appendix A provides more detailed maps for the four quadrants of the City, including ground elevation contours and an outline of the sanitary sewer drainage concept for the development areas. Details of the storm drainage and stormwater management concept are reported separately.

Appendix C provides details of the proposed pipe sizes and capacities. The tables in Appendix C show the existing capacity of the individual pipes as well as the peak flows and required capacities for ultimate development. The model results were generated for the 1:100 year 4 hour storm. Where a pipe is affected by interim and ultimate servicing arrangements, the peak flows are provided for both cases and the required capacity is defined as the greater of the two. Preliminary pipe sizes are also provided.

The drainage concept plan is conceptual in nature. Specific alignments, pipe sizes, and capacities are subject to review at the design stage, using the design criteria that may apply at that time. Other opportunities that may arise, depending on the nature and timing of the proposed development which cannot always be predicted in advance, may be considered in subsequent stages of development planning.

The following is an overview of the proposed sanitary servicing concept plan, for the four quadrants of the City.

### 5.2.1 Northwest Camrose

The Northwest quadrant of the City provides some unique challenges. The direction of drainage is generally from southwest to northeast, but existing trunks run from north to south. The existing trunks have limited capacity to serve future development areas.

**South of CPR**: The area south of the CPR drains to the Cornerstone pump station, south of Highway 13, and from there by force main and gravity trunk along 68 Street to the 43 Avenue trunk constructed in 2000. The Cornerstone pump station and forcemain were originally designed to service an area of approximately 100 ha. The proposed service area has increased substantially to about 500 ha and would overload the downstream system in wet-weather flows if all of the proposed development areas were to be drained directly.

Consequently, in-line storage of wet-weather flow is proposed in order to accommodate these areas beyond the initial 100 ha. Appendix B provides details of the in-line storage tank concept. Briefly, it involves a length of oversized pipe, 800 m long by 1800 mm in diameter that would be designed to store peak flows. A flow control device (an orifice or a short section of small-diameter pipe) at the outlet would restrict the outflows during wet-weather flows. The excess flow would then be stored in the pipe upstream during the storm peak and would be released after the storm when downstream capacity is available.

The flow control would be sized to pass peak dry-weather flows without restriction, so as to minimize the potential for deposition of solids and the use of storage during dry-weather flows. The tank would be self-cleaning by through-flows after the storm event.

Ultimately, when the required trunk mains in the southwest portion of the City are constructed, the sanitary flow would be intercepted upstream of the storage tank and would be pumped over the drainage divide to the south to trunk sewers in the southwest. This concept would reduce the flows that would have to be pumped out of the creek valley at the South Lift Station, thereby reducing the pumping costs and capacity required of that facility.

Section 6 of this report provides details of the implementation plan for the Cornerstone basin. Another 130 ha west of Westpark would drain by gravity to the Westpark and 68 Street trunk sewers.

**North of CPR:** The area north of the CPR would drain to the existing trunk main along Camrose Creek. Most of this area, or approximately 600 ha, would connect to the Camrose Creek trunk main at the future Ring Road.

The trunk main has adequate capacity for dry-weather flows but, as indicated previously, is overloaded in a major storm event at present levels of development. The City plans to upgrade the trunk main over time as the resources come available, and this upgrade will provide capacity for the long-term development of the region. In the meantime the City requires a strategy to accommodate development on the north side of the City.

Accordingly, Associated Engineering investigated the feasibility of in-line storage to service these areas on an interim basis. An in-line storage pipe would store peak flows during storm conditions and would discharge at a controlled rate to the existing trunk after the storm has ended, thus making maximum use of the available trunk capacity. This concept would enable new development to proceed while contributing development levies to the cost of the ultimate trunk replacement.

Appendix B provides details of the concept and the conceptual analysis of its feasibility. The analysis demonstrated that in-line storage of wet-weather flows could be feasible for larger development areas of the scale of a quarter-section in size (65 ha) or larger. Details will depend on local topography and development layout and will need to be confirmed by the developers prior to detailed design.

Potentially, 250 to 400 hectares could be serviced in this manner prior to the main trunk sewer being replaced. Ultimately, when the trunk sewer is replaced, the in-line storage pipes could be converted to a gravity system to permit the remaining upstream areas to be developed and drain freely through the system.

**Victoria Park West:** The quarter-section (65 ha) west of Victoria Park could be serviced through the Victoria Park trunk sewer. A short section of trunk east of 60 Street was upgraded in 2007 to provide capacity for this development. Wet-weather storage is not feasible in this development area due to the shallow sewer and flat grades.

### 5.2.2 Southwest Camrose

Land in the southwest of the City is anticipated to develop into residential land uses. It generally slopes to the southeast toward Camrose Creek. Development of this area is anticipated to extend in concentric rings outward from the existing development, starting at Camrose Creek and progressing toward the west, then to the north.

This area is generally easier to service than is the northwest and could probably be developed at a lower cost per hectare. The sanitary drainage concept for this area involves a series of ring mains generally running around the southwest of the City, following the general lie of land and the anticipated development sequence in this region.

The initial development will be serviced through the Valleyview trunk to the Camrose Creek mains and the South Lift Station. Later, as the next ring to the south is developed, a new trunk sewer system will be required to the south of the existing sewage treatment plant, as this area is too low to be drained by gravity to Valleyview. A new crossing of Camrose Creek (pipe bridge or siphon) will be required, as will a new pump station to pump the sewage flow into the sewage treatment plant, if it remains at the present location (the new mechanical plant may be located to the south of the present facility).

The plan provides for the potential future residential areas in the extreme southwest. A pump station will be required to drain three quarter sections, which are too low to be serviced by gravity connection. Another pump station will be required for a small area to the south of Valleyview.

As these ring mains are constructed, they will be provided with the capacity required for the ultimate development, including capacity to drain the pumped flows from the northwest quadrant of the City. Ultimately, most of this flow will be diverted away from the valley trunk, toward the south of the sewage treatment plant, to reduce the pumping costs and capacities required at the South Lift Station.

### 5.2.3 Northeast Camrose

Development on the northeast of the City is mostly planned to be industrial. These are anticipated to be big-lot, low water-use developments, similar to the existing pipe plants in this quadrant.

Servicing constraints in this region include the following:

| | |
|---|---|
| **Topography:** | The area is flat and poorly drained. There is a drainage divide that extends eastward from the north end of the airport. The area to the north of this divide will be difficult to service by gravity. |
| **Trunk Capacity:** | Trunk sewers along Camrose Creek and 55 Avenue are at or exceed their capacity during major storm events and will need to be upgraded or replaced prior to the servicing of this area. |

The area to the east of the airport will be drained westward along the Ring Road to the Camrose Creek trunk. A new trunk is proposed along the Ring Road to serve as much of this area as possible.

Much of the area to the northeast, north of the drainage divide, could be serviced with a pump station discharging to this trunk system. Later, as areas further north of the airport are developed, the pump station could be relocated further west on the north side of the existing Braim subdivision to drain more of the area. It would then discharge into the Creek trunk on the west side of Camrose Creek.

If the north areas were to be developed first, the interim pump station east of the airport would not be required.

### 5.2.4 Southeast Camrose

Development in this area is anticipated to be mostly industrial, with some commercial development along Highway 13 as has been the recent trend. There is a drainage divide that roughly parallels Camrose Drive and Highway 13. Land on the north of this divide drains naturally to the Mohler Industrial area. Land on the south drains mostly to the southeast into the County, and, therefore, the servicing requirements for these two areas will be somewhat different.

**East Mohler:** The eastern portion (approximately 400 ha) will be serviced through the Mohler Industrial area. The existing Mohler trunks have capacity for approximately 100 ha. Therefore, in-line storage is required for the area to the northeast of Highway 13 and the CPR tracks, west of the Camrose Drive intersection. Development areas on the north side of this service area are anticipated to be large-lot, low water users, and will generate relatively small flows.

The model analysis indicated that the Bethany trunk, west of the CNR, is overloaded in wet-weather flow conditions. Therefore a pump station is proposed to divert the flows from this trunk, southward to a new trunk along Camrose Drive. This diversion will also reduce the flow in the Camrose Creek trunk, from the Bethany trunk to Camrose Drive, by about 200 L/s at present. The diversion flow will increase to 445 L/s in the future when the tributary area is fully developed.

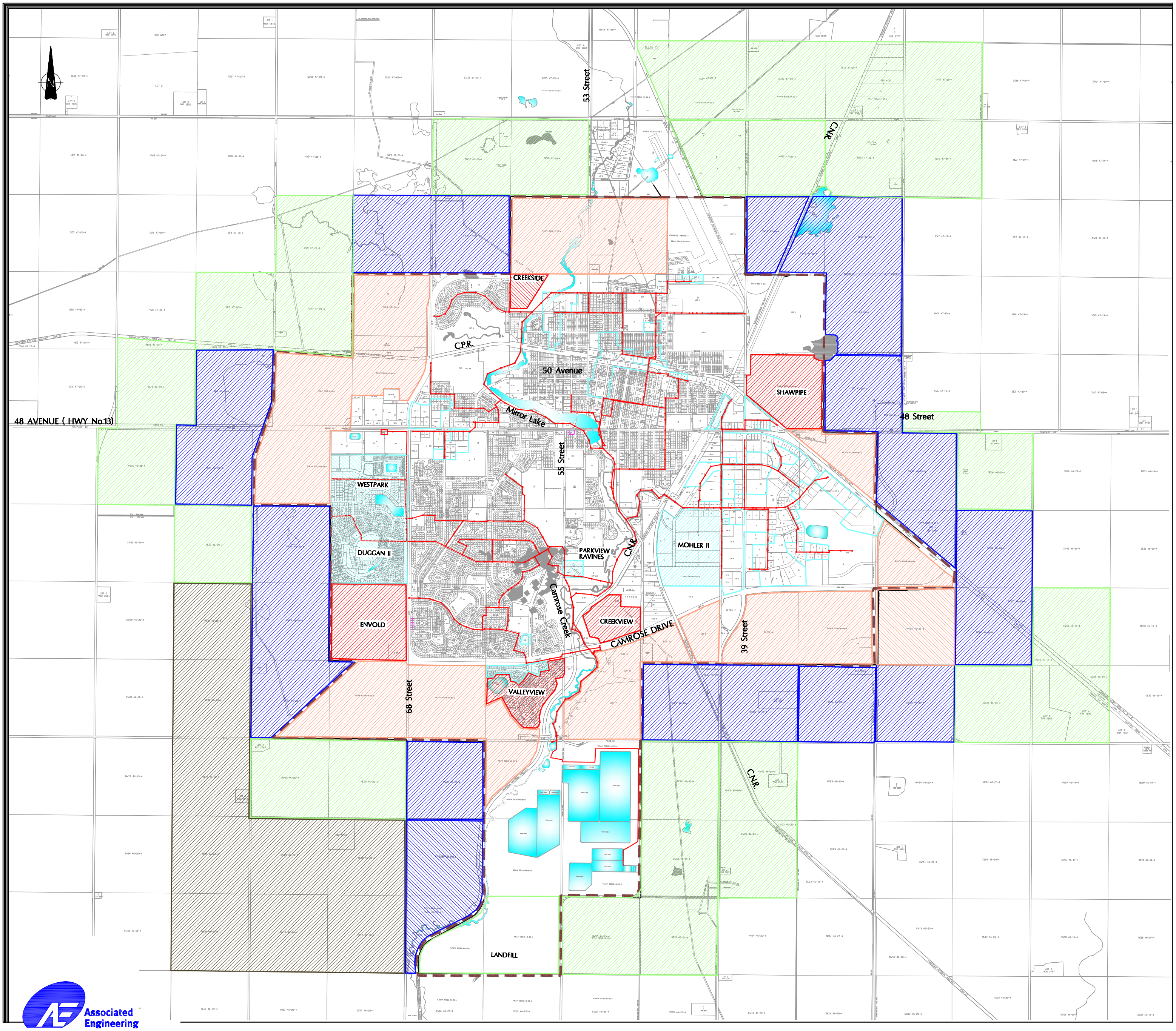
The eastern fringe along Highway 13, east of the Camrose Drive turnoff, will be drained to the south and then westward in future trunk sewers south of Camrose Drive, as had been anticipated in the previous Master Plan.

**Southeast:** A new trunk sewer will be required along Camrose Drive to the main Creek trunk and the South Lift Station, to serve areas along Camrose Drive and east of Highway 13.

Later as areas to south are developed, new trunks will be required to service these areas. Initially this trunk system can connect to the proposed Camrose Drive trunk and thus will drain to the South Lift Station.

Ultimately when the areas east of the sewage treatment plant are developed, they will require new trunks draining to the south of the sewage treatment plant. At that time the Camrose Drive trunk can be intercepted to the proposed trunks further south to divert as much flow as possible away from the Camrose Creek trunk system and the South lift Station. This will reduce the required pump capacities and pumping costs at the South Lift Station.

Extension of services into the future development areas will increase the flows in the existing trunk sewers. Some of these trunks will need to be upgraded as will be discussed in the following section.



THE CITY OF
CAMROSE

# SANITARY SEWER COLLECTION SYSTEM

## ASSUMED GROWTH SEQUENCE

**LEGEND:**

| | |
|---|---|
| ▬ ▬ ▬ | CITY BOUNDARY |
| ▨ | PARTIALLY DEVELOPED (< 5 Years) UNDER EXISTING CONDITIONS |
| ▨ | SHORT TERM DEVELOPMENT (< 5 Years) |
| ▨ | REMAINING LAND WITHIN CITY LIMIT (5 - 20 Year) |
| ▨ | MEDIUM TERM (10-30 Years) |
| ▨ | LONG TERM (>30 Years) |
| ▨ | POTENTIAL FUTURE RESIDENTIAL AREA |
| ― | EXISTING SANITARY TRUNK SEWER |
| • | MANHOLE |

0 500 1000

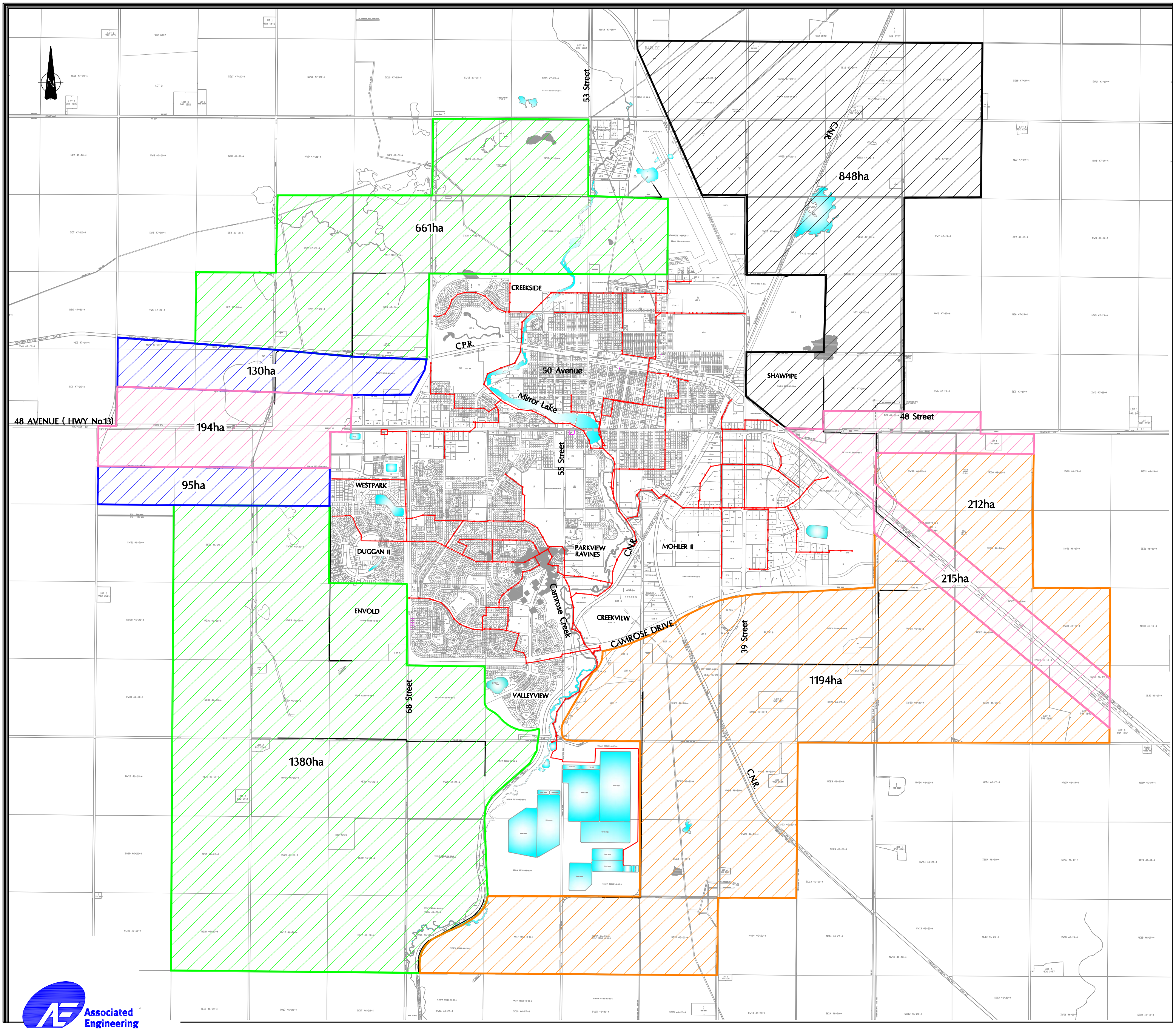
SCALE: 1 : 40,000

NOVEMBER, 2007

FIGURE 5.1

Time: 2:13pm
Date: Jan 15, 2008
File: Q:\053804\Report\Final Report\3804-fg_5.1.DWG by BW
Xrefs: 3804-RP01_BASE_2005_nad27
EXpipes

Associated Engineering



THE CITY OF
CAMROSE

## ASSUMED LAND USE IN FUTURE DEVELOPMENT AREAS

**LEGEND:**

▨ HEAVY INDUSTRIAL
▨ LIGHT INDUSTRIAL
▨ PRIMARILY SINGLE FAMILY RESIDENTIAL
▨ MULTI-FAMILY RESIDENTIAL
▨ HIGHWAY COMMERCIAL
— EXISTING SANITARY TRUNK SEWER
• MANHOLE

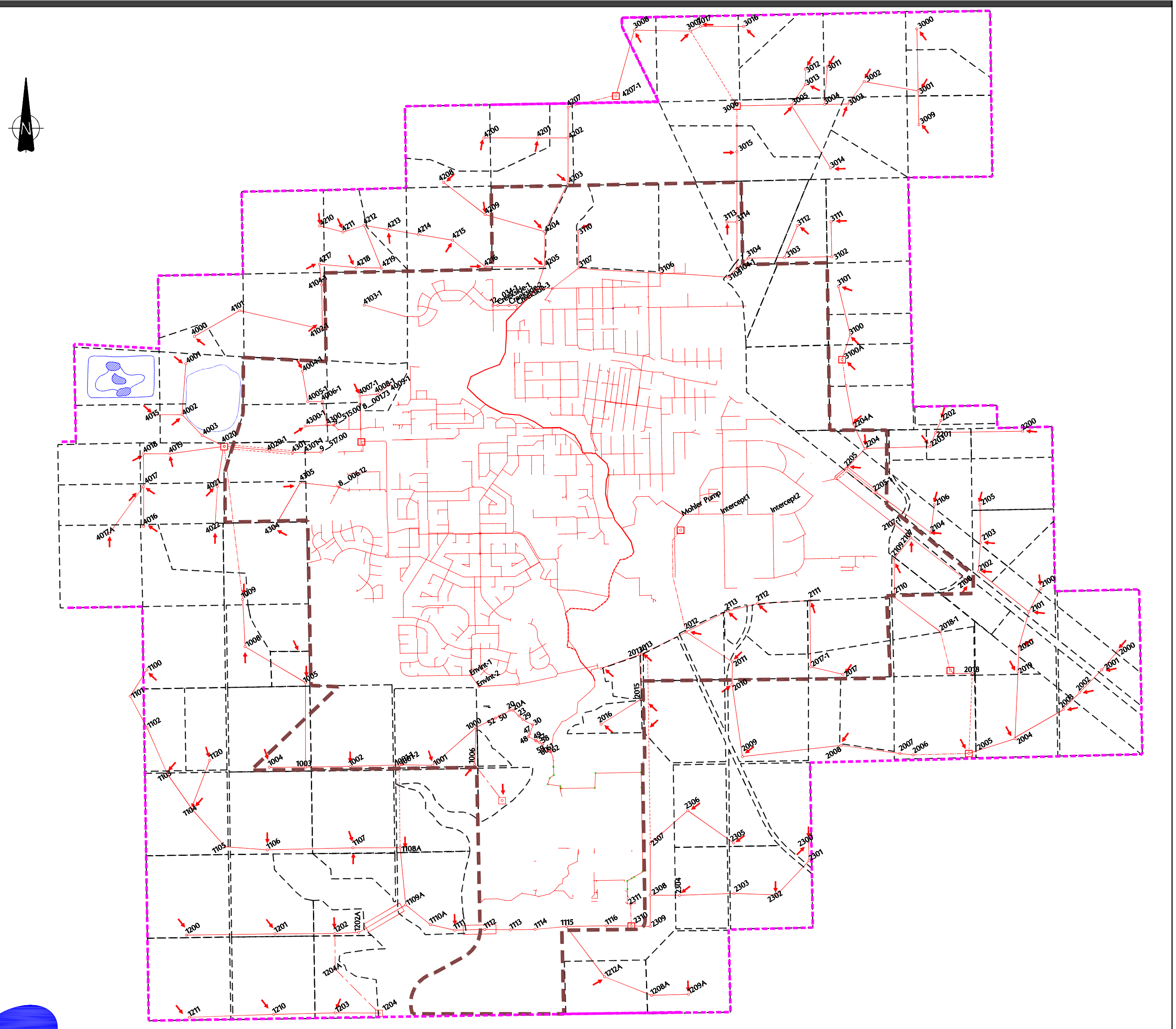
0 500 1000
SCALE: 1 : 40,000

NOVEMBER, 2007

FIGURE 5.2

Time: 2:13pm
Date: Jan 15, 2008
File: Q:\053804\Report\Final Report\3804-fg_5.2.DWG by BW
Xrefs: 3804-RP01_BASE_2005_nad27
EXpipes

Associated
Engineering



# THE CITY OF CAMROSE

## SANITARY SEWER DRAINAGE CONCEPT PLAN

**LEGEND:**

- EXISTING SANITARY TRUNK
- PROPOSED SANITARY TRUNK
- OPTIONAL ULTIMATE SANITARY TRUNK
- SANITARY FORCEMAIN
- SANITARY INLET NODE
- SANITARY PUMP STATION
- SUB-CATCHMENT BOUNDARY
- CITY BOUNDARY
- PLAN AREA BOUNDARY
- PIPE BRIDGE
- IN-LINE STORAGE PIPE

SCALE : 1 : 40 000

JANUARY, 2008

FIGURE 5.3

Associated Engineering

Time: 2:17pm
Date: Jan 15, 2008
File: Q:\053804\Report\3804-FG__figure_5.3_MASTER SAN.dwg by BW
Xrefs: EVERYTHING
3804-RP01_BASE_2005_nad27
3804-RP04_SAN_EX
3804-RT-01_TITLE
FinalNetwork

# 6 Proposed Upgrade/Expansion Plan

Based on the modelling results for present and future development conditions, Associated Engineering refined the upgrade plan and defined system expansion requirements for the interim and future development areas considering:

- hydraulic and structural capacity concerns,
- future development plans and their requirements,
- costs and timing of upgrade and expansion requirements,
- plans for street rehabilitation to minimize street disruption,
- coordination of storm and sanitary upgrade/expansion plans to minimize neighbourhood disruption and street repairs.

The upgrade/expansion plan was then modelled to define peak flows and pipe sizing requirements and to develop the conceptual design and cost estimates of the required system upgrades.

## 6.1 PROPOSED UPGRADING

Figure 6.1 shows the locations of the proposed system upgrading to provide capacity for the next 50 years. Following is a summary of the anticipated upgrade plan and an indication of its timing and the events that may trigger the individual upgrades:

**Victoria Park:** The trunk sewer through Victoria Park has sufficient capacity to service the ¼ section to the west. A 250 m section from 60th Street to the Camrose Creek trunk was upgraded as part of the Creekside development to provide capacity for future development (Item 1 in Figure 6.1).

**In the future, when the west ¼ section is to be developed, a 45 m long section of pipe on 60 Street will need to be replaced to complete the connection.**

**Enevold/Century Meadows:** The trunk along Enevold Drive is at capacity under wet-weather conditions at present, and is intended to serve the Enevold quarter section to the west of 68 Street, which is planned for development in the near future. Surcharge levels will increase if the quarter section were to be drained directly to this trunk.

According to the model simulation results, the resulting surcharge levels would be below the basement levels along this trunk; however there is some uncertainty as to the Inflow/infiltration rates in this area, especially from houses that may not have been provided with sump pumps. Recent experience in the storms of May-June, 2007 suggests that the flows in this trunk may be higher than anticipated. **Therefore, smoke and dye testing should be undertaken in the tributary catchment to search for and eliminate any extraneous inflows.**

Due to grade constraints, in-line storage of wet-weather flow is not feasible for the Enevold quarter. **Therefore it is proposed that the Enevold trunk be intercepted in a southerly route along 61A Street to Camrose Drive, and then eastward along Camrose Drive to the existing 900 mm trunk at Parkview Drive (Item 3 in Figure 6.1).** This work would involve approximately 800 m of 450 mm pipe at an estimated cost of $1.3 million.

As it is required to facilitate the development, the cost would reasonably be recovered through a development levy of approximately $2,000 per lot. This upgrade would also reduce the possibility of overflows to the Marler/Mount Pleasant system.

**Marler/Mount Pleasant**: The original trunk sewers through these neighbourhoods carry substantially more than their design flow in the 1:100 year storm. The 43 Avenue Interceptor was constructed in 1999 to prevent flooding in these neighbourhoods and, as shown previously in Section 2 of this report, has achieved this goal. There is some surcharging in the model in the 1:100 year storm, to within 1.0 m of basement elevation, in the area south of 43 Avenue, but none was observed in the recent storm events.

**A new sewer connection is proposed along Mount Pleasant Drive from 42 Avenue to 43 Avenue (Item #7)**. It would act as an overflow in a severe storm event to reduce the risk of flooding in the Mount Pleasant area.

**Upper Camrose Creek Trunk**: The upstream portions of the trunk main, from 55 Avenue to 44 Avenue, at Augustana College, are surcharged to grade and could overflow to ground surface and possibly to Camrose Creek during a major storm event.

The City has recognized this potential for some time and is upgrading the trunk as funds become available. The portion southwest of 50 Street, near the CNR trestle, has been upgraded in recent years, and the City plans to extend this upgrade to 47 Avenue in the near future. The simulation results show that these upgrades have been effective at reducing surcharge levels and preventing overflows. The upstream portions, which have not been upgraded, will surcharge to ground level in a major storm event. This surcharge is a contributing factor to the sewer backup that flooded three homes at 53 Street/55 Avenue in the June 25, 2007 storm.

**It is recommended that the main trunk along Camrose Creek, upstream of the 2005 construction, be replaced with a minimum 1200-1350 mm trunk sewer as shown as Item #6 in Figure 6.1.** This upgrade would reduce the potential overflows from the trunk to the Creek. It would also make additional capacity available for future development to the north, and would reduce surcharge levels along 55 Avenue.

**We recommend that the City proceed with the preliminary design of this trunk upgrade to evaluate alternative routings and costs and to develop a more detailed implementation plan.**

In the interim, pending the replacement of the mainline trunk, approximately 250 to 400 ha of development area could potentially be accommodated with in-line storage of wet-weather flows as described above. This would permit development levies to be collected for the ultimate replacement of the trunk. Later, when the trunk is upgraded, the in-line storage tank(s) can be converted to operate by gravity to service the development beyond the initial 250-400 ha. This concept should be confirmed through more specific analysis by the affected developer(s) to confirm that it can be implemented to suit the specific site conditions.

**55 Avenue Trunk**

The trunk along the north side of the city, east along 55 Avenue from Camrose Creek to the pipe plants, is overloaded and has no spare capacity for additional development on the northeast side of the City. This area is also affected by backup from the trunk main along Camrose Creek during a major storm event.

The model results show that under present development conditions the 55 Avenue trunk would surcharge to grade at several locations in a major storm event. Three houses on 53 Street were flooded by sewer backup in the June 25, 2007 event. Upgrading the main trunk would substantially reduce, but not eliminate, the risk of basement flooding in this area, as the resulting surcharge in the model was within 0.75 m of ground surface, which is less than the typical basement depth.

These findings are, however, highly dependent on the wet-weather flows in this trunk, which have not been monitored. **Therefore, this trunk should be monitored to confirm the flows and the potential surcharge levels.**

**A new sanitary trunk will be required along the Ring Road to serve future developments to the east (Item 2 in Figure 6.1).** The existing trunk can be intercepted into the new trunk, to reduce the risk of basement flooding along this line in peak wet-weather conditions.

**Mohler Industrial Area:**

The lateral sewers in the southern part of the Mohler industrial area will operate above their capacity in a major storm and, in some cases, may surcharge to grade with present levels of development. Some overflow to the street could occur. However, as there are no basements in this area, the risk of flooding is low.

The City has recently constructed a new 600 mm pipe through the Mohler industrial area, which was not inter-connected with the existing sewers. **The original trunk should be intercepted at two locations as shown in Item 4, Figure 6.1 into the new trunk.** This upgrade would virtually eliminate surcharging of this trunk.

With this relatively minor upgrade the Mohler trunk sewer will have capacity for about 100 to 150 ha of additional development. In-line storage of wet-weather flows is proposed for the future development areas east of Highway 13.

**Mohler Pump Station:**

The new 600 mm Mohler trunk drains into an existing 450 mm trunk on 44 Avenue (the Bethany Trunk), just east of the CNR. Portions of the pipe downstream of this connection are flowing above capacity in a major storm event, and will surcharge the pipe to a depth of about 1 m with existing development conditions. Under ultimate conditions, without upgrades, the trunk would surcharge to grade and would spill to the ravine.

Terrasen Utility Services carried out a CCTV inspection of the Bethany sanitary trunk's structural condition. There were indications of infiltration from the coulee and the possibility of high flows having occurred in the pipe as indicated by debris accumulation at the crown of pipe. Also, in the May 2007 storm, there were indications of the trunk surcharging as indicated by the computer model.

**In order to accommodate future development, a new pump station is proposed in the Mohler Industrial area (Item 9 in Figure 6.1)**. It would divert the sewer flows from the Bethany trunk to a new trunk along Camrose Drive, thus preventing overflows into the coulee. It would also make more capacity available in the Camrose Creek trunk.

This upgrade can be staged over several years. As development of the Mohler II area is on-going, a site will need to be reserved for the pump station. Sections of the force main may be installed as the area streets are constructed. The force main can then be connected to the future Camrose

Driver trunk, when it is constructed to service the development area to the east. The pump station would be constructed at the same time.

The Bethany Trunk inspection identified several minor issues that should be addressed through point repairs in the near future to ensure that they do not lead to further problems. The trunk will need to be left in service to provide service connections to the Augustana College and other users in the area. It will also provide overflow protection for the proposed pump station. **Therefore, it is recommended that the point repairs, which were identified in the inspection report, be completed as soon as possible (Item 5 in Figure 6.1). Manholes in the coulee should be raised and made water-tight**.

**Lower Camrose Creek Trunk:** Recently, the City has upgraded the main trunk from Augustana College to the South Lift Station. With the proposed Mohler upgrades, the portion from 44 Avenue to Camrose Drive has capacity to serve approximately 400-500 ha of additional development before it will need to be upgraded again, which will provide from approximately 20 to 50 years. Ultimately, the trunk sewer from 44 Avenue to Camrose Drive will need to be twinned or replaced.

**The proposed replacement would be a 1,350 mm trunk sewer (Item 11 in Figure 6.1).**

There are two short constricted sections (900 mm in diameter) in the existing trunk at 42 Avenue and under Camrose Drive. Simulation results indicate that these constrictions, at present, have relatively minor effect under peak flow conditions. Surcharging will increase as development continues and upstream upgrades are completed. **The Camrose Drive crossing (Item 10 in Figure 6.1) will need to be replaced when the upper Camrose Creek upgrades are completed.** The 42 Avenue portion can be deferred until the lower creek trunk is replaced or twinned.

**South Lift Station:** The South Lift Station and force main were last upgraded in 1991, and new treatment cells were constructed in 1992. Anaerobic Cell A, which is located within the creek valley, was previously used for treatment. This cell has a capacity of 15,000 m$^3$ and was retained for temporary storage of excess flows during storm events. A 450 mm overflow diameter pipe carries the excess flow from the South Lift Station to the storage cell.

City personnel have observed several high-flow events since 2005 when the South Lift Station was operating at or near its capacity. On three occasions in 2007, the Lift Station overflowed to the storage cell and on two occasions the storage cell was filled and spilled to the creek. In the model, the storage cell was filled to capacity in the 1:100 year storm.

Preliminary assessment of the Lift station and force main capacity reveals that the Lift Station has a capacity, with all three pumps running, of 312 L/s (0.31 $m^3$/s). The force main is operating at capacity and would need to be upgraded or twinned if flows were increased.

Continuing development in the City, and upgrading of trunk sewers, will add to the flows at the South Lift Station. According to the model results, the 1:100 year storm would generate peak flows as follows:

- 1.3 $m^3$/s under present development conditions (without storage of peak flows),
- Increasing to 1.8 $m^3$/s with the interim upgrades to the trunk sewers,
- Further increasing to 3.4 $m^3$/s with full development of the plan area,
- In the long term, large portions of the development area will be diverted away from the mainline trunk and South Lift Station and the peak flows will be reduced to approximately 2.5 $m^3$/s.

This implies that large-scale upgrades of the pump station and forcemain could be required. Since these upgrades will be made in discrete increments, their staging needs to be carefully planned. A more detailed analysis of pump and force main staging should be completed. The exact magnitude of the design flow is subject to review based on further monitoring as the upstream upgrades are completed.

**We recommend that the City develop a plan to upgrade the South Lift Station and force main to accommodate future development and to optimize the use of peak flow storage (Item 8 in Figure 6.1).**

The City Plans to upgrade its wastewater treatment plant by 2009, which would be the logical time frame to upgrade the pump station and force main.

**The overflow and storage cell should be retained (and possibly expanded, depending on the pump capacity that is provided) to protect against the possibility of pump station overflows. The upgrade plan should consider the use of storage to reduce the peak flows.**

**Inflow/Infiltration Reduction**: The recent experience demonstrates that stormwater inflows are rapid and large, which implies that a source of direct inflow is involved. In the recent storm events, substantial depths of runoff occurred on the streets, and these contribute to inflows to sanitary sewers through manhole lift/vent holes and other sources. Several manholes in the creek valley are at risk of overtopping from the creek in a major flood, and significant inflows were observed at one manhole in the valley.

**It is recommended that the City undertake a program of Inflow/Infiltration reduction, to include:**

- **Sealing of lift/vent holes in manhole lids,**
- **Raising and water-proofing of manholes located in the creek valley to reduce the extraneous inflows.**

**Cornerstone Basin:** The existing Cornerstone pumps have a capacity of 62 L/s which provides capacity for approximately 70 ha (the existing commercial area plus 30 ha of residential development in the remnant of Quarter-section SE-4-27-4 immediately north of Cornerstone).

Development of the remainder of the basin will require in-line storage and staged upgrading of the pump station, as follows:

a. After the initial 70 ha is developed, replace or upgrade the pumps (one service plus one standby pump) to provide a minimum capacity of 93 L/s. This upgrade will permit development of the Quarter-section SE-4-27-4 to the west of Cornerstone and north of the highway, which increases the cumulative service area to 130 ha.

b. In the second stage, provide in-line storage with real-time control (RTC), releasing off-peak to the pump station when capacity is available, to develop the commercial areas comprising about 65 ha in the two Quarter-sections to the west of Cornerstone (NW 32 and NE 31-46-21-4), on the south side of the highway and west of the current development area. Peak flow from the pump station will be limited to 93 L/s and the maximum service area will increase to 195 ha.

c. In the third stage, twin or replace the existing force main, and upgrade or replace the pumps(s) if required, to increase their capacity to 145 L/s. Convert the operation of the RTC and storage tank from “off-peak discharge” to “peak shaving[1] “ to serve the remainder of the basin (345 ha), increasing the cumulative service area to 540 ha.

d. Ultimately, divert the 345 ha in Stage 3, with a pump station and force main to the southwest basin, to offload this area from the Cornerstone pump station and the South Lift Station and to reduce the pumping costs. The peak flow rate from the Cornerstone pump station would be reduced to 93 L/s with limited storage in the in-line storage tank.

## 6.2 SYSTEM EXPANSION

Figure 6.1 shows, schematically, the additional trunk sewers that will be required over time to serve the future development areas. Generally, the system expansion and extension into the future development areas will be driven by development and will be funded by that development.

The analysis indicates that some upgrading will be required in the existing sanitary sewer system as development progresses. In most areas, upgrading is already required to accommodate peak wet-weather flows that presently occur as indicated earlier, and most of the costs of the upgrading will therefore be the responsibility of the City at large. These upgrades will be designed with sufficient capacity to serve the long-term (50 year) development plan.

In about 20-50 years, depending on growth rates, the Camrose Creek trunk sewer from Augustana College to Camrose Drive will need to be replaced to provide capacity for additional development. The existing trunk has capacity for about 400-500 ha of development with the other upgrades that are proposed above.

## 6.3 SIMULATION OF THE PROPOSED UPGRADE/EXPANSION PLAN

The proposed upgrades were simulated to assess their performance. Figure 6.2 shows simulated surcharge levels in the 1:100 year design storm for ultimate development conditions, with the proposed upgrades. It indicates a substantial improvement in surcharge levels compared with existing conditions in Figure 4.2.

Figure 6.3 shows the longitudinal profile of the main trunk along with the simulated hydraulic grade lines for existing conditions and with the proposed upgrades, starting at the pipe plants in northeast Camrose and continuing to the South Lift Station. The profile shows that surcharging of the main trunk would be

---

[1] Off-peak discharge refers to storage of all flow during the storm event, and releasing at a controlled rate after the storm has passed, in a system that is loaded to capacity during the storm event. Peak-shaving refers to discharge at a controlled rate both during and after the storm event, in a system where some capacity is available during the storm event. Peak -shaving can be accomplished with less storage volume.

eliminated with the proposed upgrades. Note that the trunk sewer is very shallow and provides less than 1.5 m of cover in places. This is illustrated by the dark blue dots along the trunk in Figure 6.2, which indicate that the water levels are within 1.5 m of ground, even though the pipe is not surcharged.

Figure 6.4 shows the longitudinal profile and simulated hydraulic grade lines in the Mohler trunk sewer. It shows that the trunk would surcharge to grade with existing conditions and this could be prevented with the proposed upgrades. Figure 6.5 shows the alignment of the profile shown in Figure 6.4.

Figure 6.6 shows the profile of the Enevold trunk with the proposed development of the Enevold quarter section west of 68 Street. The simulated surcharge levels are within 2.5 m of ground surface if the additional area were to be drained directly to the trunk system. The proposed interceptor would allow the system to flow by gravity without restriction, thus reducing the risk of flooding.

## 6.4 PIPE SIZES AND CAPACITIES

Appendix C provides details of the simulation results for existing and future development scenarios, including:

- Length, slope, and inverts used in the model,
- The peak flows from the various scenarios,
- The existing and required pipe sizes.

Appendix D, included on CD, contains GIS data base files with the details of the ultimate development scenario including:

- Length,
- Slope,
- Inverts,
- Existing and ultimate peak flow,
- Existing and ultimate diameters,
- Land use,
- Estimated cost for each of the ultimate pipes.

These data base files will allow the City personnel to easily access all the details of the Master Plan report. The information they contain is at a conceptual level of detail and is subject to review during the detailed design process.

Cost estimates assume the following:

- The costs included for future projects are conceptual only.
- Costs are for 2007.
- Costs include 10% engineering, 40% contingency and 6% G.S.T.

- Costs for open cut include stripping, trenching, supply/install pipe and manholes every 120 m.

## 6.5 IMPLEMENTATION PLAN

The sequencing and scheduling of these upgrades will depend on availability of resources and on the development schedule. Table 6.1 which follows provides a summary. Line items in this Table are numbered to match Figure 6.1.

# Table 6.1
# Camrose Sanitary Sewer Master Plan
## Capital Priorities Plan

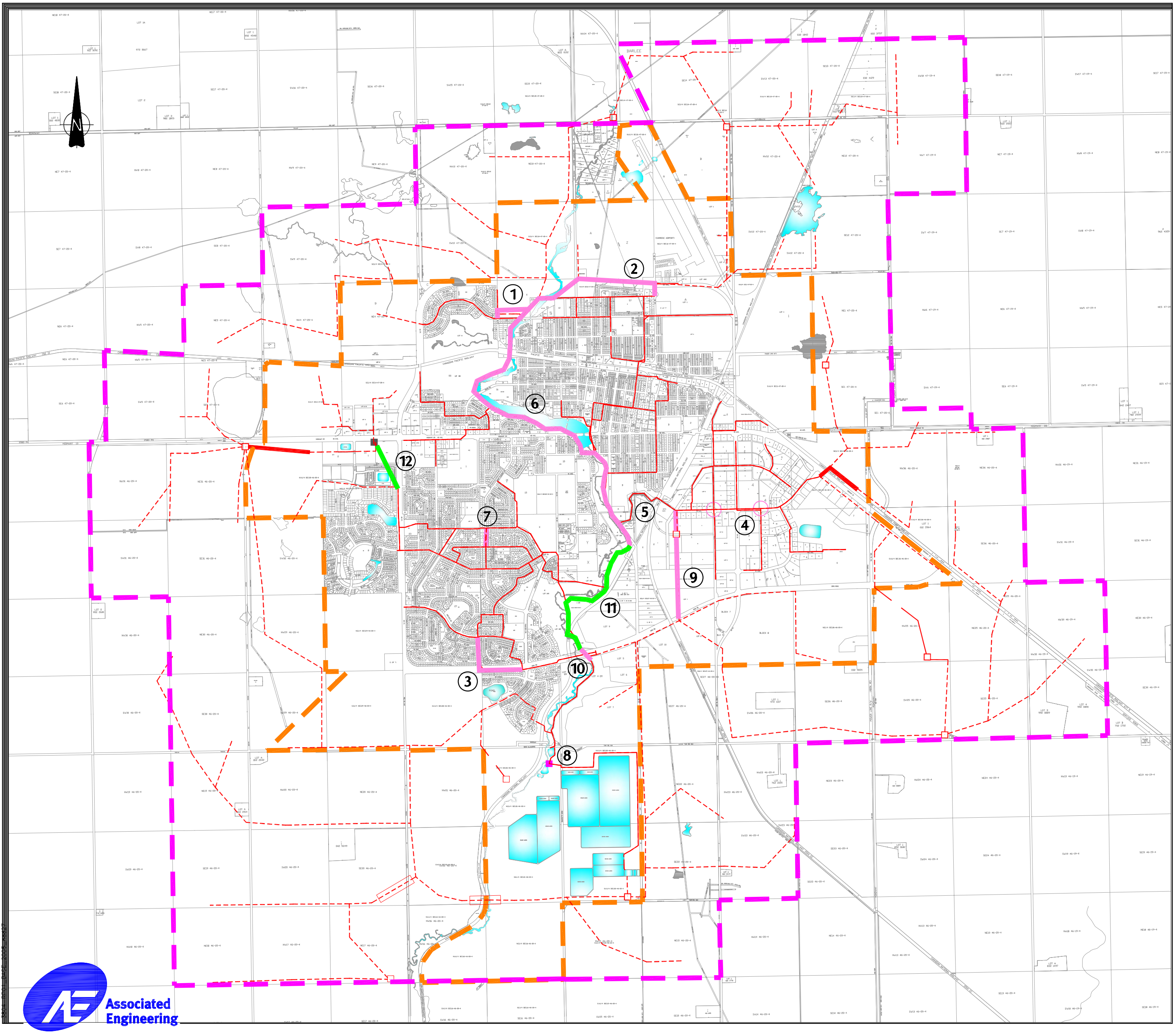
| ITEM # | PROPOSED UPGRADE | PURPOSE | SCOPE OF WORK** | APPROXIMATE COST** | WHEN REQUIRED | APPROXIMATE DATE | CAPITAL PRIORITIES PLAN (YEARS) |
|---|---|---|---|---|---|---|---|
| 1 | Design and construct the Creekside trunk (completed in 2007) | Provide capacity for future development west of 68 Street | 250 m of 375 mm sanitary sewer | $ 171,000 | Prior to street construction in Creekside | Completed in 2007 | 5 |
| 2A | Monitor flow rates in the 55 Avenue trunk for one season | Confirm the flows from the pipe plants and review the capacity of the trunk along 55 Avenue | Monitoring contract | $ 15,000 | Immediately | 2008 | 5 |
| 2B | Ring Road Sanitary Trunk | Prevent flooding at 53 Street and provide capacity for future development | 1239 m 1050 mm sanitary trunk | $ 1,500,000 | Prior to Ring Road construction | 2010 | >10 |
| 3 | Intercept the Enevold trunk to Camrose Drive | Provide capacity for Enevold 1/4 section | 800 m of 450 mm sanitary trunk | $ 1,300,000 | Prior to development | 2008 | >10 |
| 4 | Intercept lateral lines at two locations in the Mohler industrial area into the 600 mm diameter trunk | Reduce surcharging of lateral sewers | 2 manholes<br>plus 30 m of 600 mm sanitary sewer | $ 72,000 | Budget year 2008 | 2008 | 5 |
| 5 | Point repair to the Bethany trunk and waterproofing manholes<br>Raise and repair manholes to reduce I/I | Prevent further deterioration and risk of failure | 10 m of 450 mm sanitary trunk<br>Waterproof five manholes | $ 82,000 | Budget year 2008 | 2008 | 5 |
| 6A | Pre-design the mainline upgrades in the Camrose Creek Valley | Select routing and plan for replacement as funds become available | Study | $ 40,000 | Budget year 2008 | 2008 | 5 |
| 6B | Replace Camrose Creek trunk from 55 Avenue to 43 Avenue (limit of 2005 construction) | Reduce surcharge and risk of overflow, reduce surcharge in 55 Avenue trunk, and provide capacity for future development | 3100 m of 1200 mm<br>plus 5500 m of 1350 mm sanitary trunk | $ 10,500,000 | < 250 ha development in north Camrose* | 2026* | >10 |
| 7 | Construct overflow trunk along Mount Pleasant Drive from 42 Avenue to 43 Avenue | Provide additional protection against flooding in the Mount Pleasant area | 200 m of 600 mm storm sewer | $ 150,000 | Budget year 2009 | 2009 | 5 |
| 8A | Develop an upgrade plan for the South Lift Station and force main | Prevent overflows from the lift station and provide capacity for further development | Pre-design | $ 50,000 | Budget year 2009 | 2009 | 5 |
| 8B | Upgrade South Lift Station and Force Main | Prevent overflows from the lift station and provide capacity for further development | Replace pumps and force main | To be determined | With plant upgrades | 2006 | 5 |
| 9 | Pump station and force main in the Mohler area | Divert flows from the Bethany trunk and mainline trunk<br>Provide capacity for further development | Pump station<br>plus 1100 m force main and gravity main | $ 3,000,000 | Prior to 50 ha development in Mohler Basin | 2011 | 10 |
| 10 | Replace 900 mm trunk under Camrose Drive | Provide capacity for future development | 138 m of 1350 mm and 38 m of 1500 mm sanitary trunk (trenchless construction) | $ 500,000 | < 250 ha development in north Camrose* | 2026* | >10 |
| 11 | Twin or replace Camrose Creek Trunk from 43 Avenue to Camrose Drive | Provide capacity for future development | 1,800 m of 1,350 mm sanitary trunk (or twin existing) | $ 3,200,000 | >400 ha development upstream | 2040 | >10 |
| 12A | Upgrade Cornerstone pump station to 93 L/s | Provide capacity for future development | Replace or upgrade pumps to 93 L/s capacity | $ 100,000 | >70 ha cumulative development in Cornerstone Basin | 2010 | 5 |
| 12B | Provide in-line storage in Cornerstone basin | Provide capacity for future development (93 L/s) | 800 m of 1800 mm in-line storage tank c/w RTC | $ 2,000,000 | >130 ha cumulative development in Cornerstone Basin | 2015 | 10 |
| 12C | Upgrade Cornertsone pump station and force main to 145 L/s | Provide capacity for future development (145 L/s) | 700 m of 400 mm HDPE force main | $ 700,000 | >195 ha cumulative development in Cornerstone Basin | 2020 | >10 |
|  | Total Cost |  |  | $ 23,380,000 |  |  |  |
|  | Within 5 years |  |  | $ 680,000 |  |  |  |
|  | 5-10 years |  |  | $ 5,000,000 |  |  |  |
|  | Beyond 10 years |  |  | $ 17,700,000 |  |  |  |

* with in-line storage of wet-weather flows

** 2007 budget level estimates only; subject to pre-design; including construction, contingency (40%), engineering (10%), and GST (6%)

** Subject to confirmation in final design

Note: excludes developer-funded system expansion costs



**THE CITY OF CAMROSE**

# PROPOSED SANITARY SEWER SYSTEM UPGRADE AND EXPANSION PLAN

| | |
|---|---|
| ― | EXISTING TRUNK SEWERS |
| ■ | EXISTING PUMP STATION |
| ― | PROPOSED UPGRADING FOR PRESENT DEVELOPMENT |
| ― | PROPOSED UPGRADING FOR FUTURE DEVELOPMENT |
| ① | UPGRADE NUMBER (TABLE 6.1) |
| - - - | FUTURE TRUNK SEWER |
| □ | EXISTING PUMP STATION |
| - -▭- - | FUTURE PIPE BRIDGE |
| - -▬- - | FUTURE STORAGE TANK |
| ▬ ▬ ▬ | PLAN AREA BOUNDARY |

0 500 1000

SCALE: 1 : 40,000

JANUARY, 2008

FIGURE 6.1

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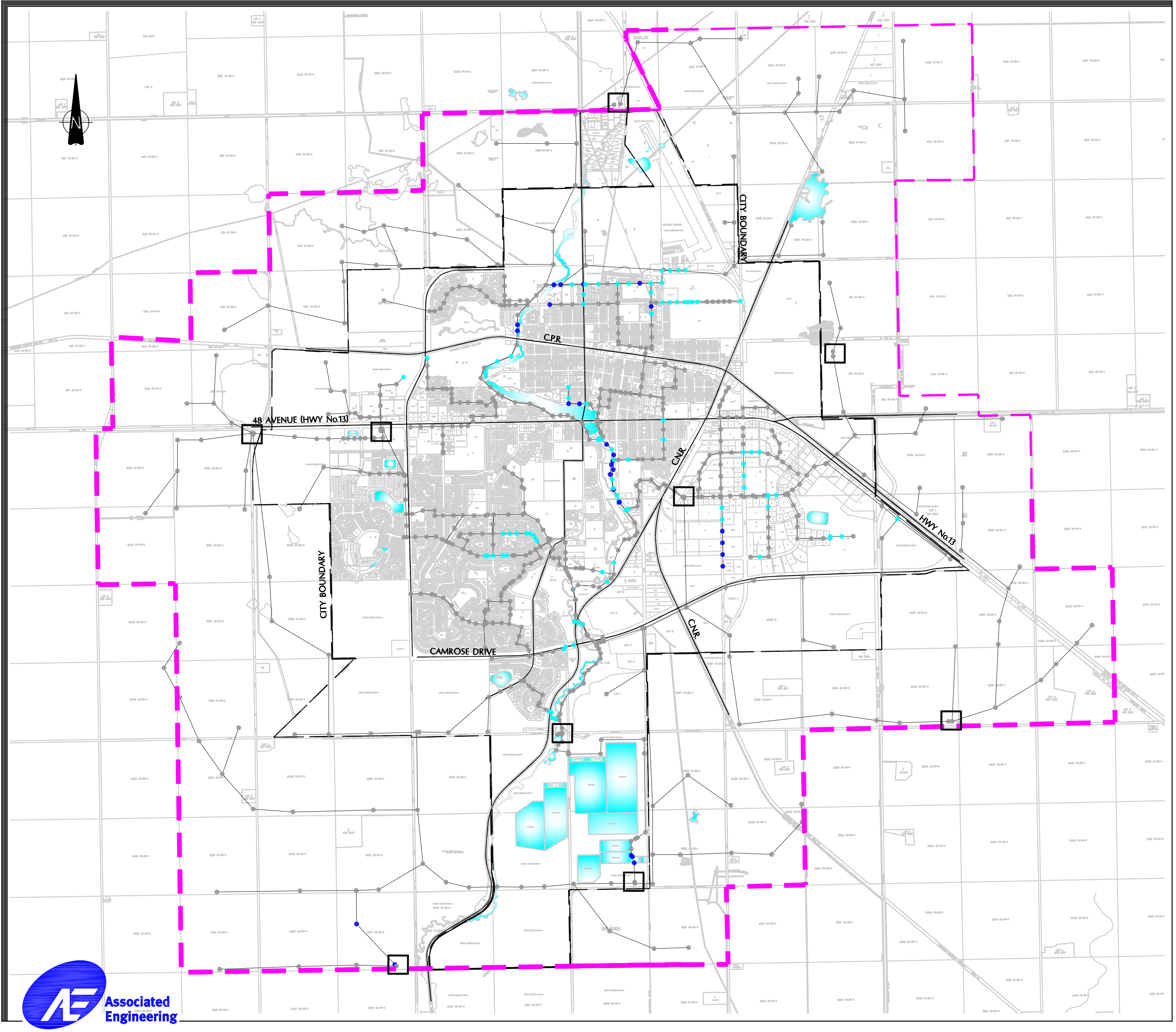

**THE CITY OF**
*CAMROSE*

## SIMULATED SURCHARGE LEVELS FOR THE 1:100 YEAR 4 HOUR STORM WITH PROPOSED UPGRADES AND ULTIMATE DEVELOPMENT

DEPTH BELOW GROUND SURFACE

● -1.50 to 0.00

● -2.50 to -1.50

● < -2.50

☐ LIFT STATION

- - - PLAN AREA BOUNDARY

0 500 1000

SCALE: 1 : 40,000

JANUARY, 2008

FIGURE 6.2

Associated Engineering

Time: 2:14pm
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Future

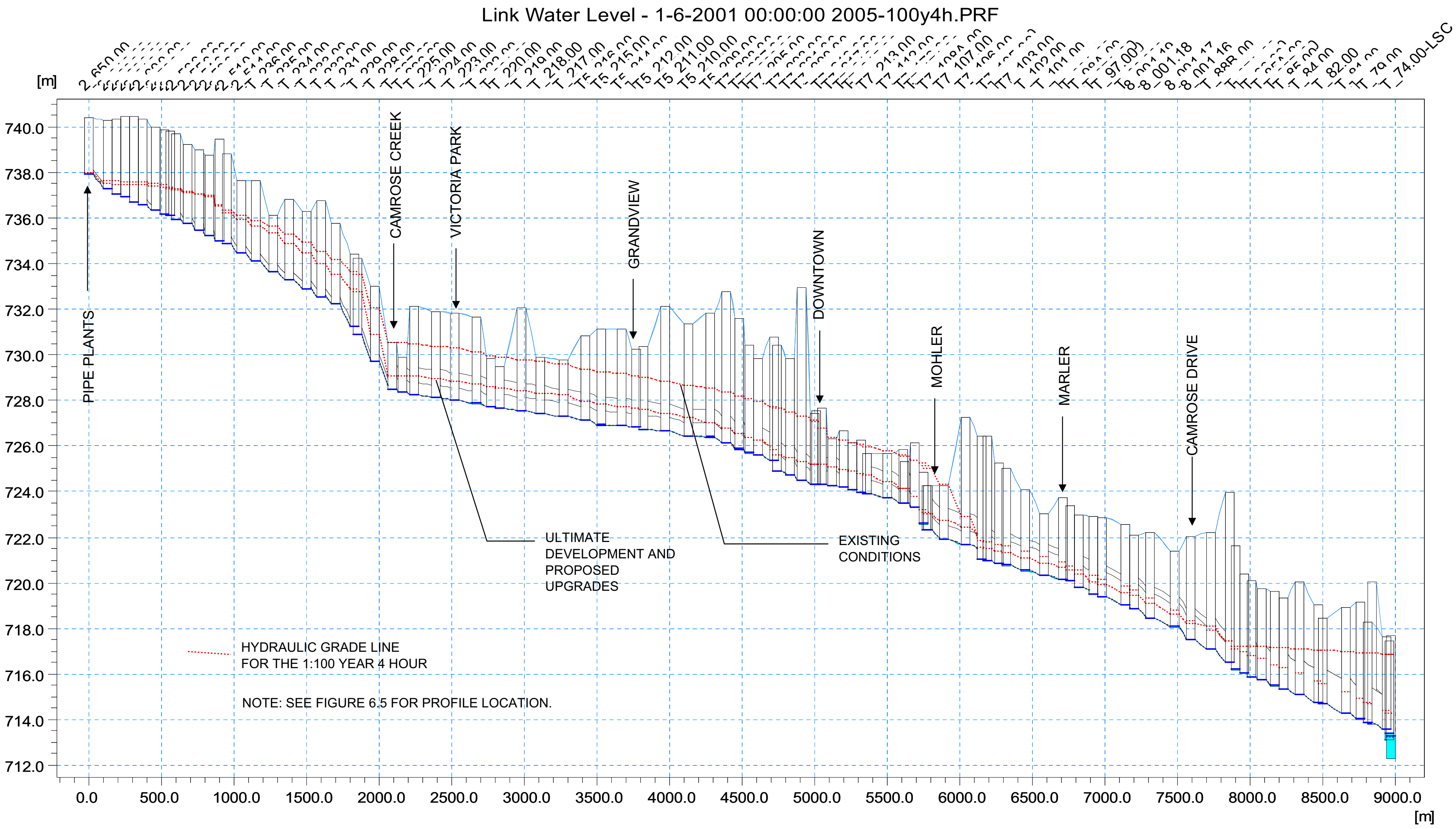


FIGURE 6.3
SIMULATED HYDRAULIC GRADE LINE PROFILES IN CAMROSE CREEK/ MAIN TRUNK
1:100 YEAR 4 HOUR STORM

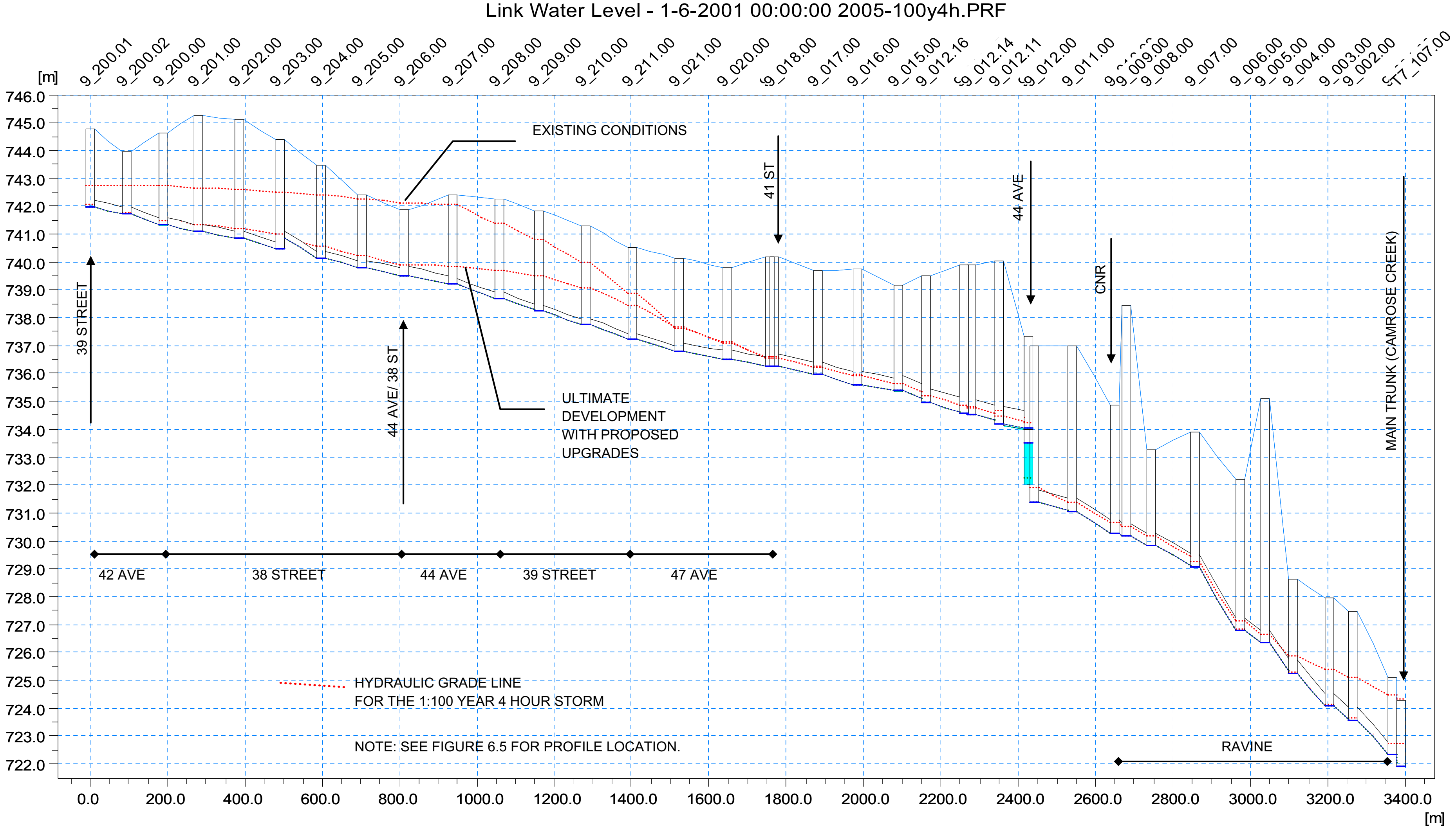


FIGURE 6.4
SIMULATED HYDRAULIC GRADE LINE PROFILES IN THE MOHLER TRUNK
1:100 YEAR 4 HOUR STORM

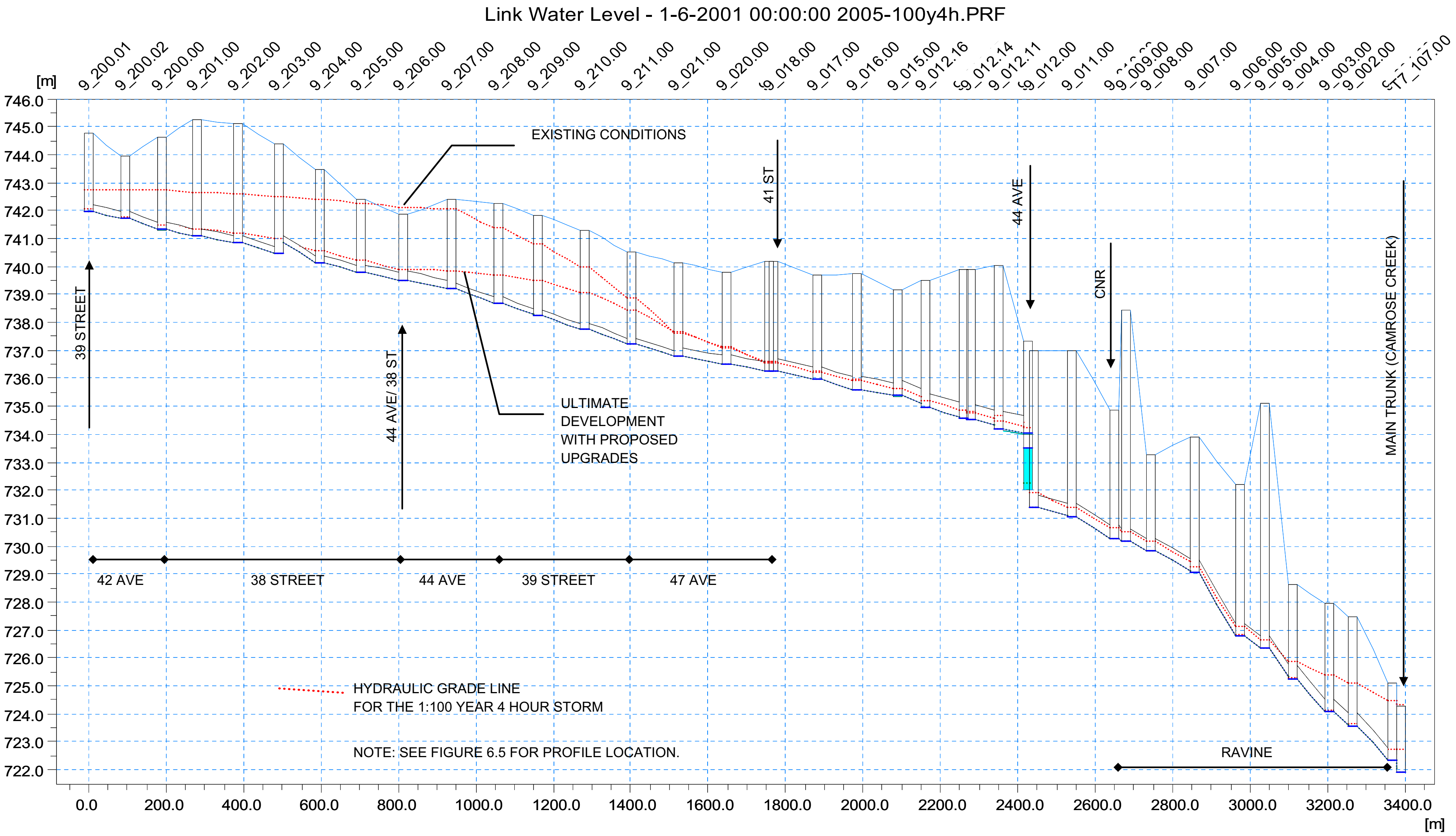


FIGURE 6.4
SIMULATED HYDRAULIC GRADE LINE PROFILES IN THE MOHLER TRUNK
1:100 YEAR 4 HOUR STORM

Standard - 2005-100y4h.PRF

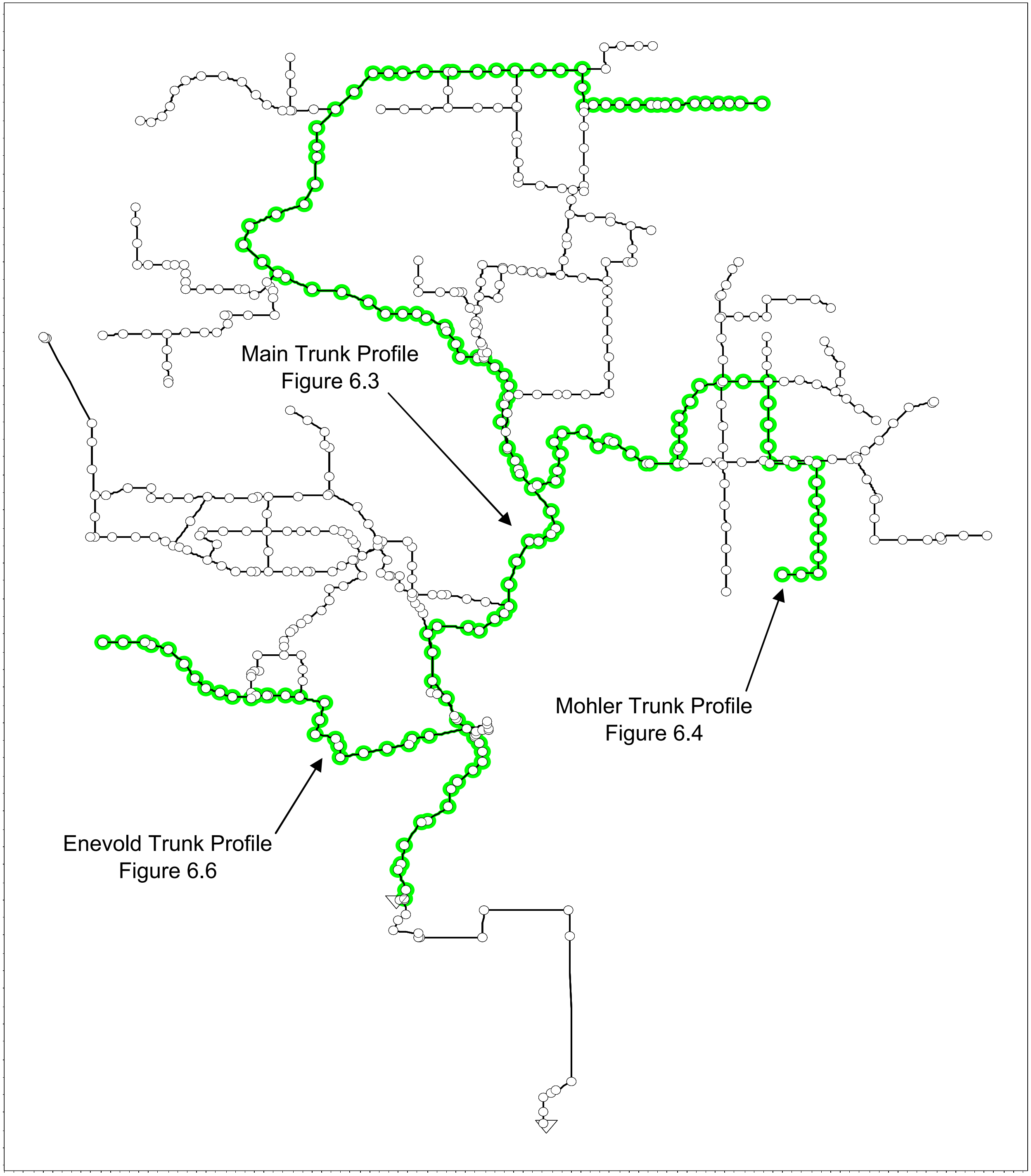


FIGURE 6.5
PROFILE LOCATION PLAN

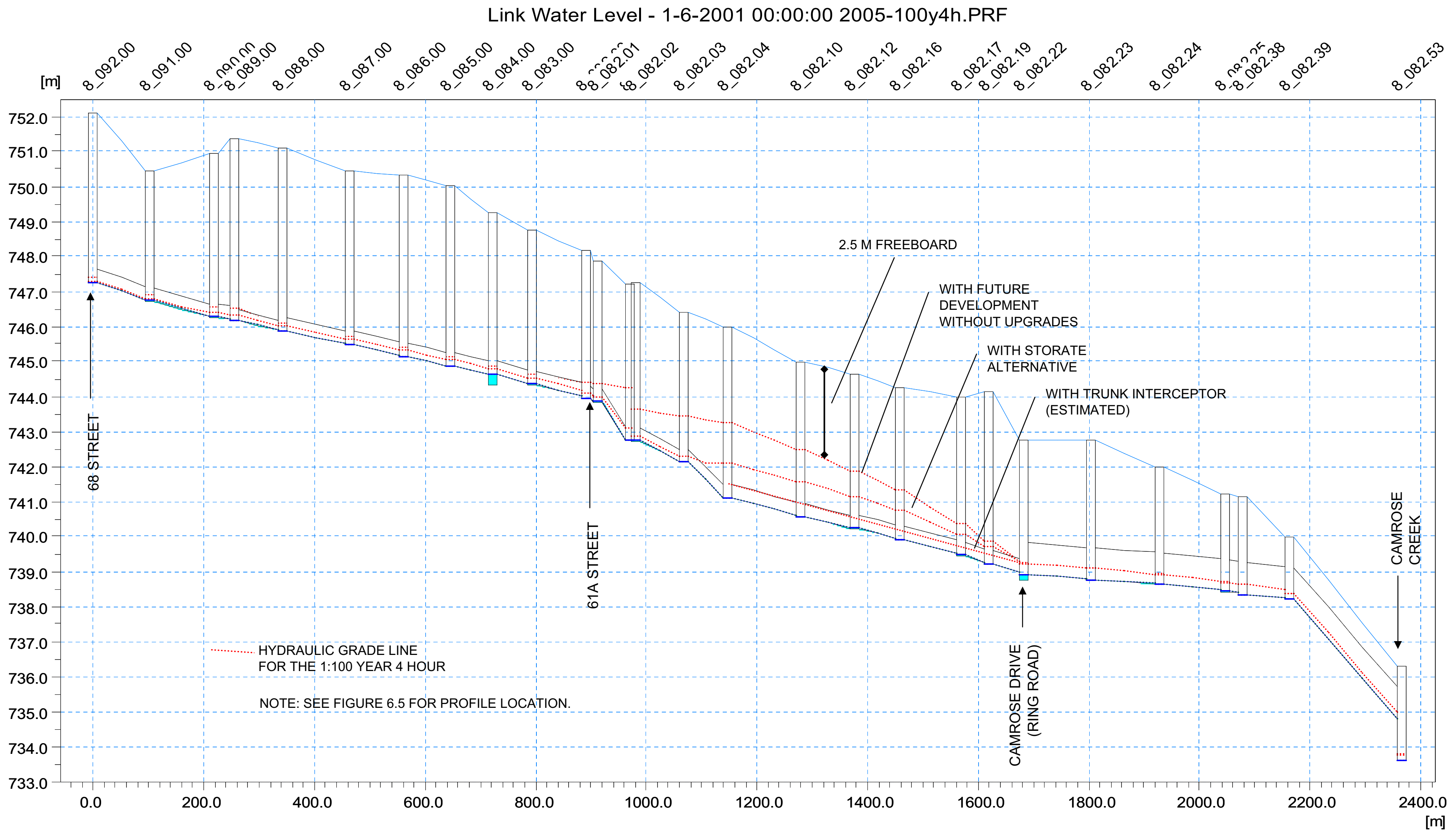


FIGURE 6.6

SIMULATED HYDRAULIC GRADE LINE PROFILES IN THE ENEVOLD TRUNK

1:100 YEAR 4 HOUR STORM

# 7 Conclusions

The flow and rainfall data that were collected over the six-year period from 1999 to 2004 were extremely valuable in calibrating the sanitary trunk model and indicated that the model provides a realistic simulation of actual conditions. However, a definitive calibration was not possible due to the lack of a significant storm event during the monitoring program and due to natural rainfall variations over the City area that may not be represented in the rainfall data.

Proposed design criteria, based on the model simulation results, are slightly more conservative than were assumed in the 2000 Master Drainage Plan in areas where weeping tiles are connected to the sanitary sewer. Design criteria for future development conditions without weeping tile connections are comparable with the City's current design standards.

The sanitary sewer system generally has enough capacity for wet-weather flows for events up to the 1:100 year storm, under existing development conditions, with the exception of the following:

- The Camrose Creek trunk could overflow to the creek in a major storm event, in those areas that remain to be upgraded.
- There is some risk of basement flooding along the 55 Avenue trunk, in part due to backup from the Camrose Creek trunk. Flows in the 55th Avenue trunk are sensitive to the assumed wet weather flows from the pipe plants and should be confirmed by monitoring.
- The Mohler laterals are not connected to the new trunk sewer. The risk of surcharging in the Mohler Industrial Area could be substantially eliminated or reduced by inter-connecting the new trunk, with the older trunk sewers.

Initial upgrades will provide capacity for development up to the present City limits. Further development will require additional upgrading and construction of new trunk facilities into the new development area. As the City grows to the south, new trunk sewer systems will be required to serve these areas and to divert as much flow as possible away from the main creek trunk.

Storage of peak wet-weather flows may be required to facilitate development north of the Ring Road, west of Cornerstone, and east of Highway 13, which drain through existing trunk sewers that have limited capacity.

# 8 Recommendations

The following upgrades are recommended in accordance with Figure 6.1 and Table 6.1:

- Extend the recent upgrades of trunk mains along Camrose Creek, upstream of the 44 Avenue, to reduce the potential overflows from the trunk to the Creek,
- Design and construct the Creekside trunk to provide capacity for the potential future development west of 68 Street (completed in 2007),
- Intercept the lateral lines in the Mohler industrial area into the 600 mm diameter trunk, to reduce surcharging of the laterals,
- Construct a new overflow trunk along Mount Pleasant Drive from 42 Avenue to 43 Avenue, to provide additional protection against flooding in the Mount Pleasant area,
- Construct a pump station and force main in the Mohler area to divert flows from the Bethany trunk and the mainline trunk, and complete point repairs to the Bethany trunk,
- Upgrade the South Lift Station and force main to reduce the frequency of overflows at the lift station,
- Construct a new sanitary trunk to intercept the Enevold trunk and provide capacity for proposed development to the west.

Details are provided in Section 6.

Other recommendations are:

- Monitor flow rates in the 55 Avenue trunk for one season and confirm the capacity of this trunk,
- Pre-design the mainline upgrades in the Camrose Creek Valley to assess alignment options and develop cost estimates,
- Review the design and operational aspects of the in-line storage concept, and related provisions of the Master Plan, based on experience gained in the development process,
- Collect development levies to fund the replacement of trunk facilities that will be required for future development,

- Revise City Development Standards for future development areas in accordance with Section 3.3 and 3.4 and Table 3.6,

- Undertake a program of Inflow/Infiltration reduction to reduce the peak wet weather flows in the sewer system,

- Conduct smoke and dye testing in the area contributing to the Enevold Trunk to search for and eliminate the possibility of extraneous inflows,

- Complete point repairs and waterproof manholes in the Mohler Ravine.

- Update the development projections and the Master Plan as development conditions change over time.

# Closure

This report was prepared for the City of Camrose to provide a Sanitary Sewer Master Plan drainage concept for the City.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Engineering Alberta Ltd.

LARRY E. BODNARUK

Dec. 11, 2007

ALICIA M. DMYTRUK

Dec 11/07

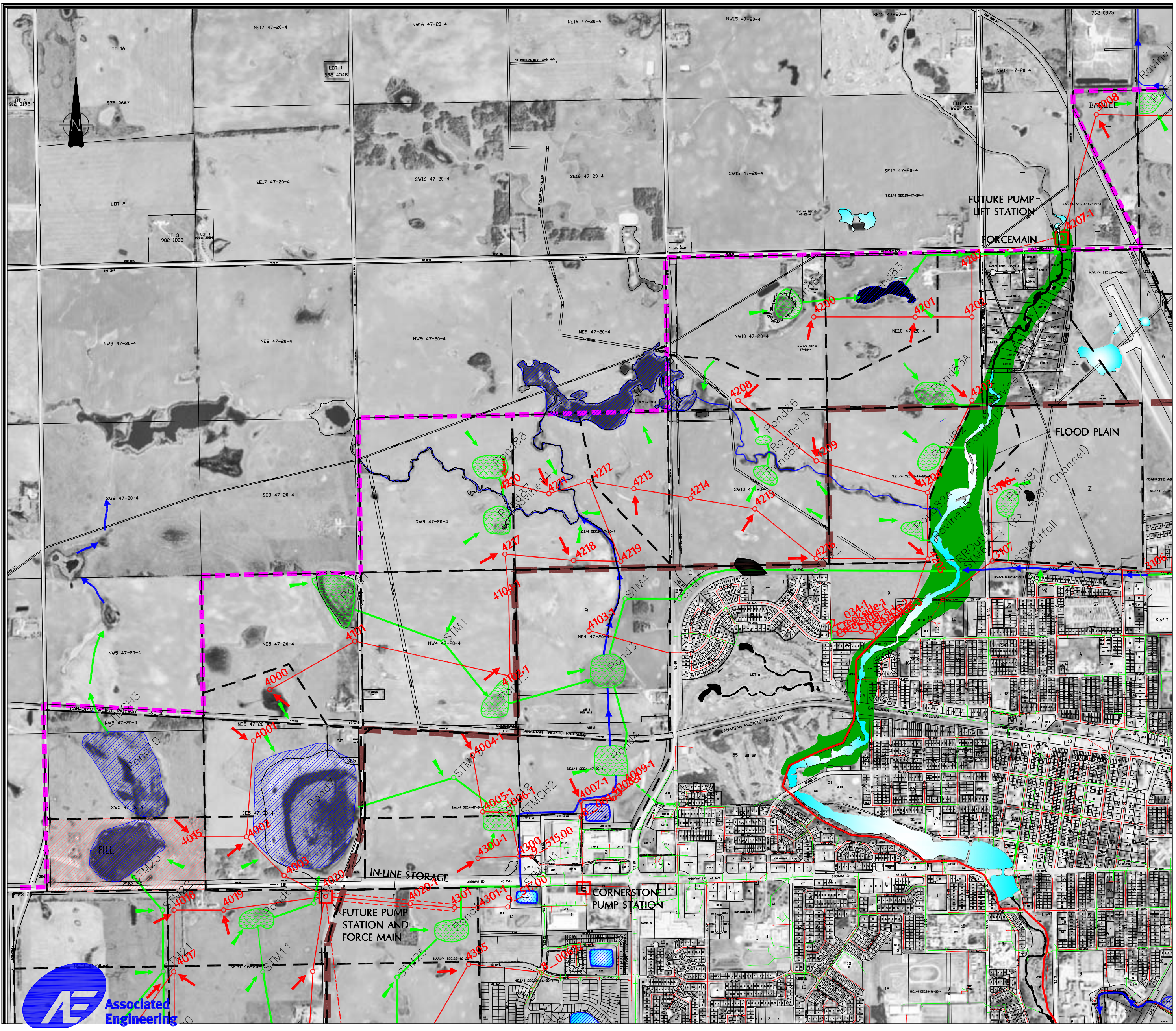
Larry E. Bodnaruk, P.Eng.
Project Manager

Alicia Dymtruk, P.Eng.
Project Engineer

**PERMIT TO PRACTICE**
ASSOCIATED ENGINEERING ALBERTA LTD.
Signature
Date Dec. 11, 2007
**PERMIT NUMBER: P 3979**
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

PERMIT STAMP

# A Appendix A - Sub-Basin Maps



THE CITY OF CAMROSE

# DRAINAGE CONCEPT PLAN
## NORTHWEST CAMROSE

## LEGEND:

- EXISTING SANITARY TRUNK
- PROPOSED SANITARY TRUNK
- OPTIONAL (ULTIMATE) SANITARY TRUNK
- SANITARY FORCEMAIN
- PIPE BRIDGE
- IN-LINE STORAGE PIPE
- SANITARY INLET NODE
- SANITARY PUMP STATION
- 4214 STORM NODE NUMBERS
- CAMROSE CREEK FLOOD PLAIN
- EXISTING WETLAND
- EXISTING STORM SEWER
- STORM TRUNK
- OPTIONAL STORM TRUNK
- STORM INLET NODE
- STORM PUMP STATION
- STORMWATER MANAGEMENT FACILITY
- EXISTING DRAINAGE CHANNEL
- PROPOSED DRAINAGE CHANNEL
- SUB-CATCHMENT BOUNDARY
- CITY BOUNDARY
- PLAN AREA BOUNDARY

SCALE : 1 : 20 000

JANUARY, 2008

FIGURE S-NW

Associated Engineering

Date: Jan 18, 2008
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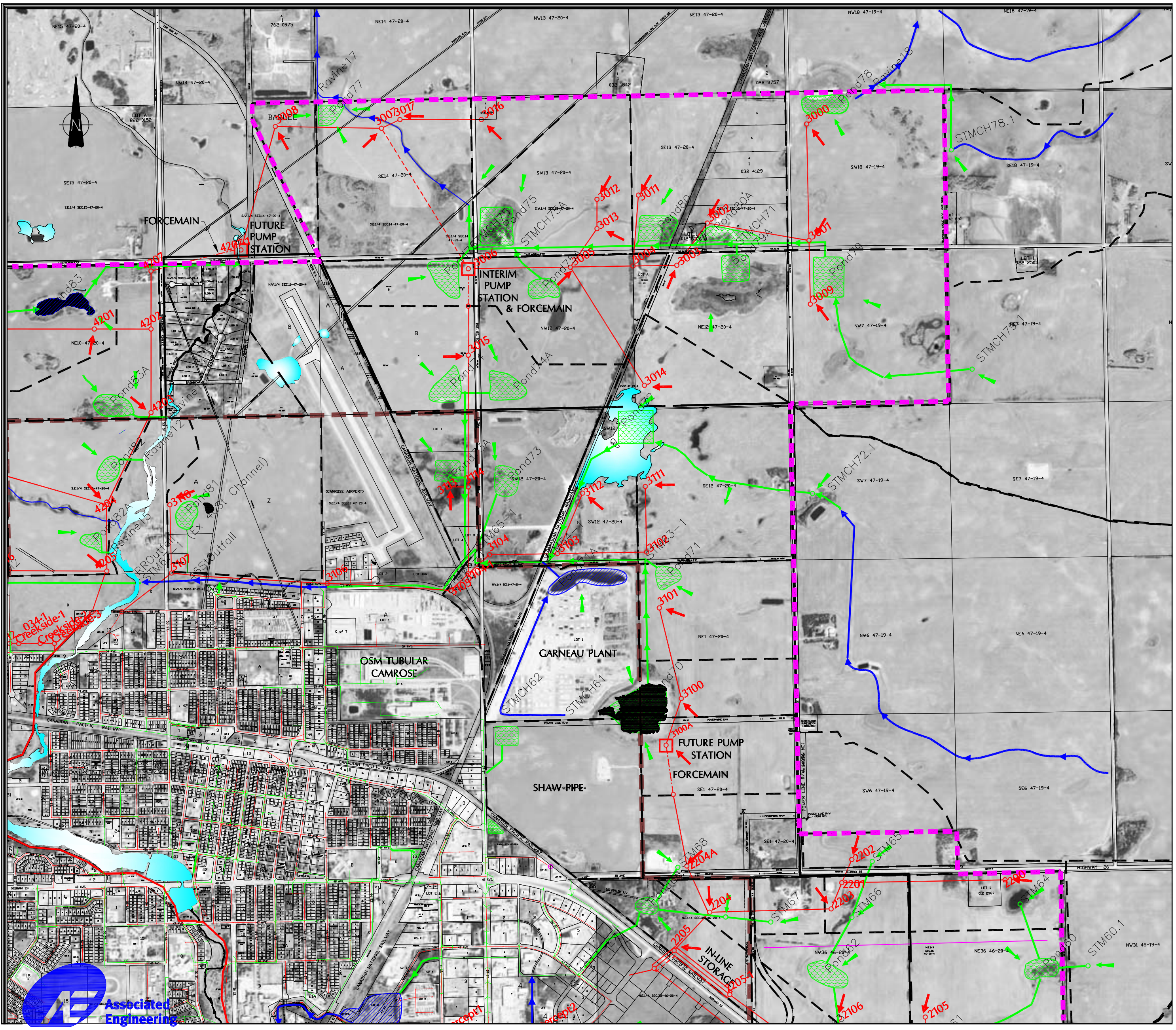


![THE CITY OF CAMROSE]

# THE CITY OF CAMROSE

# DRAINAGE CONCEPT PLAN
## NORTHEAST CAMROSE

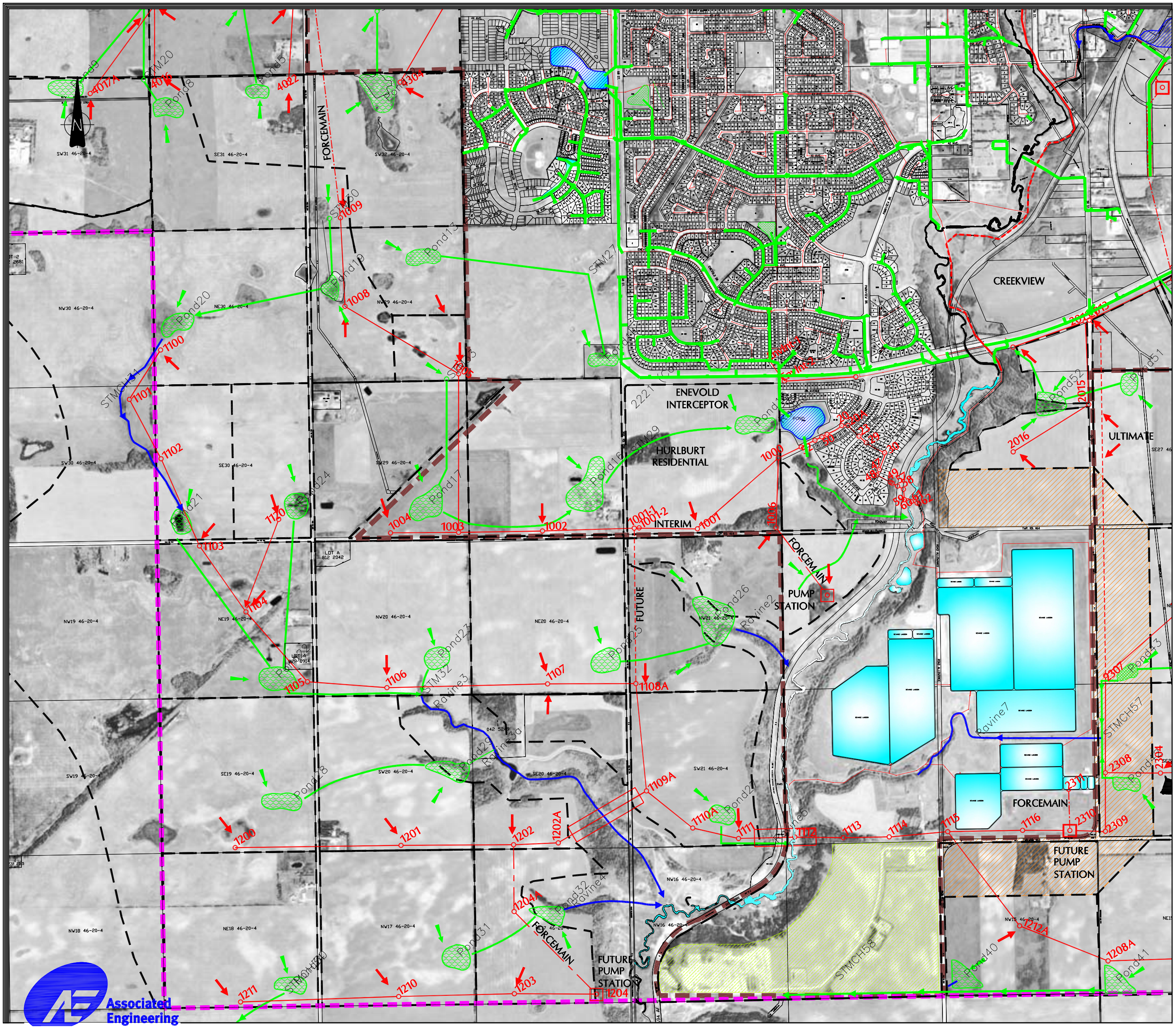
**LEGEND:**

- EXISTING SANITARY TRUNK
- PROPOSED SANITARY TRUNK
- OPTIONAL (ULTIMATE) SANITARY TRUNK
- SANITARY FORCEMAIN
- PIPE BRIDGE
- IN-LINE STORAGE PIPE
- SANITARY INLET NODE
- SANITARY PUMP STATION
- 4214 STORM NODE NUMBERS
- CAMROSE CREEK FLOOD PLAIN
- EXISTING WETLAND
- EXISTING STORM SEWER
- STORM TRUNK
- OPTIONAL STORM TRUNK
- STORM INLET NODE
- STORM PUMP STATION
- STORMWATER MANAGEMENT FACILITY
- EXISTING DRAINAGE CHANNEL
- PROPOSED DRAINAGE CHANNEL
- SUB-CATCHMENT BOUNDARY
- CITY BOUNDARY
- PLAN AREA BOUNDARY

SCALE : 1 : 20 000

JANUARY, 2008

FIGURE 5-NE



## THE CITY OF CAMROSE

# DRAINAGE CONCEPT PLAN
## SOUTHWEST CAMROSE

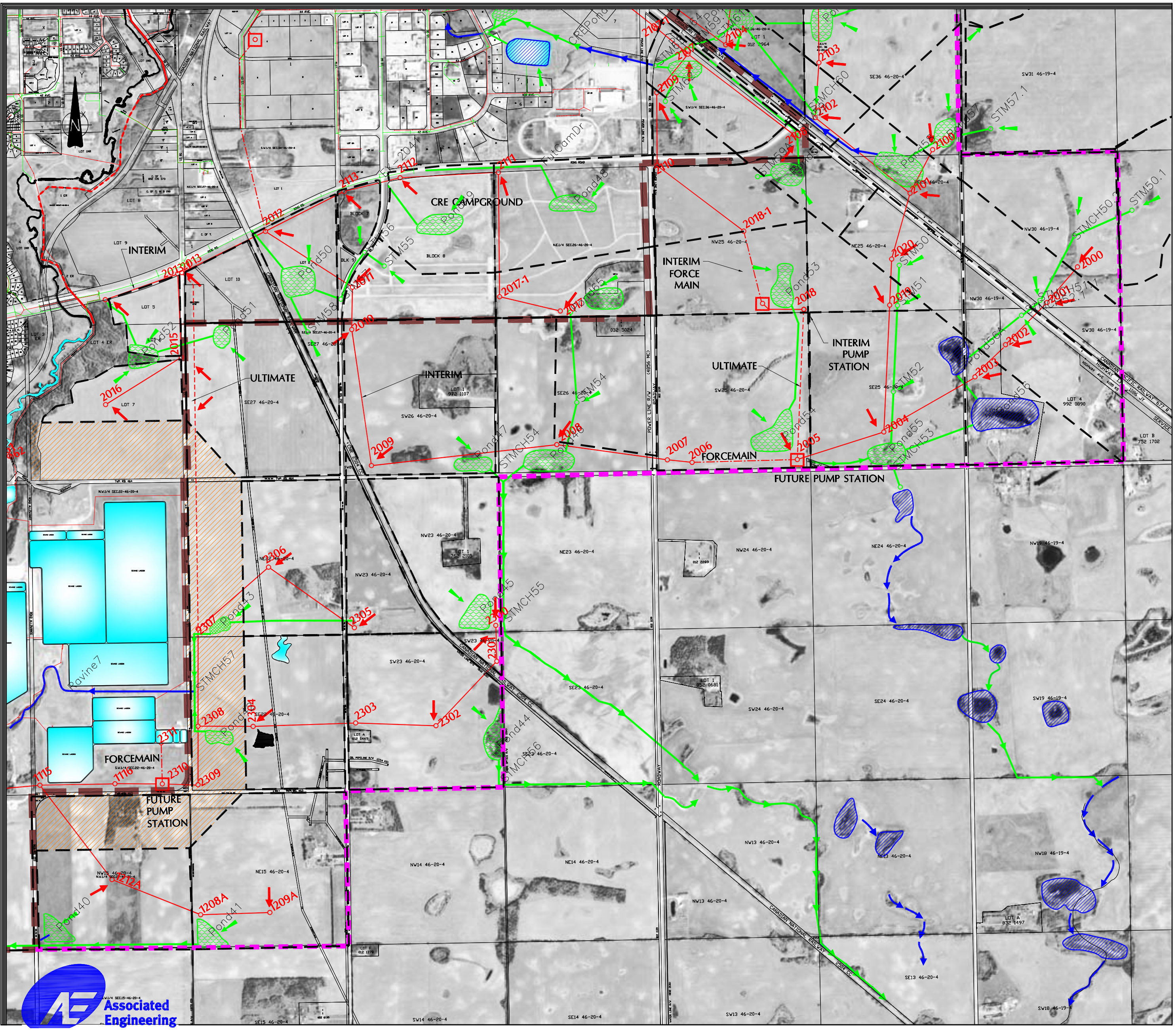
**LEGEND:**

| | |
|---|---|
| —s— | EXISTING SANITARY TRUNK |
| —— | PROPOSED SANITARY TRUNK |
| – – – | OPTIONAL (ULTIMATE) SANITARY TRUNK |
| —·— | SANITARY FORCEMAIN |
| ▭ | PIPE BRIDGE |
| ⬚ | IN-LINE STORAGE PIPE |
| ○← | SANITARY INLET NODE |
| ⊡ | SANITARY PUMP STATION |
| 4214 ○ | STORM NODE NUMBERS |
| ● | CAMROSE CREEK FLOOD PLAIN |
| ▨ | EXISTING WETLAND |
| —D— | EXISTING STORM SEWER |
| —— | STORM TRUNK |
| - - - | OPTIONAL STORM TRUNK |
| ○← | STORM INLET NODE |
| ☐ | STORM PUMP STATION |
| ▨ | STORMWATER MANAGEMENT FACILITY |
| ← | EXISTING DRAINAGE CHANNEL |
| ← | PROPOSED DRAINAGE CHANNEL |
| — — — | SUB-CATCHMENT BOUNDARY |
| — — — | CITY BOUNDARY |
| — — — | PLAN AREA BOUNDARY |

SCALE : 1 : 20 000

JANUARY, 2008

FIGURE S-SW



# THE CITY OF CAMROSE

# DRAINAGE CONCEPT PLAN
## SOUTHEAST CAMROSE

**LEGEND:**

| | |
|---|---|
| —— s —— | EXISTING SANITARY TRUNK |
| ———— | PROPOSED SANITARY TRUNK |
| – – – – | OPTIONAL (ULTIMATE) SANITARY TRUNK |
| —— - —— | SANITARY FORCEMAIN |
| ▭ | PIPE BRIDGE |
| ⬚ | IN-LINE STORAGE PIPE |
| ○← | SANITARY INLET NODE |
| ▣ | SANITARY PUMP STATION |
| 4214 ○ | STORM NODE NUMBERS |
| ● | CAMROSE CREEK FLOOD PLAIN |
| ▨ | EXISTING WETLAND |
| —— D —— | EXISTING STORM SEWER |
| ———— | STORM TRUNK |
| ------- | OPTIONAL STORM TRUNK |
| ○← | STORM INLET NODE |
| ☐ | STORM PUMP STATION |
| ▨ | STORMWATER MANAGEMENT FACILITY |
| ← | EXISTING DRAINAGE CHANNEL |
| ← | PROPOSED DRAINAGE CHANNEL |
| — — — | SUB-CATCHMENT BOUNDARY |
| — — — | CITY BOUNDARY |
| - - - - | PLAN AREA BOUNDARY |

SCALE : 1 : 20 000

JANUARY, 2008

FIGURE S-SE

# B Appendix B - In-Line Storage for New Development Areas

# Technical Memorandum
# City of Camrose Sanitary Master Drainage Plan
# In-Line Storage for New Development Areas

## 1. Background

A 600 mm diameter sanitary trunk runs from the north end of Camrose, alongside Camrose Creek and Mirror Lake, to Highway 13. Computer modeling has shown that the trunk sewer has ample capacity for dry-weather flows but would be surcharged in storm events. This means that the pipe system could spill out the top of manholes located in low areas along Camrose Creek in a severe storm. There is also some risk of backup into house basements in the 55 Avenue area during the 1:100 year storm event as shown in Figure 1.

The City plans to replace the trunk sewer system over time as funding and resources are available, with priority given to the section downstream of Highway 13. In the meantime, the City requires a strategy to accommodate development on the north side of the City.

Accordingly, the City has requested Associated Engineering to investigate the feasibility of in-line storage to service these areas on an interim basis. An in-line storage pipe would store peak flows during storm conditions and would discharge at a controlled rate to the existing trunk after the storm has ended, thus making maximum use of the available trunk capacity.

This concept would enable new development to proceed while contributing development levies to the cost of the ultimate trunk replacement.

## 2. In-Line Storage Concept

Figure 2 illustrates the in-line storage concept and how it might be applied in the Camrose area. It consists of the following components:

- an oversized pipe would convey the normal (dry-weather) flows from the development area to the existing trunk, and would store all the flow during wet-weather conditions when downstream capacity is not available,

- a gate valve in the outlet from the storage pipe would close automatically when the downstream trunk is surcharged and would open again when the downstream flows have decreased and the trunk had enough capacity,

- a water level sensor located in the downstream pipe would signal the gate valve to close and open as required,

- a control orifice in the storage pipe outlet would be sized to pass the dry-weather flows without restriction and to release the stored water at a controlled rate that the trunk sewer can accommodate, after the storm is finished,

- an overflow pipe would allow the storage pipe to overflow to the downstream trunk in the event that it is overfilled, in order to limit the water levels in the in-line storage pipe and to prevent upstream basements from flooding. It would be sized for peak wet-weather flows, but would likely never be used (i.e. it is intended as a fail-safe device).

The overflow pipe is intended as a backup or redundant device to protect against two possibilities:

.1 Malfunction or plugging of the control gate could occur under normal operating conditions. In this case, the overflow would protect upstream houses from flooding, and the downstream trunks have enough capacity to protect downstream houses from floodings.

.2 A major storm event, more severe than the design (1:100 year) storm, could occur and fill up the storage tank. In this case, the overflow would help to protect upstream houses from flooding. Downstream trunks would already be loaded to capacity due to the severity of the storm, and therefore the additional flow could possibly contribute to spillage to the creek. However, the storage tank would delay the peak flow such that it would probably not coincide with the downstream peak and would have, at most, only minor impact even in the most severe conditions.

The in-line storage pipe would have a low-flow section in the bottom of the pipe (a “cunette” section, as shown in Figure 3) that would be sized to carry the dry-weather flow and minimize the deposition of solids during and between storm events.

### 3. Design Criteria

Peak dry-weather flows were estimated from the development area according to the following assumptions:

| | |
|---|---|
| Development density: | 40 persons per gross hectare |
| Average dry-weather flow: | 300 L/person per day |
| Peaking factor: | 2.0 (for areas 65 ha or ¼ section and larger) |

Based on these (conservative) design parameters the average dry-weather flow is 0.14 L/s/ha and the corresponding peak flow is 0.28 L/s/ha.

Storm-related inflow/infiltration (I/I) was estimated using the following parameters:

General I/I: 0.28 L/s/ha consistent with City standards
Depressed manholes: 0.12 L/s/ha
Total peak I/I: 0.40 L/s/ha

Design storage volumes for the in-line storage pipe were estimated with the following assumptions:

Storm duration: no outflow for 12 hours

Peak I/I inflow rate: 0.4 L/s/ha
(average rate is 0.2 L/s/ha over a duration of 12 hours)

Average sanitary inflow rate: 70% of the design peak flow rate, or 0.32 L/s/ha,
over the 12-hour period

Using these assumptions and the development densities cited above, the design storage volume is calculated to be 20.8 m$^3$/ha, which is equivalent to 1.4 m$^3$ per residential lot. For comparison, the City of Edmonton uses a design figure of 1.6 m$^3$/lot for sizing of sanitary wet-weather storage facilities.

The storage pipe would need to be emptied within 48 hours after the storm has ended in order to prevent the stored water from becoming septic and generating odours, and to ensure that storage capacity is available for the next storm event. The required outflow rate is calculated as follows:

Storage drawdown rate : = 20.8 m$^3$/ha ÷ 48 hours
= 0.12 L/s/ha,

plus dry-weather inflow rate: average rate of 0.18 L/s/ha as noted above
over the same 48-hour period,

equals: 0.30 L/s/ha, the total design outflow rate from the
storage pipe during the drawdown period.

## 4. Assessment of System Capacity

The previous computer modeling defined the trunk capacities and peak dry-weather flows under existing conditions. These are summarized in Table 1, along with estimates of allowable flows and development areas which will be discussed below. Note that the flow monitoring program from 1999 to 2004 (Gauge #7) confirms the peak dry-weather flow to be 30 L/s at Highway 13 as indicated by the computer model.

The trunk slope varies somewhat from place to place; furthermore the trunk should not be designed to flow full. Therefore, a safety factor of 20% has been subtracted from the pipefull capacity to determine the maximum available capacity or allowable discharge. Subtracting the peak dry-weather trunk flow that is generated by existing development yields the net capacity that is available during dry-weather conditions. The net capacity can be utilized for draining the proposed in-line storage pipe, after the storm has ended.

As shown in Table 1, the net available dry-weather flow capacity varies from 85 L/s at the upstream end to 186 L/s at Highway 13. Dividing the net available capacity by the required outflow rate from the in-line storage pipe (0.31 L/s/ha as indicated above) yields the maximum allowable development area of 277 ha. This figure is based on the net capacity of the smallest link, a short section of 525 mm diameter pipe from 55 Avenue to Victoria Park. With replacement of this short section of pipe, the allowable development area could be increased to 465 ha.

Therefore, conservatively, 250 to 400 ha could conceivably be serviced with in-line storage without aggravating surcharge conditions in the existing trunks.

For a typical development area of 65 ha (¼ section) the required storage volume is 1,460 $m^3$. Assuming a pipe length of 800 m, the length of a quarter-section, the pipe would need to be 1,800 mm in diameter, which is large but not impossible. The size of pipe and the need for outlet control works would likely rule out the feasibility of this concept for smaller developments.

By constructing a series of in-line storage pipes with their own control works, this concept could be extended upstream as required until all of the allowable development area (250-450 ha) is developed.

The specific design of the storage pipe will vary from location to location. The developer would be required to demonstrate that the concept would work to the City's satisfaction, prior to development approval. Primary requirements would be to confirm the flows, storage volumes, water levels, and operating conditions for the in-line storage conditions, and to minimize the operation and maintenance requirements of the City.

Ultimately, when the existing trunk sewers are replaced downstream, the outlet control orifice and gate valve could be removed and the system would be permitted to flow freely in order to permit additional areas to be developed. Alternatively, the orifice can be modified to maximize the storage in the pipe as the upstream contributing areas are developed, in order to reduce the downstream flows and demands on the South Lift Station, further downstream.

## 5. Conclusions

Based on the analysis described above, it is concluded that in-line storage of wet-weather flows could be feasible for the areas draining to the existing sanitary trunk sewers, and that 250 to 400 hectares could potentially be serviced in this manner prior to the trunk sewer being replaced. Details will depend on local topography and development layout and will need to be confirmed prior to detailed design.

Replacement of the trunk sewer will be required in the longer term as the pipe continues to deteriorate over time, and to permit additional areas to be developed and serviced. The in-line storage pipes could then be converted to a gravity system to permit upstream areas to be developed and drain freely through the system.

Operation and maintenance concerns will be prime considerations in the final acceptance of this concept. These concerns can be minimized through the design provisions described above and with a cautious approach of restricting the number of such facilities until some experience is gained in their operation. This implies that the concept will likely be feasible only for larger development areas of the scale of a quarter-section in size (65 ha) or larger.

The analysis was carried out at a conceptual level of analysis and is subject to confirmation through detailed design. Therefore, no guarantee is expressed or implied that the concept will be feasible for individual or site-specific development areas.

**Table 1**
**City of Camrose North Trunk**
**Pipefull Capacities and Allowable Development Areas**

| Reach | Manholes | Pipefull Capacity (L/s) | Allowable Discharge (L/s)* | Peak DWF Dry-Weather Flow (L/s) | Net Available DWF Capacity (L/s) | Maximum Allowable Development Area (ha)** |
|---|---|---|---|---|---|---|
| 55 Avenue to Victoria Park | T_225.00 to T-223.00 | 120 | 96 | 10 | 86 | 277 |
| Victoria Park to Grandview | T_223.00 to T5-213.00 | 200 | 160 | 16 | 144 | 465 |
| Grandview to Highway 13 | T5_213.00 to T7-219.00 | 270 | 216 | 30 | 186 | 600 |

* 80% of pipefull capacity

** With in-line storage of wet-weather flows

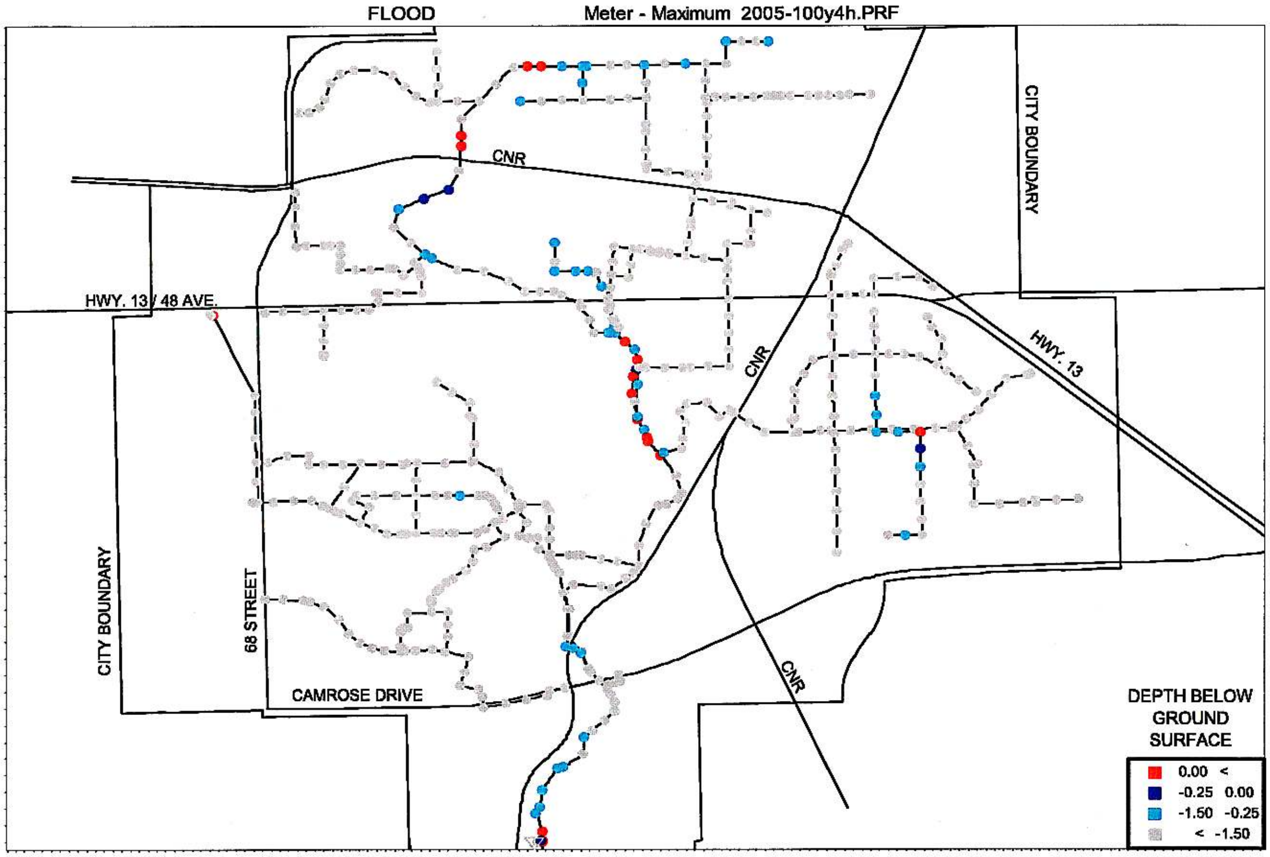
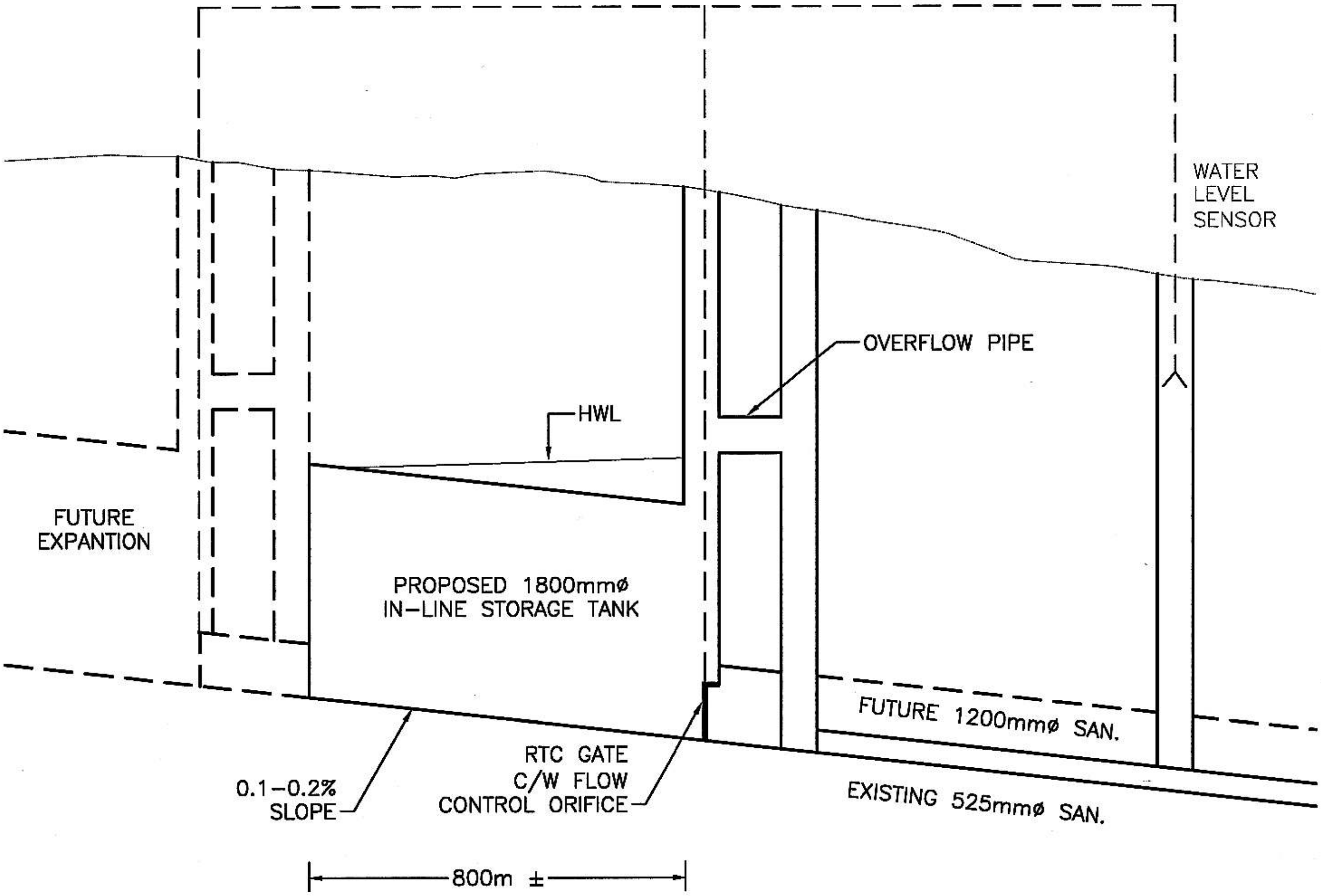


FIGURE 1:
HYDRAULIC GRADE LINE
1:100 YEAR 4 HOUR STORM - EXISTING CONDITIONS



CONCEPTUAL DRAWING
N.T.S.

Time: 1:13pm
Date: Jan 26, 2007
File: Q:\053804\CIVIL\fig_5.0.dwg by

| | |
|---|---|
| PROJECT No. | 053804 |
| DATE: | JANUARY 2007 |
| APPROVED: | APPROVED |
| SCALE: | N.T.S. |
| DWG. No. | FIGURE 2 |

Associated Engineering

## CITY OF CAMROSE

IN-LINE STORAGE CONCEPT

FIGURE 2

# C Appendix C - System Upgrade and Expansion Requirements

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 20l1 | 20 | 20A | Future | 600 | Future | 0.17 | 0.061 | 0.17 | 600 | 32.5 | 0.10 | 734.51 | 734.48 |
| 23l1 | 23 | 29 | Future | 600 | Future | 0.171 | 0.062 | 0.171 | 600 | 52.6 | 0.10 | 734.36 | 734.31 |
| 29l1 | 29 | 30 | Future | 600 | Future | 0.171 | 0.062 | 0.171 | 600 | 115.0 | 0.10 | 734.30 | 734.18 |
| 30l1 | 30 | 47 | Future | 600 | Future | 0.176 | 0.067 | 0.176 | 600 | 92.3 | 0.10 | 734.16 | 734.06 |
| 47l1 | 47 | 48 | Future | 600 | Future | 0.176 | 0.067 | 0.176 | 600 | 31.3 | 0.10 | 734.05 | 734.02 |
| 48l1 | 48 | 49 | Future | 600 | Future | 0.179 | 0.07 | 0.179 | 600 | 90.9 | 0.10 | 733.68 | 733.59 |
| 49l1 | 49 | 57 | Future | 600 | Future | 0.179 | 0.07 | 0.179 | 600 | 33.6 | 33.60 | 733.43 | 722.14 |
| 50l1 | 50 | 20 | Future | 600 | Future | 0.165 | 0.055 | 0.165 | 600 | 120.0 | 0.10 | 734.67 | 734.54 |
| 52l1 | 52 | 50 | Future | 600 | Future | 0.165 | 0.055 | 0.165 | 600 | 120.0 | 0.10 | 734.79 | 734.67 |
| 57l1 | 57 | 58 | Future | 600 | Future | 0.179 | 0.07 | 0.179 | 600 | 35.2 | 8.41 | 721.88 | 718.92 |
| 58l1 | 58 | 59 | Future | 600 | Future | 0.179 | 0.07 | 0.179 | 600 | 56.7 | 3.90 | 718.80 | 716.58 |
| 59l1 | 59 | 60 | Future | 600 | Future | 0.179 | 0.07 | 0.179 | 600 | 32.5 | 1.34 | 716.54 | 716.10 |
| 60l1 | 60 | 61 | Future | 600 | Future | 0.179 | 0.07 | 0.179 | 600 | 31.3 | 3.65 | 716.07 | 714.92 |
| 61l1 | 61 | 62 | Future | 900 | Future | 0.179 | 0.07 | 0.179 | 900 | 10.0 | 0.30 | 714.63 | 714.59 |
| 62l1 | 62 | T_78.00 | Future | 1500 | Future | 3.625 | 2.585 | 3.625 | 1500 | 98.9 | 0.25 | 713.84 | 713.59 |
| 1000 | 1000 | 52 | Future | 600 | Future | 0.165 | 0.055 | 0.165 | 600 | 132.1 | 0.12 | 738.60 | 738.44 |
| 1001 | 1001 | 1000 | Future | Future | Future | 0.146 | 0.035 | 0.146 | 600 | 575.6 | 0.12 | 739.29 | 738.60 |
| 1002 | 1002 | 1001-1 | Future | Future | Future | 0.112 | 0.297 | 0.297 | 675 | 466.1 | 0.54 | 742.44 | 739.91 |
| 1003 | 1003 | 1002 | Future | Future | Future | 0.077 | 0.263 | 0.263 | 675 | 436.6 | 0.28 | 743.65 | 742.44 |
| 1004 | 1004 | 1003 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 300 | 354.2 | 0.05 | 745.78 | 744.02 |
| 1005 | 1005 | 1003 | Future | Future | Future | 0.04 | 0.229 | 0.229 | 600 | 824.9 | 0.62 | 748.80 | 743.72 |
| 1006 | 1006 | 1000 | Future | Future | Future | 0.02 | 0.02 | 0.02 | 300 | 362.4 | 0.22 | 739.70 | 738.90 |
| 1008l1 | 1008 | 1005 | Future | Future | Future | 0.02 | 0.21 | 0.21 | 600 | 687.5 | 0.46 | 751.97 | 748.80 |
| 1009l1 | 1009 | 1008 | Future | Future | Future | 0.004 | 0.195 | 0.195 | 600 | 461.5 | 0.45 | 754.05 | 751.97 |
| 1100 | 1100 | 1101 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 375 | 304.2 | 0.15 | 748.88 | 748.42 |
| 1101 | 1101 | 1102 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 375 | 350.1 | 0.15 | 748.42 | 747.89 |
| 1102 | 1102 | 1103 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 375 | 495.5 | 0.38 | 747.89 | 746.03 |
| 1103 | 1103 | 1104 | Future | Future | Future | 0.054 | 0.054 | 0.054 | 375 | 419.8 | 0.55 | 746.03 | 743.73 |
| 1104 | 1104 | 1105 | Future | Future | Future | 0.108 | 0.108 | 0.108 | 450 | 484.5 | 0.31 | 743.65 | 742.15 |
| 1105 | 1105 | 1106 | Future | Future | Future | 0.108 | 0.108 | 0.108 | 450 | 414.2 | 0.36 | 742.15 | 720.65 |
| 1106 | 1106 | 1107 | Future | Future | Future | 0.143 | 0.143 | 0.143 | 525 | 836.5 | 0.30 | 740.58 | 738.08 |
| 1107 | 1107 | 1108A | Future | Future | Future | 0.188 | 0.188 | 0.188 | 600 | 459.3 | 0.24 | 738.00 | 736.90 |
| 1111 | 1111 | 1112 | Future | Future | Future | 0.389 | 0.684 | 0.684 | 1200 | 292.5 | 0.11 | 733.33 | 733.00 |
| 1112 | 1112 | 1113 | Future | Future | Future | 0.389 | 0.683 | 0.683 | 1200 | 252.7 | 0.11 | 733.00 | 732.72 |
| 1113 | 1113 | 1114 | Future | Future | Future | 0.388 | 0.683 | 0.683 | 1200 | 238.9 | 0.11 | 732.72 | 732.45 |
| 1114 | 1114 | 1115 | Future | Future | Future | 0.388 | 0.682 | 0.682 | 1200 | 300.0 | 0.11 | 732.45 | 732.12 |
| 1115 | 1115 | 1116 | Future | Future | Future | 0.449 | 0.741 | 0.741 | 1200 | 389.4 | 0.10 | 732.12 | 731.73 |
| 1116 | 1116 | 2310 | Future | Future | Future | 0.449 | 0.741 | 0.741 | 1200 | 246.2 | 0.10 | 731.73 | 731.48 |
| 1120l1 | 1120 | 1104 | Future | Future | Future | 0.018 | 0.018 | 0.018 | 300 | 510.8 | 0.84 | 749.20 | 744.93 |
| 1200 | 1200 | 1201 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 375 | 863.1 | 0.20 | 739.42 | 737.70 |
| 1201 | 1201 | 1202 | Future | Future | Future | 0.066 | 0.066 | 0.066 | 450 | 585.7 | 0.20 | 737.62 | 736.45 |
| 1202 | 1202 | 1202A | Future | Future | Future | 0.167 | 0.167 | 0.167 | 675 | 232.7 | 0.10 | 736.23 | 735.99 |
| 1203 | 1203 | 1204 | Future | Future | Future | 0.095 | 0.095 | 0.095 | 525 | 416.0 | 0.10 | 732.77 | 732.36 |
| 1210 | 1210 | 1203 | Future | Future | Future | 0.073 | 0.073 | 0.073 | 450 | 598.0 | 0.12 | 733.56 | 732.85 |
| 1211 | 1211 | 1210 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 375 | 823.6 | 0.15 | 734.88 | 733.64 |
| 2000 | 2000 | 2001 | Future | Future | Future | 0.027 | 0.027 | 0.027 | 300 | 243.0 | 0.53 | 745.95 | 744.65 |
| 2001 | 2001 | 2002 | Future | Future | Future | 0.044 | 0.044 | 0.044 | 300 | 307.7 | 0.50 | 744.65 | 743.12 |
| 2002 | 2002 | 2003 | Future | Future | Future | 0.064 | 0.064 | 0.064 | 375 | 230.3 | 0.51 | 743.04 | 741.87 |
| 2003 | 2003 | 2004 | Future | Future | Future | 0.082 | 0.082 | 0.082 | 375 | 553.0 | 0.51 | 741.87 | 739.04 |
| 2004 | 2004 | 2005 | Future | Future | Future | 0.221 | 0.221 | 0.221 | 750 | 471.6 | 0.13 | 738.67 | 738.07 |
| 2006 | 2006 | 2007 | Future | Future | Future | 0.262 | 0.285 | 0.285 | 900 | 242.4 | 0.10 | 742.80 | 742.55 |
| 2007 | 2007 | 2008 | Future | Future | Future | 0.262 | 0.285 | 0.285 | 900 | 466.1 | 0.10 | 742.55 | 742.08 |
| 2008 | 2008 | 2009 | Future | Future | Future | 0.303 | 0.326 | 0.326 | 900 | 968.6 | 0.10 | 742.08 | 741.11 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 2009 | 2009 | 2010 | Future | Future | Future | 0.34 | 0.363 | 0.363 | 900 | 713.7 | 0.10 | 741.11 | 740.40 |
| 2010 | 2010 | 2011 | Future | Future | Future | 0.342 | 0.365 | 0.365 | 900 | 220.0 | 0.18 | 740.40 | 740.00 |
| 2011 | 2011 | 2012 | Future | Future | Future | 0.355 | 0.378 | 0.378 | 900 | 537.0 | 0.16 | 740.00 | 739.15 |
| 2012 | 2012 | 2013 | Future | Future | Future | 0.872 | 0.895 | 0.895 | 1200 | 484.6 | 0.12 | 738.85 | 738.25 |
| 2013I1 | 2013 | 2307 | Future | Future | Future | Future | 0.903 | 0.903 | 1350 | 1850.0 | 0.12 | 738.10 | 735.95 |
| 2015 | 2015 | 2013-1 | Future | Future | Future | 0.048 | 0.048 | 0.048 | 375 | 439.1 | 0.22 | 737.32 | 736.36 |
| 2016 | 2016 | 2015 | Future | Future | Future | 0.012 | 0.012 | 0.012 | 300 | 463.8 | 0.22 | 738.42 | 737.40 |
| 2017I1 | 2017 | 2017-1 | Future | Future | Future | 0.017 | 0.017 | 0.017 | 300 | 325.0 | 0.22 | 744.72 | 744.00 |
| 2018 | 2018 | 2005 | Future | Future | Future | Future | 0.024 | 0.024 | 300 | 780.3 | 0.22 | 741.08 | 739.37 |
| 2019 | 2019 | 2004 | Future | Future | Future | 0.1 | 0.1 | 0.1 | 600 | 659.0 | 0.16 | 740.85 | 739.83 |
| 2020 | 2020 | 2019 | Future | Future | Future | 0.09 | 0.09 | 0.09 | 525 | 239.5 | 0.16 | 741.30 | 740.92 |
| 2100 | 2100 | 2101 | Future | Future | Future | 0.013 | 0.013 | 0.013 | 300 | 254.6 | 0.40 | 746.10 | 745.08 |
| 2101I1 | 2101 | 2020 | Future | Future | Future | 0.079 | 0.079 | 0.079 | 525 | 355.0 | 0.17 | 741.90 | 741.30 |
| 2101 | 2102 | 2101 | Future | Future | Future | 0.054 | 0.054 | 0.054 | 375 | 630.2 | 0.22 | 743.45 | 742.04 |
| 2103 | 2103 | 2102 | Future | Future | Future | 0.049 | 0.049 | 0.049 | 375 | 285.9 | 0.22 | 744.08 | 743.45 |
| 2104I2 | 2104 | 2205-1 | Future | Future | Future | 0.039 | 0.039 | 0.039 | 375 | 685.0 | 0.15 | 741.48 | 740.48 |
| 2105I1 | 2105 | 2103 | Future | Future | Future | 0.029 | 0.029 | 0.029 | 300 | 375.0 | 0.22 | 744.98 | 744.15 |
| 2106 | 2106 | 2104 | Future | Future | Future | 0.026 | 0.026 | 0.026 | 300 | 277.1 | 0.22 | 742.17 | 741.55 |
| 2107I1 | 2107 | 2107-1 | Future | Future | Future | 0.049 | 0.047 | 0.049 | 300 | 212.1 | 0.22 | 742.86 | 742.40 |
| 2108 | 2108 | 2107 | Future | Future | Future | 0.011 | 0.012 | 0.012 | 300 | 690.3 | 0.22 | 744.35 | 742.86 |
| 2107 | 2109 | 2107 | Future | Future | Future | 0.025 | 0.023 | 0.025 | 375 | 257.6 | 0.22 | 743.42 | 742.86 |
| 2110 | 2110 | 2109 | Future | Future | Future | 0.019 | 0.018 | 0.019 | 375 | 377.3 | 0.25 | 744.38 | 743.42 |
| 2111 | 2111 | 2112 | Future | Future | Future | 0.042 | 0.042 | 0.042 | 375 | 511.2 | 0.23 | 742.47 | 741.33 |
| 2112 | 2112 | 2113 | Future | Future | Future | 0.061 | 0.061 | 0.061 | 450 | 300.3 | 0.21 | 741.25 | 740.61 |
| 2113 | 2113 | 2012 | Future | Future | Future | 0.065 | 0.065 | 0.065 | 450 | 457.1 | 0.22 | 740.61 | 739.60 |
| 2200 | 2200 | 2201 | Future | Future | Future | 0.016 | 0.016 | 0.016 | 300 | 848.8 | 0.32 | 745.62 | 742.90 |
| 2201 | 2201 | 2203 | Future | Future | Future | 0.025 | 0.025 | 0.025 | 300 | 146.7 | 0.22 | 742.90 | 742.58 |
| 2202 | 2202 | 2201 | Future | Future | Future | 0.009 | 0.009 | 0.009 | 300 | 131.5 | 0.22 | 743.19 | 742.90 |
| 2203 | 2203 | 2204 | Future | Future | Future | 0.04 | 0.04 | 0.04 | 375 | 631.6 | 0.25 | 742.50 | 740.92 |
| 2204 | 2204 | 2205 | Future | Future | Future | 0.132 | 0.132 | 0.132 | 525 | 271.9 | 0.25 | 740.77 | 740.10 |
| 2205I1 | 2205 | 9_012.33 | Future | Future | Future | 0.18 | 0.171 | 0.18 | 1200 | 118.8 | 0.18 | 739.26 | 739.05 |
| 2300 | 2300 | 2301 | Future | Future | Future | 0.031 | 0.031 | 0.031 | 300 | 186.1 | 0.44 | 741.45 | 740.64 |
| 2301 | 2301 | 2302 | Future | Future | Future | 0.03 | 0.03 | 0.03 | 375 | 460.2 | 0.21 | 740.56 | 739.60 |
| 2302 | 2302 | 2303 | Future | Future | Future | 0.072 | 0.072 | 0.072 | 450 | 417.3 | 0.21 | 739.52 | 738.65 |
| 2303 | 2303 | 2304 | Future | Future | Future | 0.072 | 0.072 | 0.072 | 450 | 532.8 | 0.21 | 738.65 | 737.53 |
| 2304 | 2304 | 2308 | Future | Future | Future | 0.099 | 0.099 | 0.099 | 525 | 286.6 | 0.17 | 737.45 | 736.96 |
| 2305 | 2305 | 2306 | Future | Future | Future | 0.014 | 0.014 | 0.014 | 300 | 545.1 | 0.28 | 740.75 | 739.20 |
| 2306 | 2306 | 2307 | Future | Future | Future | 0.043 | 0.043 | 0.043 | 375 | 486.4 | 0.24 | 739.13 | 737.95 |
| 2307 | 2307 | 2308 | Future | Future | Future | 0.042 | 0.931 | 0.931 | 1350 | 505.2 | 0.12 | 735.95 | 735.35 |
| 2308 | 2308 | 2309 | Future | Future | Future | 0.141 | 1.009 | 1.009 | 1350 | 304.3 | 0.12 | 735.35 | 735.00 |
| 2309 | 2309 | 2310 | Future | Future | Future | 0.141 | 1.009 | 1.009 | 1350 | 185.1 | 0.12 | 735.00 | 734.77 |
| 3000 | 3000 | 3001 | Future | Future | Future | 0.026 | 0.026 | 0.026 | 300 | 583.1 | 0.22 | 736.45 | 735.17 |
| 3001 | 3001 | 3002 | Future | Future | Future | 0.094 | 0.094 | 0.094 | 525 | 513.0 | 0.14 | 734.92 | 734.22 |
| 3002 | 3002 | 3003 | Future | Future | Future | 0.118 | 0.118 | 0.118 | 600 | 248.1 | 0.14 | 734.15 | 733.80 |
| 3003 | 3003 | 3004 | Future | Future | Future | 0.136 | 0.136 | 0.136 | 600 | 205.4 | 0.14 | 733.80 | 733.51 |
| 3004 | 3004 | 3005 | Future | Future | Future | 0.156 | 0.157 | 0.157 | 675 | 302.9 | 0.14 | 733.44 | 733.02 |
| 3005 | 3005 | 3006 | Future | Future | Future | 0.252 | 0.252 | 0.252 | 750 | 519.2 | 0.14 | 732.94 | 732.21 |
| 3006 | 3006 | 3007 | Future | Future | Future | Future | 0.251 | 0.251 | 750 | 835.5 | 0.22 | 732.21 | 730.40 |
| 3007 | 3007 | 3008 | Future | Future | Future | 0.057 | 0.303 | 0.303 | 750 | 503.8 | 0.19 | 729.50 | 728.55 |
| 3008I1 | 3008 | 4207-1 | Future | Future | Future | 0.066 | 0.312 | 0.312 | 750 | 665.0 | 0.17 | 728.55 | 727.40 |
| 3009 | 3009 | 3001 | Future | Future | Future | 0.046 | 0.046 | 0.046 | 375 | 308.6 | 0.34 | 736.13 | 735.09 |
| 3011I1 | 3011 | 3004 | Future | Future | Future | 0.02 | 0.02 | 0.02 | 300 | 370.0 | 0.24 | 734.70 | 733.81 |
| 3012 | 3012 | 3013 | Future | Future | Future | 0.026 | 0.026 | 0.026 | 300 | 129.6 | 0.22 | 734.13 | 733.85 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 3013 | 3013 | 3005 | Future | Future | Future | 0.035 | 0.035 | 0.035 | 375 | 221.3 | 0.21 | 733.78 | 733.32 |
| 3014 | 3014 | 3005 | Future | Future | Future | 0.016 | 0.016 | 0.016 | 300 | 701.8 | 0.25 | 735.16 | 733.39 |
| 3015I1 | 3015 | 3114 | Future | Future | Future | 0.264 | 0.035 | 0.264 | 750 | 685.0 | 0.20 | 734.20 | 732.86 |
| 3016 | 3016 | 3017 | Future | Future | Future | 0.011 | 0.011 | 0.011 | 300 | 400.3 | 0.22 | 733.45 | 732.57 |
| 3017 | 3017 | 3007 | Future | Future | Future | 0.022 | 0.022 | 0.022 | 300 | 83.7 | 0.24 | 732.57 | 732.37 |
| 3100AI1 | 3100 | 3100A | Future | Future | Future | 0.045 | 0.045 | 0.045 | 375 | 249.3 | 0.19 | 736.58 | 736.10 |
| 3100 | 3101 | 3100 | Future | Future | Future | 0.029 | 0.029 | 0.029 | 300 | 484.5 | 0.22 | 737.70 | 736.65 |
| 3102 | 3102 | 3103 | Future | Future | Future | 0.046 | 0.046 | 0.046 | 375 | 440.5 | 0.17 | 735.05 | 734.29 |
| 3103 | 3103 | 3104 | Future | Future | Future | 0.065 | 0.065 | 0.065 | 450 | 331.5 | 0.20 | 734.22 | 733.56 |
| 3104I1 | 3104 | 3104-1 | Future | Future | Future | 0.092 | 0.092 | 0.092 | 525 | 150.0 | 0.17 | 732.51 | 732.25 |
| 3105 | 3105 | 3106 | Future | Future | Future | 0.367 | 0.141 | 0.367 | 900 | 628.2 | 0.18 | 731.64 | 730.50 |
| 3106 | 3106 | 3107 | Future | Future | Future | 0.367 | 0.14 | 0.367 | 900 | 787.7 | 0.19 | 730.50 | 729.03 |
| 3107 | 3107 | T_227.00 | Future | Future | Future | 0.423 | 0.205 | 0.423 | 900 | 305.7 | 0.17 | 729.03 | 728.50 |
| 3110 | 3110 | 3107 | Future | Future | Future | 0.063 | 0.063 | 0.063 | 375 | 332.5 | 0.32 | 730.63 | 729.55 |
| 3111 | 3111 | 3102 | Future | Future | Future | 0.046 | 0.046 | 0.046 | 375 | 318.7 | 0.18 | 735.63 | 735.05 |
| 3112 | 3112 | 3103 | Future | Future | Future | 0.02 | 0.02 | 0.02 | 300 | 317.3 | 0.22 | 735.07 | 734.37 |
| 3113 | 3113 | 3114 | Future | Future | Future | 0.015 | 0.015 | 0.015 | 300 | 176.4 | 0.22 | 733.70 | 733.31 |
| 3114 | 3114 | 3104-1 | Future | Future | Future | 0.278 | 0.049 | 0.278 | 750 | 450.0 | 0.19 | 732.86 | 732.02 |
| 4000I1 | 4000 | 4101 | Future | Future | Future | 0.007 | 0.007 | 0.007 | 300 | 525.0 | 0.24 | 744.55 | 743.29 |
| 4001 | 4001 | 4002 | Future | Future | Future | 0.014 | 0.014 | 0.014 | 375 | 477.3 | 0.15 | 746.36 | 745.65 |
| 4002 | 4002 | 4003 | Future | Future | Future | 0.045 | 0.045 | 0.045 | 375 | 258.3 | 0.15 | 745.65 | 745.26 |
| 4003I1 | 4003 | 4020 | Future | Future | Future | 0.044 | 0.044 | 0.044 | 375 | 240.0 | 0.15 | 745.26 | 744.90 |
| 4015 | 4015 | 4002 | Future | Future | Future | 0.02 | 0.02 | 0.02 | 300 | 246.5 | 0.22 | 746.74 | 746.20 |
| 4016 | 4016 | 4017 | Future | Future | Future | 0.017 | 0.017 | 0.017 | 300 | 367.6 | 0.27 | 750.72 | 749.73 |
| 4017 | 4017 | 4018 | Future | Future | Future | 0.071 | 0.071 | 0.071 | 450 | 298.8 | 0.27 | 749.58 | 748.77 |
| 4018 | 4018 | 4019 | Future | Future | Future | 0.092 | 0.092 | 0.092 | 450 | 235.0 | 0.29 | 748.77 | 748.08 |
| 4019 | 4019 | 4020 | Future | Future | Future | 0.114 | 0.114 | 0.114 | 450 | 512.7 | 0.31 | 748.08 | 746.50 |
| 4021 | 4021 | 4020 | Future | Future | Future | 0.034 | 0.034 | 0.034 | 300 | 374.8 | 0.50 | 748.56 | 746.69 |
| 4022 | 4022 | 4021 | Future | Future | Future | 0.015 | 0.015 | 0.015 | 300 | 383.8 | 0.55 | 750.67 | 748.56 |
| 4101I1 | 4101 | 4102-1 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 375 | 828.3 | 0.25 | 743.22 | 741.14 |
| 4200 | 4200 | 4201 | Future | Future | Future | 0.028 | 0.028 | 0.028 | 300 | 504.7 | 0.30 | 736.09 | 734.58 |
| 4201 | 4201 | 4202 | Future | Future | Future | 0.046 | 0.046 | 0.046 | 375 | 272.1 | 0.30 | 734.50 | 733.67 |
| 4202 | 4202 | 4203 | Future | Future | Future | 0.111 | 0.356 | 0.356 | 750 | 437.2 | 0.35 | 733.30 | 731.75 |
| 4203 | 4203 | 4204 | Future | Future | Future | 0.129 | 0.373 | 0.373 | 750 | 518.4 | 0.30 | 731.75 | 730.20 |
| 4204 | 4204 | 4205 | Future | Future | Future | 0.162 | 0.405 | 0.405 | 750 | 380.6 | 0.26 | 730.20 | 729.22 |
| 4205 | 4205 | T_225.00 | Future | Future | Future | 0.36 | 0.586 | 0.586 | 900 | 212.4 | 0.35 | 729.08 | 728.33 |
| 4207 | 4207 | 4202 | Future | Future | Future | 0.066 | 0.311 | 0.311 | 675 | 278.4 | 0.33 | 734.28 | 733.37 |
| 4208 | 4208 | 4209 | Future | Future | Future | 0.01 | 0.01 | 0.01 | 300 | 490.5 | 0.45 | 736.70 | 734.47 |
| 4209 | 4209 | 4204 | Future | Future | Future | 0.017 | 0.017 | 0.017 | 300 | 495.8 | 0.77 | 734.47 | 730.64 |
| 4210 | 4210 | 4211 | Future | Future | Future | 0.014 | 0.014 | 0.014 | 300 | 213.1 | 0.25 | 739.20 | 738.67 |
| 4211 | 4211 | 4212 | Future | Future | Future | 0.03 | 0.03 | 0.03 | 300 | 194.2 | 0.25 | 738.67 | 738.18 |
| 4212 | 4212 | 4213 | Future | Future | Future | 0.131 | 0.131 | 0.131 | 525 | 215.8 | 0.32 | 736.66 | 735.97 |
| 4213 | 4213 | 4214 | Future | Future | Future | 0.144 | 0.144 | 0.144 | 525 | 276.1 | 0.26 | 735.97 | 735.26 |
| 4214 | 4214 | 4215 | Future | Future | Future | 0.144 | 0.144 | 0.144 | 525 | 316.0 | 0.33 | 735.26 | 734.21 |
| 4215 | 4215 | 4216 | Future | Future | Future | 0.172 | 0.172 | 0.172 | 525 | 387.4 | 0.31 | 734.21 | 733.01 |
| 4216 | 4216 | 4205 | Future | Future | Future | 0.172 | 0.172 | 0.172 | 525 | 530.9 | 0.67 | 733.01 | 729.46 |
| 4217 | 4217 | 4218 | Future | Future | Future | 0.095 | 0.095 | 0.095 | 450 | 336.3 | 0.32 | 739.38 | 738.30 |
| 4218 | 4218 | 4219 | Future | Future | Future | 0.103 | 0.103 | 0.103 | 450 | 222.8 | 0.17 | 738.30 | 737.93 |
| 4219 | 4219 | 4212 | Future | Future | Future | 0.103 | 0.103 | 0.103 | 450 | 437.3 | 0.27 | 737.93 | 736.74 |
| 4300I1 | 4300 | 9_515.00 | Future | 300 | Future | 0.044 | 0.044 | 0.044 | 300 | 60.6 | 0.20 | 742.18 | 742.06 |
| 4301I2 | 4301 | 4301-1 | Future | Future | Future | 0.112 | 0.008 | 0.112 | 1800 | 120.0 | 0.20 | 743.24 | 743.00 |
| 4304I1 | 4304 | 4305 | Future | Future | Future | 0.033 | 0.033 | 0.033 | 300 | 479.8 | 0.22 | 748.75 | 747.69 |
| 4305I1 | 4305 | 8_006.12 | Future | Future | Future | 0.046 | 0.046 | 0.046 | 375 | 366.4 | 0.28 | 745.13 | 744.09 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 1001-1I2 | 1001-1 | 1108A | Future | Future | Future | Future | 0.297 | 0.297 | 675 | 800.5 | 0.38 | 739.91 | 736.83 |
| 1001-1I1 | 1001-2 | 1001 | Future | Future | Future | 0.112 | 0 | 0.112 | 600 | 340.0 | 0.18 | 739.91 | 739.29 |
| 11_000.00 | 11_000.02 | 3_700.00 | 0.029 | 250 | 0.033 | 0.033 | 0.033 | 0.033 | 250 | 111.3 | 0.29 | 736.42 | 736.09 |
| 11_010.00 | 11_000.03 | 11_000.02 | 0.023 | 250 | 0.033 | 0.033 | 0.033 | 0.033 | 250 | 106.1 | 0.18 | 736.61 | 736.42 |
| 11_020.00 | 11_000.04 | 11_000.03 | 0.03 | 250 | 0.032 | 0.032 | 0.032 | 0.032 | 250 | 18.3 | 0.31 | 736.75 | 736.69 |
| 11_030.00 | 11_030.00 | 11_000.04 | 0.031 | 250 | 0.033 | 0.032 | 0.033 | 0.033 | 250 | 113.5 | 0.33 | 737.16 | 736.78 |
| 11_040.00 | 11_040.00 | 11_030.00 | 0.033 | 250 | 0.029 | 0.03 | 0.029 | 0.03 | 250 | 101.1 | 0.37 | 737.53 | 737.16 |
| 1108A | 1108A | 1109A | Future | Future | Future | 0.201 | 0.496 | 0.496 | 900 | 561.0 | 0.24 | 736.60 | 735.23 |
| 1109A | 1109A | 1110A | Future | Future | Future | 0.368 | 0.663 | 0.663 | 900 | 308.6 | 0.43 | 735.23 | 733.90 |
| 1110A | 1110A | 1111 | Future | Future | Future | 0.368 | 0.663 | 0.663 | 1200 | 244.8 | 0.11 | 733.60 | 733.33 |
| 12_032.00 | 12_032.00 | 12_033.00 | 0.059 | 250 | 0.004 | 0.004 | 0.004 | 0.004 | 250 | 99.2 | 0.90 | 735.39 | 734.50 |
| 12_033.00 | 12_033.00 | 12_034.00 | 0.051 | 250 | 0.004 | 0.004 | 0.004 | 0.004 | 250 | 99.3 | 0.68 | 734.51 | 733.83 |
| 12_034.00 | 12_034.00 | 12_034-1 | 0.057 | 250 | 0.011 | 0.011 | 0.011 | 0.011 | 250 | 55.0 | 0.87 | 733.81 | 733.33 |
| Creekside-1I1 | 12_034-1 | Creekside-1 | Future | 380 | Future | 0.119 | 0.119 | 0.119 | 375 | 47.1 | 1.10 | 731.68 | 731.16 |
| 12_040.00 | 12_040.00 | 12_041.00 | 0.136 | 380 | 0.056 | 0.096 | 0.096 | 0.096 | 375 | 92.2 | 0.55 | 733.68 | 733.17 |
| 12_041.00 | 12_041.00 | 12_042.00 | 0.147 | 380 | 0.054 | 0.096 | 0.096 | 0.096 | 375 | 35.6 | 0.65 | 733.17 | 732.94 |
| 12_042.00 | 12_042.00 | 12_043.00 | 0.081 | 250 | 0.063 | 0.096 | 0.096 | 0.096 | 250 | 10.0 | 1.70 | 732.94 | 732.77 |
| 12_034-1I1 | 12_043.00 | 12_034-1 | Future | Future | Future | 0.108 | 0.108 | 0.108 | 375 | 44.5 | 1.10 | 732.17 | 731.68 |
| 12_044.00 | 12_043.00 | Creekside-4 | 0.085 | 250 | 0.075 | 0 | 0 | 0.079 | 250 | 46.4 | 1.90 | 732.77 | 731.89 |
| 12_047.00 | 12_044.00 | T_223.00 | 0.091 | 250 | 0.073 | 0.001 | 0 | 0.079 | 250 | 120.2 | 2.18 | 730.63 | 728.02 |
| 12_050.00 | 12_050.00 | 12_040.00 | 0.112 | 380 | 0.055 | 0.095 | 0.094 | 0.095 | 375 | 85.1 | 0.38 | 734.03 | 733.71 |
| 12_060.00 | 12_060.00 | 12_050.00 | 0.137 | 380 | 0.051 | 0.091 | 0.091 | 0.091 | 375 | 97.0 | 0.57 | 734.65 | 734.10 |
| 12_070.00 | 12_070.00 | 12_060.00 | 0.13 | 380 | 0.041 | 0.081 | 0.081 | 0.081 | 375 | 109.4 | 0.51 | 735.23 | 734.67 |
| 12_080.00 | 12_080.00 | 12_070.00 | 0.129 | 380 | 0.04 | 0.08 | 0.08 | 0.08 | 375 | 113.9 | 0.50 | 735.80 | 735.23 |
| 12_090.00 | 12_090.00 | 12_080.00 | 0.079 | 300 | 0.036 | 0.076 | 0.076 | 0.076 | 300 | 78.1 | 0.61 | 736.35 | 735.87 |
| 12_100.00 | 12_100.00 | 12_090.00 | 0.075 | 300 | 0.024 | 0.063 | 0.063 | 0.063 | 300 | 82.2 | 0.56 | 736.81 | 736.35 |
| 12_110.00 | 12_110.00 | 12_100.00 | 0.065 | 300 | 0.023 | 0.063 | 0.064 | 0.064 | 300 | 95.3 | 0.42 | 737.25 | 736.85 |
| 12_120.00 | 12_120.00 | 12_110.00 | 0.075 | 300 | 0.004 | 0.045 | 0.045 | 0.045 | 300 | 68.6 | 0.55 | 737.67 | 737.29 |
| 12_130.00 | 12_130.00 | 12_120.00 | 0.072 | 300 | 0.003 | 0.044 | 0.044 | 0.044 | 300 | 69.0 | 0.51 | 738.03 | 737.68 |
| 12_140.00 | 12_140.00 | 12_130.00 | 0.076 | 300 | 0 | 0.041 | 0.041 | 0.041 | 300 | 43.4 | 0.58 | 738.28 | 738.03 |
| 1202A | 1202A | 1109A | Future | Future | Future | 0.167 | 0.167 | 0.167 | 675 | 532.4 | 0.10 | 735.99 | 735.46 |
| 1204A | 1204A | 1202 | Future | Future | Future | 0.095 | 0.094 | 0.095 | 375 | 347.4 | -0.41 | 735.10 | 736.53 |
| 1208A | 1208A | 1212A | Future | Future | Future | 0.044 | 0.044 | 0.044 | 375 | 495.1 | 0.17 | 737.03 | 736.21 |
| 1209A | 1209A | 1208A | Future | Future | Future | 0.044 | 0.044 | 0.044 | 375 | 359.9 | 0.16 | 737.62 | 737.03 |
| 1212A | 1212A | 1115 | Future | Future | Future | 0.072 | 0.072 | 0.072 | 450 | 616.5 | 0.18 | 736.13 | 735.05 |
| 2_130.00 | 2_130.00 | 2_140.00 | 0.018 | 200 | 0.008 | 0.008 | 0.008 | 0.008 | 200 | 117.6 | 0.37 | 735.10 | 734.66 |
| 2_140.00 | 2_140.00 | 2_220.00 | 0.044 | 300 | 0.015 | 0.015 | 0.015 | 0.015 | 300 | 117.6 | 0.26 | 734.66 | 734.36 |
| 2_141.00 | 2_220.00 | 2_230.00 | 0.039 | 300 | 0.024 | 0.025 | 0.025 | 0.025 | 300 | 117.6 | 0.19 | 734.34 | 734.11 |
| 2_360.00 | 2_230.00 | 2_360.00 | 0.051 | 300 | -0.015 | -0.016 | -0.016 | -0.015 | 300 | 154.7 | 0.34 | 734.09 | 733.57 |
| 2_231.00 | 2_230.00 | 2_231.00 | 0.065 | 250 | 0.043 | 0.047 | 0.047 | 0.049 | 250 | 99.1 | 1.46 | 734.10 | 732.65 |
| 2_232.00 | 2_231.00 | T_229.00 | 0.068 | 250 | 0.043 | 0.049 | 0.049 | 0.051 | 250 | 106.2 | 1.56 | 732.62 | 730.96 |
| 2_370.00 | 2_360.00 | 2_370.00 | 0.019 | 250 | 0.013 | -0.014 | -0.014 | 0.013 | 250 | 99.7 | 0.10 | 733.57 | 733.47 |
| 2_400.00 | 2_370.00 | 2_410.00 | 0.019 | 250 | 0.015 | 0.014 | 0.014 | 0.015 | 250 | 98.9 | 0.09 | 733.47 | 733.38 |
| 2_430.00 | 2_381.00 | 2_382.00 | 0.179 | 300 | 0.023 | 0.022 | 0.023 | 0.023 | 300 | 10.0 | 4.13 | 733.59 | 733.18 |
| 2_470.00 | 2_382.00 | 2_385.00 | 0.023 | 300 | 0.023 | 0.022 | 0.022 | 0.023 | 300 | 88.6 | 0.07 | 733.18 | 733.12 |
| 2_480.00 | 2_385.00 | T_233.00 | 0.03 | 300 | 0.025 | 0.024 | 0.025 | 0.025 | 300 | 109.7 | 0.12 | 733.12 | 732.99 |
| 2_410.00 | 2_400.00 | 2_410.00 | 0.033 | 200 | 0.002 | 0.002 | 0.002 | 0.002 | 200 | 155.2 | 1.20 | 737.23 | 735.37 |
| 2_420.00 | 2_410.00 | 2_381.00 | 0.09 | 250 | 0.017 | 0.016 | 0.016 | 0.017 | 250 | 10.0 | -2.14 | 733.38 | 733.59 |
| 3_735.00 | 2_510.00 | 3_734.00 | 0.093 | 250 | -0.004 | -0.004 | -0.004 | -0.004 | 250 | 39.6 | 0.20 | 737.36 | 737.28 |
| 2_511.00 | 2_510.00 | 2_511.00 | 0.06 | 300 | 0.046 | 0.049 | 0.049 | 0.059 | 300 | 106.1 | 0.40 | 734.88 | 734.45 |
| 2_512.00 | 2_511.00 | T_236.00 | 0.055 | 300 | 0.048 | 0.051 | 0.051 | 0.061 | 300 | 97.9 | 0.34 | 734.45 | 734.12 |
| 2_513.00 | 2_512.00 | T_237.00 | 0.044 | 300 | 0.013 | -0.009 | -0.009 | 0.013 | 300 | 126.0 | 0.25 | 734.67 | 734.35 |
| 2_515.00 | 2_514.00 | 2_512.00 | 0.05 | 300 | -0.009 | 0.007 | 0.007 | 0.007 | 300 | 86.2 | 0.32 | 734.91 | 734.63 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 2_516.00 | 2_516.00 | 2_514.00 | 0.041 | 300 | -0.008 | -0.006 | -0.006 | -0.006 | 300 | 86.2 | 0.22 | 735.10 | 734.91 |
| 2_518.00 | 2_517.00 | 2_516.00 | 0.048 | 300 | -0.006 | -0.004 | -0.004 | -0.004 | 300 | 74.3 | 0.30 | 735.39 | 735.17 |
| 2_510.00 | 2_520.00 | 2_510.00 | 0.028 | 250 | 0.044 | 0.045 | 0.045 | 0.056 | 250 | 49.5 | 0.27 | 735.01 | 734.88 |
| 2_520.00 | 2_530.00 | 2_520.00 | 0.03 | 250 | 0.044 | 0.046 | 0.046 | 0.057 | 250 | 67.2 | 0.31 | 735.21 | 735.01 |
| 2_530.00 | 2_540.00 | 2_530.00 | 0.03 | 250 | 0.022 | 0.024 | 0.024 | 0.037 | 250 | 75.6 | 0.31 | 735.49 | 735.25 |
| 2_540.00 | 2_550.00 | 2_540.00 | 0.031 | 250 | 0.021 | 0.023 | 0.023 | 0.036 | 250 | 76.7 | 0.33 | 735.75 | 735.50 |
| 2_550.00 | 2_560.00 | 2_550.00 | 0.028 | 250 | 0.021 | 0.023 | 0.023 | 0.035 | 250 | 80.8 | 0.26 | 735.96 | 735.75 |
| 2_560.00 | 2_570.00 | 2_560.00 | 0.025 | 250 | 0.021 | 0.022 | 0.022 | 0.034 | 250 | 34.8 | 0.40 | 736.10 | 735.96 |
| 2_570.00 | 2_580.00 | 2_570.00 | 0.019 | 250 | 0.017 | 0.019 | 0.019 | 0.031 | 250 | 41.1 | 0.24 | 736.20 | 736.10 |
| 2_580.00 | 2_590.00 | 2_580.00 | 0.027 | 250 | 0.017 | 0.018 | 0.018 | 0.03 | 250 | 57.2 | 0.25 | 736.35 | 736.21 |
| 2_590.00 | 2_600.00 | 2_590.00 | 0.026 | 250 | 0.018 | 0.019 | 0.019 | 0.03 | 250 | 99.3 | 0.24 | 736.59 | 736.36 |
| 2_600.00 | 2_610.00 | 2_600.00 | 0.029 | 250 | 0.011 | 0.012 | 0.012 | 0.024 | 250 | 57.9 | 0.28 | 736.74 | 736.57 |
| 2_610.00 | 2_620.00 | 2_610.00 | 0.031 | 250 | 0.01 | 0.011 | 0.011 | 0.024 | 250 | 58.4 | 0.32 | 736.92 | 736.73 |
| 2_620.00 | 2_630.00 | 2_620.00 | 0.028 | 250 | 0.01 | 0.011 | 0.01 | 0.023 | 250 | 58.8 | 0.27 | 737.07 | 736.91 |
| 2_630.00 | 2_640.00 | 2_630.00 | 0.033 | 250 | 0.01 | 0.011 | 0.011 | 0.024 | 250 | 57.7 | 0.38 | 737.29 | 737.07 |
| 2_640.00 | 2_650.00 | 2_640.00 | 0.023 | 200 | 0.01 | 0.011 | 0.011 | 0.025 | 200 | 132.2 | 0.45 | 737.91 | 737.31 |
| 2013 | 2013-1 | 8_082.50 | Future | Future | Future | 0.922 | 0.048 | 0.922 | 900 | 420.8 | 0.59 | 735.83 | 733.35 |
| 2017-1I1 | 2017-1 | 2111 | Future | Future | Future | 0.017 | 0.017 | 0.017 | 300 | 650.0 | 0.22 | 744.00 | 742.55 |
| 2018-1I1 | 2018-1 | 2110 | Future | Future | Future | 0.008 | 0 | 0.008 | 300 | 565.0 | 0.23 | 745.75 | 744.45 |
| 2018I1 | 2018-pump | 2018-1 | Future | Future | Future | 0.008 | 0 | 0.008 | 300 | 490.0 | -0.78 | 741.95 | 745.75 |
| 20AI1 | 20A | 23 | Future | 600 | Future | 0.17 | 0.061 | 0.17 | 600 | 80.3 | 0.10 | 734.45 | 734.37 |
| 2107-1I1 | 2107-1 | 9_012.33 | Future | 300 | Future | 0.049 | 0.047 | 0.049 | 300 | 775.9 | 0.35 | 742.40 | 739.68 |
| 2204AI1 | 2204A | 2204 | Future | Future | Future | 0.088 | 0.088 | 0.088 | 450 | 260.1 | 0.19 | 741.55 | 741.05 |
| 2104I1 | 2205-1 | 2205 | Future | Future | Future | 0.053 | 0.055 | 0.055 | 1200 | 350.0 | 0.12 | 739.67 | 739.26 |
| 3_016.00 | 3_016.00 | 3_215.00 | 0.04 | 250 | 0.057 | 0.059 | 0.059 | 0.059 | 250 | 29.7 | 0.43 | 727.90 | 727.77 |
| 3_017.00 | 3_017.00 | 3_016.00 | 0.038 | 250 | 0.057 | 0.059 | 0.059 | 0.059 | 250 | 71.9 | 0.38 | 728.17 | 727.90 |
| 3_018.00 | 3_018.00 | 3_017.00 | 0.042 | 250 | 0.055 | 0.057 | 0.057 | 0.057 | 250 | 111.9 | 0.47 | 728.69 | 728.17 |
| 3_019.00 | 3_019.00 | 3_018.00 | 0.07 | 200 | 0.054 | 0.055 | 0.055 | 0.055 | 200 | 59.0 | 5.52 | 732.25 | 728.99 |
| 3_020.00 | 3_020.00 | 3_019.00 | 0.027 | 200 | 0.053 | 0.053 | 0.053 | 0.053 | 200 | 113.6 | 0.82 | 733.21 | 732.28 |
| 3_005.00 | 3_120.00 | 3_130.00 | 0.04 | 250 | 0.022 | 0.022 | 0.022 | 0.022 | 250 | 117.6 | 0.55 | 738.10 | 737.45 |
| 2_120.03 | 3_120.03 | 3_120.00 | 0.02 | 200 | 0.005 | 0.005 | 0.005 | 0.005 | 200 | 102.0 | 0.47 | 738.60 | 738.12 |
| 3_120.04 | 3_120.04 | 3_120.03 | 0.019 | 200 | 0.003 | 0.003 | 0.003 | 0.003 | 200 | 101.5 | 0.42 | 739.02 | 738.59 |
| 3_120.05 | 3_120.05 | 3_120.04 | 0.019 | 200 | 0.002 | 0.002 | 0.002 | 0.002 | 200 | 100.7 | 0.41 | 739.45 | 739.04 |
| 3_127.00 | 3_120.06 | 3_120.07 | 0.025 | 200 | 0.002 | 0.002 | 0.002 | 0.002 | 200 | 109.0 | 0.70 | 740.62 | 739.86 |
| 3_126.00 | 3_120.06 | 3_120.05 | 0.034 | 200 | 0 | 0 | 0 | 0 | 200 | 101.6 | 1.30 | 740.77 | 739.45 |
| 3_128.00 | 3_120.07 | 3_120.08 | 0.029 | 200 | 0.008 | 0.008 | 0.008 | 0.008 | 200 | 66.6 | 0.93 | 739.86 | 739.24 |
| 3_445.00 | 3_120.08 | 3_440.00 | 0.021 | 200 | 0.011 | 0.011 | 0.011 | 0.011 | 200 | 55.3 | 0.52 | 739.23 | 738.94 |
| 3_004.00 | 3_130.00 | 3_140.00 | 0.066 | 250 | 0.033 | 0.033 | 0.033 | 0.033 | 250 | 105.8 | 1.50 | 737.36 | 735.78 |
| 3_003.00 | 3_140.00 | 3_150.00 | 0.033 | 250 | 0.036 | 0.036 | 0.036 | 0.036 | 250 | 47.9 | 0.38 | 735.75 | 735.57 |
| 3_002.00 | 3_150.00 | 3_160.00 | 0.038 | 250 | 0.043 | 0.043 | 0.043 | 0.043 | 250 | 99.3 | 0.50 | 735.63 | 735.13 |
| 3_160.00 | 3_160.00 | T7_141.00 | 0.137 | 250 | 0.046 | 0.046 | 0.046 | 0.046 | 250 | 103.6 | 6.46 | 735.04 | 728.35 |
| 3_217.00 | 3_214.00 | 3_217.00 | 0.039 | 250 | 0.057 | 0.059 | 0.059 | 0.059 | 250 | 92.4 | 0.40 | 727.67 | 727.30 |
| 3_215.00 | 3_215.00 | 3_214.00 | 0.041 | 250 | 0.057 | 0.059 | 0.059 | 0.059 | 250 | 15.4 | 0.43 | 727.77 | 727.71 |
| 3_218.00 | 3_217.00 | 3_218.00 | 0.007 | 300 | 0.057 | 0.059 | 0.059 | 0.059 | 300 | 37.5 | 0.01 | 727.30 | 727.30 |
| T3_149.00 | 3_218.00 | T3_148.00 | 0.066 | 300 | 0.057 | 0.059 | 0.059 | 0.059 | 300 | 82.7 | 0.56 | 727.30 | 726.83 |
| 3_224.00 | 3_222.00 | 3_224.00 | 0.052 | 250 | 0.031 | 0.033 | 0.033 | 0.033 | 250 | 92.9 | 0.94 | 733.27 | 732.39 |
| 3_225.00 | 3_224.00 | 3_225.00 | 0.053 | 250 | 0.033 | 0.035 | 0.035 | 0.035 | 250 | 83.9 | 0.95 | 732.39 | 731.60 |
| T3_120.00 | 3_225.00 | T3_120.00 | 0.336 | 380 | 0.111 | 0.116 | 0.116 | 0.116 | 375 | 77.4 | 4.43 | 731.41 | 727.97 |
| 3_226.00 | 3_226.00 | 3_225.00 | 0.222 | 380 | 0.079 | 0.081 | 0.081 | 0.081 | 375 | 96.9 | 1.93 | 733.31 | 731.43 |
| 3_230.00 | 3_231.00 | 3_226.00 | 0.074 | 380 | 0.078 | 0.08 | 0.08 | 0.08 | 375 | 77.2 | 0.21 | 733.56 | 733.39 |
| 3_231.00 | 3_232.00 | 3_231.00 | 0.058 | 380 | 0.077 | 0.079 | 0.079 | 0.079 | 375 | 91.4 | 0.13 | 733.68 | 733.56 |
| 3_232.00 | 3_233.00 | 3_232.00 | 0.017 | 380 | 0.075 | 0.077 | 0.077 | 0.077 | 375 | 58.5 | 0.01 | 734.07 | 734.06 |
| 3_233.00 | 3_234.00 | 3_233.00 | 0.076 | 380 | 0.071 | 0.073 | 0.073 | 0.073 | 375 | 50.0 | 0.23 | 734.18 | 734.07 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 3_234.00 | 3_235.00 | 3_234.00 | 0.049 | 380 | 0.069 | 0.071 | 0.071 | 0.071 | 375 | 53.8 | 0.09 | 734.21 | 734.16 |
| 3_235.00 | 3_236.00 | 3_235.00 | 0.071 | 380 | 0.064 | 0.065 | 0.065 | 0.065 | 375 | 99.2 | 0.20 | 734.41 | 734.21 |
| 3_236.00 | 3_237.00 | 3_236.00 | 0.057 | 300 | 0.06 | 0.061 | 0.061 | 0.061 | 300 | 84.2 | 0.41 | 734.79 | 734.44 |
| 3_237.00 | 3_238.00 | 3_237.00 | 0.035 | 300 | 0.059 | 0.06 | 0.06 | 0.06 | 300 | 88.9 | 0.15 | 734.98 | 734.84 |
| 3_238.00 | 3_239.00 | 3_238.00 | 0.041 | 300 | 0.059 | 0.06 | 0.06 | 0.06 | 300 | 41.8 | -0.22 | 734.89 | 734.98 |
| 3_266.00 | 3_243.00 | 3_247.00 | 0.005 | 250 | 0.025 | 0.025 | 0.025 | 0.025 | 250 | 49.9 | 0.01 | 734.92 | 734.92 |
| 3_265.00 | 3_247.00 | 3_275.00 | 0.059 | 250 | 0.025 | 0.025 | 0.025 | 0.025 | 250 | 54.6 | 1.21 | 734.91 | 734.25 |
| 3_250.00 | 3_252.00 | 3_222.00 | 0.034 | 250 | 0.027 | 0.027 | 0.027 | 0.027 | 250 | 99.3 | 0.39 | 733.66 | 733.27 |
| 3_263.00 | 3_264.00 | 3_252.00 | 0.038 | 250 | 0.025 | 0.025 | 0.025 | 0.025 | 250 | 49.7 | 0.50 | 733.91 | 733.66 |
| 3_267.00 | 3_271.00 | 3_243.00 | 0.042 | 250 | 0.025 | 0.025 | 0.025 | 0.025 | 250 | 99.4 | 0.62 | 735.53 | 734.92 |
| 3_264.00 | 3_275.00 | 3_264.00 | 0.042 | 250 | 0.025 | 0.025 | 0.025 | 0.025 | 250 | 54.9 | 0.62 | 734.25 | 733.91 |
| 3_400.00 | 3_400.00 | 11_030.00 | 0.023 | 200 | 0.003 | 0.003 | 0.003 | 0.003 | 200 | 125.9 | 0.62 | 739.14 | 738.36 |
| 3_410.01 | 3_410.00 | 3_400.00 | 0.028 | 200 | 0 | 0 | 0 | 0 | 200 | 75.3 | 0.89 | 739.87 | 739.20 |
| 3_410.00 | 3_420.00 | 3_410.00 | 0.011 | 200 | -0.001 | -0.001 | -0.001 | -0.001 | 200 | 24.2 | -0.12 | 739.71 | 739.74 |
| 3_420.00 | 3_420.00 | 3_430.00 | 0.014 | 200 | 0.004 | 0.004 | 0.004 | 0.004 | 200 | 108.6 | 0.21 | 739.71 | 739.49 |
| 3_446.00 | 3_430.00 | 3_440.00 | 0.023 | 200 | 0.005 | 0.005 | 0.005 | 0.005 | 200 | 104.4 | 0.58 | 739.49 | 738.89 |
| 3_451.00 | 3_440.00 | 3_450.00 | 0.028 | 200 | 0.018 | 0.018 | 0.018 | 0.018 | 200 | 130.7 | 0.91 | 738.84 | 737.65 |
| 3_268.00 | 3_450.00 | 3_271.00 | 0.044 | 250 | 0.025 | 0.025 | 0.025 | 0.025 | 250 | 111.5 | 0.65 | 737.64 | 736.92 |
| 3_239.00 | 3_700.00 | 3_239.00 | 0.021 | 250 | 0.058 | 0.059 | 0.059 | 0.059 | 250 | 133.9 | 0.15 | 735.09 | 734.89 |
| 3_710.00 | 3_710.00 | 3_700.00 | 0.046 | 300 | 0.028 | 0.028 | 0.028 | 0.028 | 300 | 85.5 | 0.21 | 735.63 | 735.45 |
| 3_711.00 | 3_720.00 | 3_710.00 | 0.046 | 300 | 0.027 | 0.027 | 0.027 | 0.027 | 300 | 56.7 | 0.21 | 735.75 | 735.63 |
| 3_720.00 | 3_721.00 | 3_720.00 | 0.039 | 250 | 0.004 | -0.005 | -0.004 | 0.004 | 250 | 59.2 | 0.52 | 736.06 | 735.75 |
| 3_730.00 | 3_730.00 | 3_720.00 | 0.049 | 300 | 0.008 | 0.007 | 0.006 | 0.008 | 300 | 62.1 | 0.24 | 735.95 | 735.80 |
| 3_729.00 | 3_730.00 | 3_721.00 | 0.057 | 250 | 0.003 | 0.002 | 0.002 | 0.003 | 250 | 27.0 | -1.11 | 735.80 | 736.10 |
| 3_731.00 | 3_731.00 | 3_730.00 | 0.03 | 250 | 0.008 | 0.008 | 0.008 | 0.008 | 250 | 94.9 | 0.31 | 736.39 | 736.10 |
| 3_732.00 | 3_732.00 | 3_731.00 | 0.029 | 250 | 0.008 | 0.008 | 0.008 | 0.008 | 250 | 122.1 | 0.29 | 736.74 | 736.39 |
| 3_733.00 | 3_733.00 | 3_732.00 | 0.028 | 250 | 0.006 | 0.006 | 0.006 | 0.006 | 250 | 121.8 | 0.26 | 737.06 | 736.74 |
| 3_734.00 | 3_734.00 | 3_733.00 | 0.029 | 250 | -0.004 | -0.004 | -0.004 | -0.004 | 250 | 75.0 | 0.29 | 737.28 | 737.06 |
| 3_740.00 | 3_740.00 | 3_720.00 | 0.043 | 250 | 0.019 | 0.019 | 0.019 | 0.019 | 250 | 55.0 | 0.49 | 736.12 | 735.85 |
| 3_750.00 | 3_750.00 | 3_740.00 | 0.031 | 250 | 0.016 | 0.016 | 0.016 | 0.016 | 250 | 116.8 | 0.26 | 736.42 | 736.12 |
| 3_760.00 | 3_760.00 | 3_750.00 | 0.038 | 250 | 0.012 | 0.012 | 0.012 | 0.012 | 250 | 116.3 | 0.37 | 736.85 | 736.42 |
| 3_761.00 | 3_761.00 | 3_760.00 | 0.016 | 250 | 0.01 | 0.01 | 0.01 | 0.01 | 250 | 31.7 | 0.07 | 736.95 | 736.92 |
| 3_762.00 | 3_762.00 | 3_761.00 | 0.036 | 200 | 0.01 | 0.01 | 0.01 | 0.01 | 200 | 10.0 | 2.80 | 737.23 | 736.95 |
| 3_763.00 | 3_763.00 | 3_762.00 | 0.018 | 200 | 0.003 | 0.003 | 0.003 | 0.003 | 200 | 83.4 | 0.37 | 737.54 | 737.23 |
| 3_764.00 | 3_764.00 | 3_763.00 | 0.024 | 200 | 0 | 0 | 0 | 0 | 200 | 83.4 | 0.64 | 738.08 | 737.54 |
| 3006-pumpl1 | 3006-pump | 3015 | Future | Future | Future | 0.235 | 0 | 0.235 | 450 | 450.0 | -0.44 | 732.50 | 734.50 |
| 3100-pumpl1 | 3100-pump | 2204A | Future | Future | Future | 0.068 | 0.068 | 0.068 | 300 | 590.0 | -0.95 | 736.10 | 741.70 |
| 3104 | 3104-1 | 3105 | Future | Future | Future | 0.367 | 0.141 | 0.367 | 900 | 120.0 | 0.19 | 731.87 | 731.64 |
| 4_001.01 | 4_001.00 | T5_213.00 | 0.217 | 300 | 0.044 | 0.053 | 0.053 | 0.053 | 300 | 75.3 | 6.11 | 732.03 | 727.43 |
| 4_001.00 | 4_002.00 | 4_001.00 | 0.225 | 300 | 0.037 | 0.046 | 0.046 | 0.046 | 300 | 26.0 | 6.53 | 733.73 | 732.03 |
| 4_003.00 | 4_003.00 | 4_002.00 | 0.054 | 200 | 0.01 | 0.011 | 0.011 | 0.011 | 200 | 34.4 | 3.28 | 734.83 | 733.70 |
| 4_004.00 | 4_004.00 | 4_003.00 | 0.023 | 200 | 0.008 | 0.009 | 0.009 | 0.009 | 200 | 34.8 | 0.61 | 735.07 | 734.86 |
| 4_005.00 | 4_005.00 | 4_004.00 | 0.049 | 200 | 0.008 | 0.009 | 0.009 | 0.009 | 200 | 97.5 | 2.75 | 737.75 | 735.07 |
| 4_006.00 | 4_006.00 | 4_005.00 | 0.038 | 200 | 0.008 | 0.009 | 0.009 | 0.009 | 200 | 135.0 | 1.64 | 740.05 | 737.84 |
| 4_008.00 | 4_007.00 | 4_008.00 | 0.038 | 200 | 0 | 0 | 0 | 0 | 200 | 18.3 | 1.62 | 741.60 | 741.30 |
| 4_007.00 | 4_008.00 | 4_006.00 | 0.032 | 200 | 0.007 | 0.008 | 0.008 | 0.008 | 200 | 107.3 | 1.17 | 741.30 | 740.05 |
| 4_009.00 | 4_009.00 | 4_008.00 | 0.058 | 300 | 0.007 | 0.008 | 0.008 | 0.008 | 300 | 53.0 | 0.43 | 741.60 | 741.37 |
| 4_011.00 | 4_011.00 | 4_002.00 | 0.142 | 300 | 0.027 | 0.035 | 0.035 | 0.035 | 300 | 93.8 | 2.61 | 736.30 | 733.85 |
| 4_012.00 | 4_012.00 | 4_022.00 | 0.049 | 300 | 0.021 | 0.029 | 0.029 | 0.029 | 300 | 32.0 | 0.31 | 736.74 | 736.63 |
| 4_013.00 | 4_013.00 | 4_012.00 | 0.112 | 300 | 0.021 | 0.029 | 0.029 | 0.029 | 300 | 104.8 | 1.63 | 738.44 | 736.74 |
| 4_014.00 | 4_014.00 | 4_013.00 | 0.036 | 300 | 0.018 | 0.026 | 0.026 | 0.026 | 300 | 85.1 | 0.17 | 738.51 | 738.36 |
| 4_015.00 | 4_015.00 | 4_014.00 | 0.055 | 300 | 0.018 | 0.026 | 0.026 | 0.026 | 300 | 84.6 | 0.39 | 738.84 | 738.51 |
| 4_016.00 | 4_016.00 | 4_015.00 | 0.046 | 300 | 0.017 | 0.025 | 0.025 | 0.025 | 300 | 41.1 | 0.28 | 738.95 | 738.84 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 4_017.00 | 4_017.00 | 4_016.00 | 0.009 | 300 | 0.014 | 0.02 | 0.02 | 0.02 | 300 | 53.4 | -0.01 | 739.18 | 739.19 |
| 4_019.00 | 4_018.00 | 4_019.00 | 0.052 | 300 | 0.013 | 0.019 | 0.019 | 0.019 | 300 | 49.1 | 0.35 | 739.53 | 739.35 |
| 4_018.00 | 4_019.00 | 4_017.00 | 0.043 | 300 | 0.013 | 0.019 | 0.019 | 0.019 | 300 | 50.5 | 0.23 | 739.32 | 739.21 |
| 4_020.00 | 4_020.00 | 4_018.00 | 0.031 | 250 | 0.013 | 0.019 | 0.019 | 0.019 | 250 | 44.3 | 0.34 | 739.76 | 739.62 |
| 4_021.00 | 4_021.00 | 4_020.00 | 0.029 | 250 | 0.011 | 0.017 | 0.017 | 0.017 | 250 | 100.5 | 0.28 | 740.05 | 739.76 |
| 4_021.01 | 4_021.01 | 4_021.00 | 0.03 | 250 | 0.008 | 0.014 | 0.014 | 0.014 | 250 | 54.2 | 0.31 | 740.20 | 740.03 |
| 4_021.02 | 4_021.02 | 4_021.01 | 0.033 | 250 | 0.006 | 0.013 | 0.013 | 0.013 | 250 | 120.0 | 0.28 | 740.56 | 740.22 |
| 4_021.03 | 4_021.03 | 4_021.02 | 0.033 | 250 | 0.006 | 0.013 | 0.013 | 0.013 | 250 | 120.0 | 0.28 | 740.93 | 740.59 |
| 4_021.04 | 4_021.04 | 4_021.03 | 0.033 | 250 | 0.006 | 0.013 | 0.013 | 0.013 | 250 | 80.0 | 0.28 | 741.18 | 740.96 |
| 4_022.00 | 4_022.00 | 4_011.00 | 0.066 | 300 | 0.023 | 0.031 | 0.031 | 0.031 | 300 | 62.1 | 0.56 | 736.62 | 736.27 |
| 4004-1I1 | 4004-1 | 4005-1 | Future | Future | Future | 0.008 | 0.008 | 0.008 | 300 | 298.8 | 0.28 | 744.04 | 743.20 |
| 4005-1I1 | 4005-1 | 4006-1 | Future | Future | Future | 0.019 | 0.019 | 0.019 | 300 | 143.6 | 0.30 | 743.20 | 742.77 |
| 4006-1I1 | 4006-1 | 4300 | Future | Future | Future | 0.019 | 0.019 | 0.019 | 300 | 233.6 | 0.25 | 742.77 | 742.18 |
| 4007-1I1 | 4007-1 | 8_001.73 | Future | Future | Future | 0.019 | 0.019 | 0.019 | 300 | 97.4 | 0.22 | 740.59 | 740.38 |
| 4008-1I1 | 4008-1 | 4007-1 | Future | Future | Future | 0.019 | 0.019 | 0.019 | 300 | 173.2 | 0.22 | 740.97 | 740.59 |
| 4009-1I1 | 4009-1 | 4008-1 | Future | Future | Future | 0.019 | 0.019 | 0.019 | 300 | 102.7 | 0.22 | 741.20 | 740.97 |
| 4017AI1 | 4017A | 4017 | Future | Future | Future | 0.037 | 0.037 | 0.037 | 300 | 541.7 | 0.60 | 754.45 | 751.20 |
| 4020I1 | 4020-1 | 4301 | Future | Future | Future | 0.165 | 0 | 0.165 | 1800 | 232.4 | 0.20 | 743.70 | 743.24 |
| 4020-pumpI1 | 4020-pump | 1009 | Future | Future | Future | Future | 0.191 | 0.191 | 450 | 1500.0 | -0.70 | 744.56 | 755.05 |
| 4020I2 | 4020-tank | 4020-1 | Future | Future | Future | 0.193 | 0 | 0.193 | 1800 | 440.7 | 0.20 | 744.56 | 743.70 |
| 4102-1I2 | 4102-1 | 4104-1 | Future | Future | Future | 0.061 | 0.061 | 0.061 | 375 | 435.0 | 0.23 | 741.14 | 740.12 |
| 4103-1I1 | 4103-1 | 12_140.00 | Future | Future | Future | 0.041 | 0.041 | 0.041 | 375 | 484.7 | 0.17 | 739.12 | 738.28 |
| 4104-1I2 | 4104-1 | 4217 | Future | Future | Future | 0.073 | 0.073 | 0.073 | 375 | 205.0 | 0.33 | 740.12 | 739.45 |
| 4300-1I1 | 4300-1 | 4300 | Future | Future | Future | 0.025 | 0.025 | 0.025 | 300 | 213.7 | 0.22 | 742.66 | 742.18 |
| 4301I1 | 4301-1 | 9_517.00 | Future | 450 | Future | 0.07 | 0.008 | 0.07 | 450 | 160.9 | 0.22 | 742.32 | 741.97 |
| 6_033.00 | 6_033.00 | 8_001.42 | 0.024 | 200 | 0.018 | 0 | 0 | 0.018 | 200 | 97.0 | 0.64 | 742.55 | 741.93 |
| 4_029.00 | 6_100.00 | 6_101.00 | 0.051 | 250 | 0 | 0 | 0 | 0 | 250 | 14.7 | 0.88 | 745.22 | 745.09 |
| 4_028.00 | 6_101.00 | 6_102.00 | 0.04 | 250 | 0.001 | 0.001 | 0.001 | 0.001 | 250 | 78.1 | 0.55 | 745.02 | 744.59 |
| 4_027.00 | 6_102.00 | 6_103.00 | 0.047 | 250 | 0.002 | 0.002 | 0.002 | 0.002 | 250 | 92.7 | 0.76 | 744.59 | 743.89 |
| 4_026.00 | 6_103.00 | 6_104.00 | 0.051 | 250 | 0.002 | 0.002 | 0.002 | 0.002 | 250 | 92.4 | 0.89 | 743.89 | 743.07 |
| 4_025.00 | 6_104.00 | 6_200.00 | 0.049 | 300 | 0.005 | 0.006 | 0.006 | 0.006 | 300 | 100.0 | 0.32 | 743.07 | 742.75 |
| 4_030.00 | 6_105.00 | 6_104.00 | 0 | 300 | 0.003 | 0.003 | 0.003 | 0.003 | 300 | 108.2 | 0.00 | 743.07 | 743.07 |
| 4_031.00 | 6_106.00 | 6_105.00 | 0.041 | 300 | 0.003 | 0.003 | 0.003 | 0.003 | 300 | 121.7 | 0.21 | 743.33 | 743.07 |
| 4_032.00 | 6_107.00 | 6_106.00 | 0.049 | 300 | 0.003 | 0.003 | 0.003 | 0.003 | 300 | 103.7 | 0.31 | 743.65 | 743.33 |
| 4_024.00 | 6_200.00 | 6_201.00 | 0.052 | 300 | 0.007 | 0.008 | 0.008 | 0.008 | 300 | 91.5 | 0.35 | 742.75 | 742.43 |
| 4_023.00 | 6_201.00 | 6_202.00 | 0.049 | 300 | 0.007 | 0.008 | 0.008 | 0.008 | 300 | 69.5 | 0.31 | 742.23 | 742.02 |
| 4_010.00 | 6_202.00 | 4_009.00 | 0.045 | 300 | 0.007 | 0.008 | 0.008 | 0.008 | 300 | 71.2 | 0.26 | 741.88 | 741.69 |
| 7_900.01 | 7_900.01 | 7_900.02 | 0.875 | 750 | 0 | 0 | 0 | 0 | 750 | 85.8 | 0.75 | 737.06 | 736.42 |
| 7_900.02 | 7_900.02 | 7_900.03 | 0.145 | 380 | 0.002 | 0.002 | 0.002 | 0.002 | 375 | 46.0 | 0.83 | 736.41 | 736.03 |
| 7_900.03 | 7_900.03 | 7_900.04 | 0.096 | 380 | 0.002 | 0.002 | 0.002 | 0.002 | 375 | 10.0 | 0.36 | 736.02 | 735.98 |
| 7_900.04 | 7_900.04 | 7_900.07 | 0.141 | 380 | 0.007 | 0.007 | 0.007 | 0.007 | 375 | 52.2 | 0.79 | 735.97 | 735.56 |
| 7_900.07 | 7_900.07 | 7_900.08 | 0.144 | 380 | 0.007 | 0.007 | 0.007 | 0.007 | 375 | 67.7 | 0.81 | 735.58 | 735.03 |
| 7_900.08 | 7_900.08 | 8_037.00 | 0.142 | 380 | 0.011 | 0.011 | 0.011 | 0.011 | 375 | 78.0 | 0.80 | 734.96 | 734.34 |
| 8_001.00 | 8_001.00 | T_506.00 | 0.136 | 350 | 0.011 | 0.011 | 0.011 | 0.012 | 350 | 122.2 | 1.05 | 721.97 | 720.69 |
| 8_001.15 | 8_001.16 | T_88B.00 | 1.662 | 1050 | 0.941 | 2.34 | 2.275 | 2.34 | 1350 | 130.8 | 0.34 | 717.52 | 717.08 |
| 8_001.16 | 8_001.17 | 8_001.16 | 1.93 | 1050 | 0.943 | 2.341 | 2.275 | 2.341 | 1350 | 117.9 | 0.46 | 718.07 | 717.52 |
| 8_001.17 | 8_001.18 | 8_001.17 | 1.382 | 1050 | 0.943 | 2.341 | 2.275 | 2.341 | 1350 | 163.0 | 0.24 | 718.46 | 718.07 |
| 8_001.18 | 8_001.19 | 8_001.18 | 1.637 | 1050 | 0.943 | 2.341 | 2.276 | 2.341 | 1350 | 109.8 | 0.33 | 718.88 | 718.52 |
| 8_001.19I1 | 8_001.19 | T_95.00 | 0.954 | 1050 | 0.278 | 0 | 0 | 0.278 | 0 | 10.0 | 0.10 | 718.91 | 718.90 |
| 8_001.19 | 8_001.20 | 8_001.19 | 0.929 | 750 | 0.634 | 0.778 | 0.736 | 0.778 | 750 | 117.1 | 0.64 | 719.75 | 719.00 |
| 8_001.20 | 8_001.21 | 8_001.20 | 2.112 | 750 | 0.634 | 0.778 | 0.736 | 0.778 | 750 | 35.5 | 3.33 | 721.80 | 720.61 |
| 8_001.21 | 8_001.22 | 8_001.21 | 4.062 | 750 | 0.634 | 0.778 | 0.736 | 0.778 | 750 | 34.9 | 12.31 | 726.10 | 721.80 |
| 8_001.22 | 8_001.23 | 8_001.22 | 4.241 | 750 | 0.634 | 0.778 | 0.736 | 0.778 | 750 | 36.2 | 13.42 | 730.95 | 726.10 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 8_001.23 | 8_001.24 | 8_001.23 | 4.268 | 750 | 0.634 | 0.778 | 0.736 | 0.778 | 750 | 19.7 | 13.59 | 733.63 | 730.95 |
| 8_001.24 | 8_001.25 | 8_001.24 | 0.732 | 750 | 0.624 | 0.777 | 0.735 | 0.777 | 750 | 87.5 | 0.40 | 733.98 | 733.63 |
| 8_001.25 | 8_001.26 | 8_001.25 | 0.509 | 750 | 0.624 | 0.776 | 0.734 | 0.776 | 750 | 69.2 | 0.19 | 734.11 | 733.98 |
| 8_001.26 | 8_001.27 | 8_001.26 | 0.851 | 780 | 0.624 | 0.776 | 0.735 | 0.776 | 780 | 104.9 | 0.44 | 734.57 | 734.11 |
| 8_001.27 | 8_001.28 | 8_001.27 | 0.914 | 750 | 0.624 | 0.777 | 0.735 | 0.777 | 750 | 43.3 | 0.62 | 734.87 | 734.60 |
| 8_001.28 | 8_001.29 | 8_001.28 | 0.743 | 750 | 0.608 | 0.762 | 0.72 | 0.762 | 750 | 130.0 | 0.41 | 735.41 | 734.87 |
| 8_001.29 | 8_001.30 | 8_001.29 | 0.376 | 680 | 0.466 | 0.625 | 0.582 | 0.625 | 675 | 25.5 | 0.18 | 735.56 | 735.51 |
| 8_001.30 | 8_001.31 | 8_001.30 | 0.529 | 680 | 0.467 | 0.625 | 0.582 | 0.625 | 675 | 103.6 | 0.37 | 735.99 | 735.61 |
| 8_001.31 | 8_001.32 | 8_001.31 | 0.511 | 680 | 0.466 | 0.624 | 0.58 | 0.624 | 675 | 111.7 | 0.34 | 736.37 | 735.99 |
| 8_001.32 | 8_001.33 | 8_001.32 | 0.534 | 680 | 0.464 | 0.621 | 0.578 | 0.621 | 675 | 167.7 | 0.37 | 737.00 | 736.37 |
| 8_001.33 | 8_001.34 | 8_001.33 | 0.167 | 450 | 0.146 | 0.144 | 0.146 | 0.146 | 450 | 100.1 | 0.32 | 737.92 | 737.60 |
| 8_001.34 | 8_001.35 | 8_001.34 | 0.151 | 450 | 0.147 | 0.146 | 0.147 | 0.147 | 450 | 157.0 | 0.26 | 738.33 | 737.92 |
| 8_001.35 | 8_001.36 | 8_001.35 | 0.164 | 450 | 0.147 | 0.147 | 0.147 | 0.147 | 450 | 27.7 | 0.31 | 738.49 | 738.40 |
| 8_001.36 | 8_001.37 | 8_001.36 | 0.168 | 450 | 0.148 | 0.147 | 0.148 | 0.148 | 450 | 71.7 | 0.32 | 738.75 | 738.52 |
| 8_001.37 | 8_001.38 | 8_001.37 | 0.163 | 450 | 0.148 | 0.148 | 0.148 | 0.148 | 450 | 115.8 | 0.30 | 739.16 | 738.81 |
| 8_001.38 | 8_001.39 | 8_001.38 | 0.177 | 450 | 0.147 | 0.148 | 0.147 | 0.148 | 450 | 106.6 | 0.36 | 739.54 | 739.16 |
| 8_001.40 | 8_001.40 | 8_001.33 | 0.374 | 600 | 0.315 | 0.481 | 0.434 | 0.481 | 600 | 19.0 | 0.34 | 737.57 | 737.51 |
| 8_001.41 | 8_001.41 | 8_001.40 | 0.414 | 600 | 0.316 | 0.481 | 0.434 | 0.481 | 600 | 149.6 | 0.42 | 738.25 | 737.62 |
| 8_001.42 | 8_001.42 | 8_001.41 | 0.416 | 600 | 0.316 | 0.481 | 0.435 | 0.481 | 600 | 153.4 | 0.43 | 738.90 | 738.25 |
| 8_001.43 | 8_001.43 | 8_001.42 | 0.366 | 600 | 0.245 | 0.418 | 0.366 | 0.418 | 600 | 59.8 | 0.33 | 739.10 | 738.90 |
| 8_001.44 | 8_001.44 | 8_001.43 | 0.375 | 600 | 0.245 | 0.417 | 0.366 | 0.417 | 600 | 23.2 | 0.34 | 739.18 | 739.10 |
| 8_001.45 | 8_001.45 | 8_001.44 | 0.416 | 600 | 0.242 | 0.414 | 0.363 | 0.414 | 600 | 120.1 | 0.42 | 739.69 | 739.18 |
| 8_001.46 | 8_001.46 | 8_001.45 | 0.398 | 600 | 0.239 | 0.412 | 0.363 | 0.412 | 600 | 116.8 | 0.39 | 740.14 | 739.69 |
| 8_001.47 | 8_001.47 | 8_001.46 | 0.385 | 600 | 0.153 | 0.33 | 0.278 | 0.33 | 600 | 99.0 | 0.36 | 740.51 | 740.15 |
| 8_001.48 | 8_001.48 | 8_001.47 | 0.407 | 600 | 0.152 | 0.327 | 0.275 | 0.327 | 600 | 107.1 | 0.41 | 740.95 | 740.51 |
| 8_001.49 | 8_001.49 | 8_001.48 | 0.275 | 600 | 0.154 | 0.326 | 0.275 | 0.326 | 600 | 86.3 | 0.19 | 741.11 | 740.95 |
| 8_001.50 | 8_001.50 | 8_001.49 | 0.39 | 600 | 0.154 | 0.327 | 0.275 | 0.327 | 600 | 53.5 | 0.37 | 741.38 | 741.17 |
| 8_001.51 | 8_001.51 | 8_001.50 | 0.365 | 600 | 0.154 | 0.333 | 0.275 | 0.333 | 600 | 123.6 | 0.33 | 741.87 | 741.46 |
| 8_001.52 | 8_001.52 | 8_001.51 | 0.384 | 600 | 0.152 | 0.337 | 0.275 | 0.337 | 600 | 115.6 | 0.36 | 742.29 | 741.87 |
| 8_001.53 | 8_001.53 | 8_001.52 | 0.408 | 600 | 0.148 | 0.338 | 0.275 | 0.338 | 600 | 63.2 | 0.41 | 742.55 | 742.29 |
| 8_001.55 | 8_001.54 | 8_001.53 | 0.124 | 450 | 0.122 | 0.125 | 0.125 | 0.125 | 450 | 119.2 | 0.18 | 742.95 | 742.74 |
| 8_001.55l1 | 8_001.55 | 8_026.00 | 0.025 | 380 | 0.031 | 0.032 | 0.032 | 0.032 | 375 | 84.3 | 0.02 | 743.16 | 743.14 |
| 8_001.56 | 8_001.55 | 8_001.54 | 0.151 | 450 | 0.122 | 0.125 | 0.125 | 0.125 | 450 | 120.0 | 0.26 | 743.26 | 742.95 |
| 8_001.60 | 8_001.60 | 8_001.46 | 0.068 | 300 | 0.082 | 0.082 | 0.082 | 0.082 | 300 | 161.0 | 0.45 | 741.62 | 740.89 |
| 8_001.61l1 | 8_001.61 | 8_900.00 | 0.007 | 300 | -0.026 | -0.025 | -0.026 | -0.025 | 300 | 30.7 | -0.01 | 742.43 | 742.43 |
| 8_001.61 | 8_001.61 | 8_001.60 | 0.071 | 300 | 0.082 | 0.082 | 0.082 | 0.082 | 300 | 161.3 | 0.50 | 742.42 | 741.62 |
| 8_001.62 | 8_001.62 | 8_001.53 | 0.268 | 600 | 0.04 | 0.216 | 0.154 | 0.216 | 600 | 150.3 | 0.18 | 742.88 | 742.61 |
| 8_001.63 | 8_001.63 | 8_001.62 | 0.235 | 600 | 0.051 | 0.216 | 0.153 | 0.216 | 600 | 150.0 | 0.14 | 743.09 | 742.89 |
| 8_001.64 | 8_001.64 | 8_001.63 | 0.293 | 600 | 0.07 | 0.216 | 0.153 | 0.216 | 600 | 100.0 | 0.21 | 743.30 | 743.09 |
| 8_001.65l1 | 8_001.65 | LIFT STATI | 0.258 | 380 | 0.012 | 0.15 | 0.088 | 0.15 | 375 | 12.0 | 2.00 | 738.95 | 738.71 |
| 8_001.66l1 | 8_001.66 | 8_001.67 | Future | 300 | Future | 0.047 | 0.047 | 0.047 | 300 | 86.7 | 0.20 | 741.69 | 741.52 |
| 8_001.67l1 | 8_001.67 | 8_001.68 | Future | 300 | Future | 0.047 | 0.047 | 0.047 | 300 | 114.6 | 0.18 | 741.50 | 741.29 |
| 8_001.68l1 | 8_001.68 | 8_001.65 | Future | 300 | Future | 0.068 | 0.068 | 0.068 | 300 | 119.8 | 0.44 | 739.48 | 738.95 |
| 8_001.73l1 | 8_001.73 | 8_001.74 | Future | 200 | Future | 0.019 | 0.019 | 0.019 | 200 | 111.6 | 0.36 | 740.38 | 739.98 |
| 8_001.74l1 | 8_001.74 | 8_001.68 | Future | 200 | Future | 0.019 | 0.019 | 0.019 | 200 | 117.8 | 0.42 | 739.97 | 739.47 |
| 8_002.00 | 8_002.00 | 8_001.00 | 0.135 | 300 | 0.011 | 0.011 | 0.011 | 0.011 | 300 | 97.5 | 2.35 | 724.26 | 721.97 |
| 8_003.00 | 8_003.00 | 8_002.00 | 0.127 | 300 | 0.011 | 0.011 | 0.011 | 0.011 | 300 | 107.2 | 2.10 | 726.51 | 724.26 |
| 8_004.00 | 8_004.00 | 8_003.00 | 0.155 | 300 | 0.011 | 0.011 | 0.011 | 0.011 | 300 | 29.6 | 3.09 | 729.89 | 728.98 |
| 8_005.00 | 8_005.00 | 8_004.00 | 0.102 | 300 | 0.011 | 0.011 | 0.011 | 0.011 | 300 | 45.4 | 1.35 | 733.00 | 732.39 |
| 8_006.00l1 | 8_006.00 | 8_001.64 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 14.5 | 0.14 | 743.34 | 743.32 |
| 8_006.01l1 | 8_006.01 | 8_006.00 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 16.9 | 0.36 | 743.41 | 743.35 |
| 8_006.02l1 | 8_006.02 | 8_006.01 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 48.5 | 0.14 | 743.53 | 743.46 |
| 8_006.09l1 | 8_006.09 | 8_006.02 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 98.3 | 0.12 | 743.67 | 743.55 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 8_006.10l1 | 8_006.10 | 8_006.09 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 100.8 | 0.13 | 743.80 | 743.67 |
| 8_006.11l1 | 8_006.11 | 8_006.10 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 99.5 | 0.11 | 743.95 | 743.84 |
| 8_006.12l1 | 8_006.12 | 8_006.11 | Future | 600 | Future | 0.046 | 0.046 | 0.046 | 600 | 105.8 | 0.12 | 744.09 | 743.97 |
| 8_009.01l1 | 8_009.01 | 8_001.29 | 0.352 | 450 | 0.142 | 0.139 | 0.139 | 0.144 | 450 | 34.7 | 1.41 | 737.92 | 737.43 |
| 8_009.01 | 8_009.01 | 7_900.01 | 0.089 | 300 | 0 | 0 | 0 | 0 | 300 | 87.2 | 1.03 | 738.28 | 737.38 |
| 8_009.02 | 8_009.01 | 8_009.00 | 0 | 200 | -0.038 | -0.038 | -0.038 | -0.038 | 200 | 10.0 | 0.00 | 738.30 | 738.30 |
| 8_011.00 | 8_011.00 | 8_027.04 | 0.033 | 300 | 0.062 | 0.063 | 0.063 | 0.063 | 300 | 64.9 | 0.14 | 739.00 | 738.90 |
| 8_012.00 | 8_012.00 | 8_011.00 | 0.042 | 300 | 0.062 | 0.063 | 0.063 | 0.063 | 300 | 52.7 | 0.23 | 739.15 | 739.03 |
| 8_013.00 | 8_013.00 | 8_012.00 | 0.041 | 300 | 0.059 | 0.06 | 0.06 | 0.06 | 300 | 121.9 | 0.22 | 739.45 | 739.18 |
| 8_014.00 | 8_014.00 | 8_013.00 | 0.032 | 250 | 0.056 | 0.057 | 0.056 | 0.057 | 250 | 14.4 | 0.35 | 740.10 | 740.05 |
| 8_015.00 | 8_015.00 | 8_901.00 | 0.025 | 250 | 0.042 | 0.042 | 0.042 | 0.042 | 250 | 43.6 | 0.22 | 740.42 | 740.33 |
| 8_016.00 | 8_016.00 | 8_015.00 | 0.03 | 250 | 0.043 | 0.043 | 0.043 | 0.043 | 250 | 96.7 | 0.30 | 740.74 | 740.45 |
| 8_017.00 | 8_017.00 | 8_016.00 | 0.036 | 250 | 0.028 | 0.029 | 0.029 | 0.029 | 250 | 59.7 | 0.43 | 741.00 | 740.74 |
| 8_018.00 | 8_018.00 | 8_017.00 | 0.016 | 250 | 0.028 | 0.028 | 0.028 | 0.028 | 250 | 23.7 | 0.09 | 741.02 | 741.00 |
| 8_019.00 | 8_019.00 | 8_018.00 | 0.03 | 250 | 0.028 | 0.028 | 0.028 | 0.028 | 250 | 82.8 | 0.30 | 741.30 | 741.05 |
| 8_020.00 | 8_020.00 | 8_019.00 | 0.03 | 250 | 0.028 | 0.028 | 0.028 | 0.028 | 250 | 79.6 | 0.30 | 741.57 | 741.33 |
| 8_021.00 | 8_021.00 | 8_020.00 | 0.029 | 250 | 0.028 | 0.028 | 0.027 | 0.028 | 250 | 80.5 | 0.29 | 741.83 | 741.60 |
| 8_021.01 | 8_021.01 | 8_021.00 | 0.027 | 200 | 0.005 | 0.005 | 0.005 | 0.005 | 200 | 101.4 | 0.80 | 744.95 | 744.14 |
| 8_021.02 | 8_021.02 | 8_021.01 | 0.027 | 200 | 0.002 | 0.002 | 0.002 | 0.002 | 200 | 96.4 | 0.80 | 745.75 | 744.98 |
| 8_022.00 | 8_022.00 | 8_021.00 | 0.03 | 250 | -0.021 | -0.021 | -0.021 | -0.021 | 250 | 122.0 | 0.30 | 742.23 | 741.87 |
| 8_023.00 | 8_023.00 | 8_001.61 | 0.033 | 300 | 0.073 | 0.073 | 0.073 | 0.073 | 300 | 76.1 | 0.14 | 742.54 | 742.43 |
| 8_024.00 | 8_024.00 | 8_023.00 | 0.097 | 380 | 0.052 | 0.052 | 0.052 | 0.052 | 375 | 69.1 | 0.37 | 742.79 | 742.54 |
| 8_025.00 | 8_025.00 | 8_024.00 | 0.045 | 380 | 0.051 | 0.051 | 0.051 | 0.051 | 375 | 97.9 | 0.08 | 742.91 | 742.83 |
| 8_026.00 | 8_026.00 | 8_025.00 | 0.056 | 380 | 0.032 | 0.033 | 0.033 | 0.033 | 375 | 122.0 | 0.12 | 743.08 | 742.93 |
| 8_027.00 | 8_027.00 | 8_009.00 | 0.012 | 300 | 0.038 | 0.038 | 0.038 | 0.038 | 300 | 99.5 | 0.01 | 738.72 | 738.70 |
| 8_028.00 | 8_027.02 | 8_009.01 | 0.05 | 300 | 0.104 | 0.102 | 0.102 | 0.106 | 300 | 99.4 | 0.33 | 738.70 | 738.38 |
| 8_027.03 | 8_027.03 | 8_027.02 | 0.037 | 300 | 0.104 | 0.102 | 0.102 | 0.106 | 300 | 51.8 | 0.17 | 738.84 | 738.75 |
| 8_027.04 | 8_027.04 | 8_027.03 | 0.056 | 300 | 0.104 | 0.102 | 0.102 | 0.106 | 300 | 10.0 | 0.40 | 738.88 | 738.84 |
| 8_028.01 | 8_028.01 | 8_027.04 | 0.036 | 250 | 0.04 | 0.037 | 0.037 | 0.043 | 250 | 100.6 | 0.35 | 739.32 | 738.97 |
| 8_028.02 | 8_028.02 | 8_028.01 | 0.037 | 250 | 0.04 | 0.037 | 0.037 | 0.043 | 250 | 114.3 | 0.35 | 739.73 | 739.33 |
| 8_028.03 | 8_028.03 | 8_028.02 | 0.04 | 250 | 0.036 | 0.032 | 0.032 | 0.039 | 250 | 73.8 | 0.43 | 740.05 | 739.73 |
| 8_028.06 | 8_028.06 | 8_028.03 | 0.027 | 200 | 0.031 | 0.028 | 0.028 | 0.034 | 200 | 69.5 | 0.62 | 740.49 | 740.06 |
| 8_028.07 | 8_028.07 | 8_028.06 | 0.026 | 200 | 0.03 | 0.027 | 0.027 | 0.034 | 200 | 67.5 | 0.60 | 740.90 | 740.50 |
| 8_028.08 | 8_028.08 | 8_028.07 | 0.043 | 250 | 0.028 | 0.026 | 0.026 | 0.031 | 250 | 84.4 | 0.49 | 741.32 | 740.91 |
| 8_028.09 | 8_028.09 | 8_028.08 | 0.037 | 250 | 0.023 | 0.023 | 0.023 | 0.026 | 250 | 40.3 | 0.35 | 741.47 | 741.33 |
| 8_028.10 | 8_028.10 | 8_028.09 | 0.036 | 250 | 0.025 | 0.024 | 0.024 | 0.026 | 250 | 56.4 | 0.35 | 741.67 | 741.47 |
| 8_028.11 | 8_028.11 | 8_028.10 | 0.038 | 250 | 0.009 | 0.008 | 0.008 | 0.01 | 250 | 24.2 | 0.37 | 741.76 | 741.67 |
| 8_018.12 | 8_028.12 | 8_028.11 | 0.039 | 250 | 0.008 | 0.007 | 0.008 | 0.009 | 250 | 56.7 | 0.40 | 741.99 | 741.76 |
| 8_028.13 | 8_028.13 | 8_028.12 | 0.043 | 250 | -0.007 | -0.012 | -0.012 | 0.005 | 250 | 26.8 | 0.49 | 742.12 | 741.99 |
| 8_082.30 | 8_028.14 | 8_082.09 | 0.045 | 250 | 0.053 | 0.051 | 0.051 | 0.053 | 250 | 93.9 | 0.53 | 742.28 | 741.78 |
| 8_028.14 | 8_028.14 | 8_028.13 | 0.043 | 250 | -0.007 | -0.012 | -0.012 | 0.006 | 250 | 54.8 | 0.50 | 742.40 | 742.13 |
| 8_034.00l1 | 8_034.00 | 6_033.00 | 0.024 | 200 | 0.018 | 0 | 0 | 0.018 | 200 | 97.0 | 0.63 | 743.20 | 742.59 |
| 8_034.00 | 8_034.00 | 8_062.00 | 0.021 | 200 | 0.013 | 0.013 | 0.013 | 0.013 | 200 | 106.6 | 0.48 | 742.88 | 742.37 |
| 8_034.00l2 | 8_034.00 | 8_001.42 | Future | Future | Future | 0.018 | 0.018 | 0.019 | 300 | 200.0 | 0.20 | 743.08 | 742.68 |
| 8_034.01 | 8_034.01 | 8_034.00 | 0.028 | 200 | 0.012 | 0.012 | 0.012 | 0.012 | 200 | 108.5 | 0.90 | 744.26 | 743.29 |
| 8_034.05 | 8_034.05 | 8_034.01 | 0.025 | 200 | 0.004 | 0.004 | 0.004 | 0.004 | 200 | 124.2 | 0.69 | 745.14 | 744.29 |
| 8_034.06 | 8_034.06 | 8_034.05 | 0.025 | 200 | 0.001 | 0.001 | 0.001 | 0.001 | 200 | 104.3 | 0.70 | 745.90 | 745.17 |
| 8_034.21 | 8_034.06 | 8_021.02 | 0.019 | 200 | 0.001 | 0.001 | 0.001 | 0.001 | 200 | 30.7 | 0.39 | 745.90 | 745.79 |
| 8_037.00 | 8_037.00 | 8_005.00 | 0.215 | 380 | 0.011 | 0.011 | 0.011 | 0.011 | 375 | 101.3 | 1.81 | 734.84 | 733.00 |
| 8_051.00 | 8_051.00 | 8_001.55 | 0.114 | 380 | 0.098 | 0.102 | 0.102 | 0.102 | 375 | 30.5 | 0.51 | 743.32 | 743.16 |
| 8_061.00 | 8_061.00 | 8_016.00 | 0.019 | 200 | -0.005 | -0.005 | -0.005 | -0.005 | 200 | 113.2 | 0.40 | 743.32 | 742.86 |
| 8_061.01 | 8_061.00 | 8_034.00 | 0.018 | 200 | 0.005 | 0.005 | 0.005 | 0.006 | 200 | 113.8 | 0.38 | 743.32 | 742.88 |
| 8_062.00 | 8_062.00 | 8_063.00 | 0.019 | 200 | 0.014 | 0.014 | 0.014 | 0.014 | 200 | 70.0 | 0.40 | 742.37 | 742.08 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 8_063.00 | 8_063.00 | 8_064.00 | 0.019 | 200 | 0.017 | 0.017 | 0.016 | 0.017 | 200 | 70.0 | 0.40 | 742.08 | 741.80 |
| 8_064.00 | 8_064.00 | 8_065.00 | 0.019 | 200 | 0.019 | 0.019 | 0.019 | 0.019 | 200 | 100.6 | 0.40 | 741.80 | 741.40 |
| 8_065.00 | 8_065.00 | 8_066.00 | 0.019 | 200 | 0.024 | 0.024 | 0.024 | 0.024 | 200 | 39.0 | 0.40 | 741.40 | 741.25 |
| 8_066.00 | 8_066.00 | 8_104.00 | 0.019 | 200 | 0.024 | 0.024 | 0.024 | 0.024 | 200 | 42.3 | 0.40 | 741.25 | 741.08 |
| 8_028.20 | 8_077.00 | 8_028.14 | 0.038 | 250 | 0.047 | 0.039 | 0.039 | 0.05 | 250 | 133.7 | 0.38 | 742.84 | 742.33 |
| 8_078.00 | 8_078.00 | 8_077.00 | 0.032 | 250 | 0.021 | 0.007 | 0.007 | 0.024 | 250 | 86.0 | 0.35 | 743.14 | 742.84 |
| 8_079.00 | 8_079.00 | 8_078.00 | 0.041 | 250 | 0.02 | 0.005 | 0.005 | 0.023 | 250 | 23.5 | 0.57 | 743.32 | 743.18 |
| 8_080.00 | 8_080.00 | 8_079.00 | 0.044 | 250 | 0.019 | 0.005 | 0.005 | 0.023 | 250 | 21.1 | 0.66 | 743.47 | 743.33 |
| 8_081.00 | 8_081.00 | 8_080.00 | 0.042 | 250 | 0.018 | 0.005 | 0.005 | 0.022 | 250 | 20.0 | 0.60 | 743.59 | 743.47 |
| 8_082.00 | 8_082.00 | 8_107.00 | 0.033 | 250 | 0.014 | 0 | 0 | 0.019 | 250 | 29.3 | 0.37 | 743.98 | 743.87 |
| 8_083.01 | 8_082.00 | 8_082.01 | 0.104 | 380 | 0.048 | 0.006 | 0.005 | 0.085 | 375 | 23.1 | 0.37 | 743.93 | 743.84 |
| 8_082.00-1I1 | 8_082.00-1 | EnvInt-1 | Future | Future | Future | 0.082 | 0.082 | 0.082 | 450 | 242.5 | 0.60 | 743.93 | 742.47 |
| 8_082.01 | 8_082.01 | 8_083.05 | 0.25 | 380 | 0.048 | 0.006 | 0.006 | 0.085 | 375 | 57.4 | 1.88 | 743.84 | 742.77 |
| 8_082.02 | 8_082.02 | 8_082.03 | 0.151 | 380 | 0.05 | 0.008 | 0.008 | 0.087 | 375 | 88.2 | 0.69 | 742.73 | 742.12 |
| 8_082.03 | 8_082.03 | 8_082.04 | 0.209 | 380 | 0.052 | 0.01 | 0.01 | 0.089 | 375 | 77.4 | 1.31 | 742.12 | 741.11 |
| 8_082.10 | 8_082.04 | 8_082.10 | 0.113 | 380 | 0.114 | 0.074 | 0.074 | 0.139 | 375 | 133.4 | 0.38 | 741.11 | 740.60 |
| 8_082.05 | 8_082.05 | 8_082.04 | 0.05 | 300 | 0.062 | 0.061 | 0.061 | 0.062 | 300 | 96.3 | 0.25 | 741.35 | 741.11 |
| 8_082.06 | 8_082.06 | 8_082.05 | 0.049 | 300 | 0.058 | 0.057 | 0.057 | 0.058 | 300 | 63.9 | 0.23 | 741.50 | 741.35 |
| 8_082.09 | 8_082.09 | 8_082.06 | 0.054 | 300 | 0.055 | 0.054 | 0.054 | 0.055 | 300 | 77.7 | 0.29 | 741.78 | 741.55 |
| 8_082.46 | 8_082.10 | 8_082.12 | 0.104 | 380 | 0.118 | 0.079 | 0.079 | 0.143 | 375 | 97.4 | 0.33 | 740.55 | 740.23 |
| 8_082.12 | 8_082.12 | 8_082.16 | 0.107 | 380 | 0.126 | 0.087 | 0.087 | 0.151 | 375 | 82.0 | 0.34 | 740.23 | 739.95 |
| 8_082.16 | 8_082.16 | 8_082.17 | 0.111 | 380 | 0.146 | 0.107 | 0.107 | 0.17 | 375 | 109.7 | 0.37 | 739.92 | 739.51 |
| 8_082.17 | 8_082.17 | 8_082.19 | 0.113 | 380 | 0.152 | 0.113 | 0.114 | 0.177 | 375 | 51.8 | 0.39 | 739.46 | 739.26 |
| 8_082.19 | 8_082.19 | 8_082.22 | 0.109 | 380 | 0.152 | 0.113 | 0.113 | 0.177 | 375 | 61.4 | 0.36 | 739.21 | 738.99 |
| 8_082.22 | 8_082.22 | 8_082.23 | 0.553 | 900 | 0.154 | 0.199 | 0.2 | 0.2 | 900 | 122.2 | 0.10 | 738.91 | 738.79 |
| 8_082.23 | 8_082.23 | 8_082.24 | 0.527 | 900 | 0.154 | 0.199 | 0.2 | 0.2 | 900 | 123.4 | 0.09 | 738.76 | 738.65 |
| 8_082.24 | 8_082.24 | 8_082.25 | 0.646 | 900 | 0.154 | 0.199 | 0.199 | 0.199 | 900 | 119.6 | 0.13 | 738.63 | 738.47 |
| 8_082.25 | 8_082.25 | 8_082.38 | 0.554 | 900 | 0.154 | 0.199 | 0.199 | 0.199 | 900 | 30.5 | 0.10 | 738.42 | 738.39 |
| 8_082.38 | 8_082.38 | 8_082.39 | 0.604 | 900 | 0.162 | 0.208 | 0.208 | 0.208 | 900 | 85.4 | 0.12 | 738.34 | 738.24 |
| 9_930.00 | 8_082.39 | 8_082.53 | 2.133 | 900 | 0.162 | 0.208 | 0.208 | 0.208 | 900 | 202.8 | 1.68 | 738.20 | 734.80 |
| 9_397.00 | 8_082.47 | T_87.00 | 8.863 | 900 | 0.162 | 1.136 | 0.258 | 1.136 | 900 | 10.0 | 25.22 | 719.04 | 716.52 |
| 9_396.01 | 8_082.471 | 8_082.47 | 2.903 | 900 | 0.162 | 1.136 | 0.258 | 1.136 | 900 | 12.2 | 2.71 | 721.62 | 721.29 |
| 9_396.00 | 8_082.48 | 8_082.471 | 2.989 | 900 | 0.162 | 1.136 | 0.258 | 1.136 | 900 | 12.2 | 2.87 | 723.92 | 723.57 |
| 9_395.00 | 8_082.49 | 8_082.48 | 5.979 | 900 | 0.162 | 1.136 | 0.258 | 1.136 | 900 | 30.8 | 11.48 | 729.72 | 726.18 |
| 9_394.00 | 8_082.50 | 8_082.49 | 3.589 | 900 | 0.162 | 1.136 | 0.258 | 1.136 | 900 | 34.4 | 4.14 | 731.40 | 729.98 |
| 9_394.01 | 8_082.501 | 8_082.50 | 1.933 | 900 | 0.162 | 0.208 | 0.208 | 0.208 | 900 | 10.0 | 1.20 | 731.61 | 731.49 |
| 9_393.00 | 8_082.51 | 8_082.501 | 1.372 | 900 | 0.162 | 0.208 | 0.208 | 0.208 | 900 | 20.3 | 0.60 | 731.61 | 731.49 |
| 9_392.00 | 8_082.52 | 8_082.51 | 0.407 | 900 | 0 | 0 | 0 | 0 | 900 | 16.9 | 0.05 | 731.64 | 731.63 |
| 9_391.00 | 8_082.53 | 8_082.51 | 2.388 | 900 | 0.162 | 0.208 | 0.208 | 0.208 | 900 | 109.2 | 1.83 | 733.61 | 731.61 |
| 8_083.00 | 8_083.00 | 8_082.00 | 0.099 | 380 | 0.047 | 0.082 | 0.082 | 0.082 | 375 | 96.4 | 0.35 | 744.35 | 744.01 |
| 8_083.05 | 8_083.05 | 8_082.02 | 0.019 | 200 | 0.047 | 0.006 | 0.006 | 0.085 | 200 | 10.0 | 0.30 | 742.76 | 742.73 |
| 8_084.00 | 8_084.00 | 8_083.00 | 0.101 | 380 | 0.047 | 0.082 | 0.082 | 0.082 | 375 | 72.8 | 0.37 | 744.62 | 744.35 |
| 8_085.00 | 8_085.00 | 8_084.00 | 0.09 | 380 | 0.042 | 0.078 | 0.078 | 0.078 | 375 | 74.6 | 0.32 | 744.87 | 744.63 |
| 8_086.00 | 8_086.00 | 8_085.00 | 0.096 | 380 | 0.035 | 0.071 | 0.071 | 0.071 | 375 | 84.6 | 0.33 | 745.15 | 744.87 |
| 8_083.06 | 8_087.00 | 8_086.00 | 0.092 | 380 | 0.035 | 0.071 | 0.071 | 0.071 | 375 | 97.6 | 0.31 | 745.47 | 745.17 |
| 8_088.00 | 8_088.00 | 8_087.00 | 0.09 | 380 | 0.034 | 0.07 | 0.07 | 0.07 | 375 | 121.7 | 0.30 | 745.86 | 745.50 |
| 8_089.00 | 8_089.00 | 8_088.00 | 0.051 | 300 | 0.028 | 0.064 | 0.064 | 0.064 | 300 | 88.2 | 0.33 | 746.18 | 745.89 |
| 8_090.00 | 8_090.00 | 8_089.00 | 0.07 | 380 | 0.012 | 0.048 | 0.048 | 0.048 | 375 | 36.1 | 0.18 | 746.27 | 746.21 |
| 8_091.00 | 8_091.00 | 8_090.00 | 0.105 | 380 | 0.008 | 0.045 | 0.045 | 0.045 | 375 | 114.6 | 0.40 | 746.73 | 746.27 |
| 8_092.00 | 8_092.00 | 8_091.00 | 0.116 | 380 | 0.002 | 0.039 | 0.039 | 0.039 | 375 | 103.4 | 0.49 | 747.26 | 746.75 |
| 8_104.00 | 8_104.00 | 8_105.00 | 0.019 | 200 | 0.024 | 0.024 | 0.024 | 0.024 | 200 | 37.1 | 0.40 | 741.08 | 740.93 |
| 8_105.00 | 8_105.00 | 8_106.00 | 0.019 | 200 | 0.032 | 0.031 | 0.031 | 0.032 | 200 | 31.4 | 0.39 | 740.93 | 740.81 |
| 8_106.00 | 8_106.00 | 8_027.00 | 0.019 | 200 | 0.034 | 0.033 | 0.033 | 0.034 | 200 | 67.9 | 0.40 | 740.80 | 740.53 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 8_107.00 | 8_107.00 | 8_081.00 | 0.03 | 250 | 0.014 | 0 | 0 | 0.019 | 250 | 86.2 | 0.32 | 743.86 | 743.59 |
| 8_900.00 | 8_900.00 | 8_022.00 | 0.033 | 250 | -0.026 | -0.026 | -0.026 | -0.026 | 250 | 44.8 | 0.38 | 742.43 | 742.26 |
| 8_901.00 | 8_901.00 | 8_014.00 | 0.033 | 250 | 0.05 | 0.05 | 0.05 | 0.05 | 250 | 63.0 | 0.37 | 740.33 | 740.10 |
| 9_001.00 | 9_001.00 | T7_107.00 | 0.301 | 450 | 0.215 | 0.022 | 0.022 | 0.275 | 450 | 23.1 | 1.18 | 722.35 | 722.08 |
| 9_002.00 | 9_002.00 | 9_001.00 | 0.303 | 450 | 0.215 | 0.023 | 0.023 | 0.275 | 450 | 102.5 | 1.19 | 723.57 | 722.35 |
| 9_003.00 | 9_003.00 | 9_002.00 | 0.249 | 450 | 0.197 | 0.001 | 0.001 | 0.256 | 450 | 61.1 | 0.80 | 724.09 | 723.60 |
| 9_004.00 | 9_004.00 | 9_003.00 | 0.309 | 450 | 0.197 | 0.001 | 0.001 | 0.257 | 450 | 95.6 | 1.24 | 725.27 | 724.09 |
| 9_005.00 | 9_005.00 | 9_004.00 | 0.334 | 450 | 0.196 | 0.001 | 0.001 | 0.257 | 450 | 71.3 | 1.44 | 726.36 | 725.33 |
| 9_006.00 | 9_006.00 | 9_005.00 | 0.235 | 450 | 0.196 | 0.001 | 0.001 | 0.257 | 450 | 65.0 | 0.72 | 726.80 | 726.33 |
| 9_007.00 | 9_007.00 | 9_006.00 | 0.386 | 450 | 0.195 | 0 | 0 | 0.256 | 450 | 116.0 | 1.93 | 729.04 | 726.80 |
| 9_008.00 | 9_008.00 | 9_007.00 | 0.223 | 450 | 0.196 | 0 | 0 | 0.256 | 450 | 111.5 | 0.65 | 729.84 | 729.12 |
| 9_009.00 | 9_009.00 | 9_008.00 | 0.196 | 450 | 0.196 | 0 | 0 | 0.256 | 450 | 66.6 | 0.50 | 730.17 | 729.84 |
| 9_010.00 | 9_010.00 | 9_009.00 | 0.169 | 450 | 0.196 | 0 | 0 | 0.256 | 450 | 29.8 | 0.37 | 730.28 | 730.17 |
| 9_011.00 | 9_011.00 | 9_010.00 | 0.237 | 450 | 0.196 | 0 | 0 | 0.256 | 450 | 107.6 | 0.72 | 731.06 | 730.28 |
| 9_012.00 | 9_012.00 | 9_011.00 | 0.146 | 450 | 0.196 | 0 | 0 | 0.256 | 450 | 101.6 | 0.28 | 731.36 | 731.08 |
| 9_012.10 | 9_012.10 | 9_012.00 | 0.762 | 600 | 0.195 | 0 | 0 | 0.256 | 0 | 13.3 | 1.62 | 734.01 | 733.80 |
| 9_012.11 | 9_012.11 | 9_012.10 | 0.378 | 680 | 0.182 | 0.425 | 0.425 | 0.425 | 675 | 77.4 | 0.19 | 734.16 | 734.01 |
| 9_012.13 | 9_012.12 | 9_012.11 | 1.688 | 600 | 0.061 | 0.288 | 0.288 | 0.288 | 600 | 36.0 | 7.95 | 737.05 | 734.19 |
| 9_012.14 | 9_012.13 | 9_012.12 | 0.242 | 600 | 0.058 | 0.284 | 0.284 | 0.284 | 600 | 120.0 | 0.16 | 737.25 | 737.05 |
| 9_012.15 | 9_012.14 | 9_012.11 | 0.234 | 530 | 0.121 | 0.137 | 0.137 | 0.137 | 525 | 70.9 | 0.28 | 734.53 | 734.33 |
| 9_012.16 | 9_012.15 | 9_012.14 | 0.256 | 530 | 0.121 | 0.137 | 0.137 | 0.137 | 525 | 18.9 | 0.33 | 734.59 | 734.53 |
| 9_012.17 | 9_012.16 | 9_012.15 | 0.249 | 530 | 0.121 | 0.137 | 0.137 | 0.137 | 525 | 96.8 | 0.31 | 734.93 | 734.63 |
| 9_012.20l1 | 9_012.20 | 9_012.13 | 0.237 | 600 | 0.058 | 0.284 | 0.284 | 0.284 | 600 | 70.0 | 0.16 | 737.36 | 737.25 |
| 9_012.21l1 | 9_012.21 | Intercept1 | 0.206 | 600 | 0.058 | 0.27 | 0.27 | 0.27 | 600 | 110.0 | 0.11 | 737.48 | 737.36 |
| 9_012.22l1 | 9_012.22 | 9_012.21 | 0.176 | 600 | 0.058 | 0.27 | 0.27 | 0.27 | 600 | 115.0 | 0.09 | 737.58 | 737.48 |
| 9_012.23l1 | 9_012.23 | 9_012.22 | 0.164 | 600 | 0.058 | 0.27 | 0.27 | 0.27 | 600 | 120.0 | 0.08 | 737.72 | 737.63 |
| 9_012.24l1 | 9_012.24 | 9_012.23 | 0.172 | 600 | 0.059 | 0.27 | 0.27 | 0.27 | 600 | 120.0 | 0.08 | 737.87 | 737.77 |
| 9_012.25l1 | 9_012.25 | Intercept2 | 0.208 | 600 | 0.059 | 0.256 | 0.255 | 0.256 | 600 | 85.2 | 0.11 | 738.07 | 737.97 |
| 9_012.26l1 | 9_012.26 | 9_012.25 | 0.207 | 600 | 0.059 | 0.256 | 0.255 | 0.256 | 600 | 90.0 | 0.12 | 738.17 | 738.07 |
| 9_012.27l1 | 9_012.27 | 9_012.26 | 0.221 | 600 | 0.059 | 0.256 | 0.255 | 0.256 | 600 | 29.4 | 0.14 | 738.26 | 738.22 |
| 9_012.28l1 | 9_012.28 | 9_012.27 | 0.208 | 600 | 0.027 | 0.231 | 0.23 | 0.231 | 600 | 65.9 | 0.12 | 738.39 | 738.31 |
| 9_012.29l1 | 9_012.29 | 9_012.28 | 0.209 | 600 | 0.027 | 0.231 | 0.229 | 0.231 | 600 | 90.0 | 0.12 | 738.55 | 738.44 |
| 9_012.30l1 | 9_012.30 | 9_012.29 | 0.164 | 600 | 0.018 | 0.226 | 0.225 | 0.226 | 600 | 120.0 | 0.08 | 738.69 | 738.60 |
| 9_012.31l1 | 9_012.31 | 9_012.30 | 0.173 | 600 | 0.014 | 0.223 | 0.221 | 0.223 | 600 | 120.0 | 0.08 | 738.84 | 738.74 |
| 9_012.32l1 | 9_012.32 | 9_012.31 | 0.164 | 600 | 0.014 | 0.222 | 0.221 | 0.222 | 600 | 120.0 | 0.08 | 738.98 | 738.89 |
| 9_012.33l1 | 9_012.33 | 9_012.32 | 0.163 | 600 | 0.014 | 0.222 | 0.221 | 0.222 | 600 | 17.5 | 0.07 | 739.05 | 739.03 |
| 9_012.18 | 9_015.00 | 9_012.16 | 0.278 | 530 | 0.117 | 0.134 | 0.134 | 0.134 | 525 | 73.6 | 0.39 | 735.39 | 735.11 |
| 9_016.00 | 9_016.00 | 9_015.00 | 0.122 | 450 | 0.118 | 0.134 | 0.134 | 0.134 | 450 | 104.2 | 0.19 | 735.60 | 735.40 |
| 9_017.00 | 9_017.00 | 9_016.00 | 0.162 | 450 | 0.113 | 0.128 | 0.128 | 0.128 | 450 | 103.5 | 0.34 | 735.95 | 735.60 |
| 9_018.00 | 9_018.00 | 9_017.00 | 0.145 | 450 | 0.113 | 0.128 | 0.128 | 0.128 | 450 | 114.0 | 0.27 | 736.26 | 735.95 |
| 9_019.00 | 9_018.00 | 9_019.00 | 0.124 | 450 | -0.085 | -0.102 | -0.102 | -0.085 | 450 | 10.0 | 0.20 | 736.26 | 736.24 |
| 9_020.00 | 9_020.00 | 9_019.00 | 0.041 | 300 | 0.06 | 0.06 | 0.06 | 0.06 | 300 | 109.3 | 0.22 | 736.52 | 736.28 |
| 9_021.00 | 9_021.00 | 9_020.00 | 0.042 | 300 | 0.059 | 0.058 | 0.058 | 0.059 | 300 | 122.8 | 0.22 | 736.79 | 736.52 |
| 9_021.01 | 9_021.01 | 9_021.00 | 0.024 | 200 | -0.001 | -0.002 | -0.002 | -0.001 | 200 | 84.7 | 0.63 | 737.37 | 736.84 |
| 9_021.02 | 9_021.02 | 9_021.01 | 0.035 | 200 | 0 | 0 | 0 | 0 | 200 | 84.7 | 1.37 | 738.53 | 737.37 |
| 9_021.03 | 9_021.03 | 9_021.02 | 0.035 | 200 | 0 | 0 | 0 | 0 | 200 | 84.8 | 1.40 | 739.72 | 738.53 |
| 9_022.00 | 9_022.00 | 9_021.00 | 0.047 | 300 | 0.021 | 0.026 | 0.026 | 0.026 | 300 | 83.5 | 0.28 | 737.03 | 736.79 |
| 9_023.00 | 9_023.00 | 9_022.00 | 0.045 | 300 | 0.019 | 0.024 | 0.024 | 0.024 | 300 | 83.1 | 0.27 | 737.25 | 737.03 |
| 9_024.00 | 9_024.00 | 9_023.00 | 0.044 | 300 | 0.019 | 0.024 | 0.024 | 0.024 | 300 | 89.8 | 0.25 | 737.47 | 737.25 |
| 9_025.00 | 9_025.00 | 9_024.00 | 0.043 | 300 | 0.018 | 0.022 | 0.022 | 0.022 | 300 | 105.0 | 0.24 | 737.72 | 737.47 |
| 9_025.01 | 9_025.01 | 9_025.00 | 0.041 | 250 | 0.009 | 0.01 | 0.01 | 0.01 | 250 | 68.2 | 0.57 | 738.21 | 737.82 |
| 9_025.02 | 9_025.02 | 9_025.01 | 0.041 | 250 | 0.008 | 0.008 | 0.008 | 0.008 | 250 | 90.8 | 0.56 | 738.72 | 738.21 |
| 9_025.03 | 9_025.03 | 9_025.02 | 0.042 | 250 | 0.005 | 0.005 | 0.005 | 0.005 | 250 | 91.8 | 0.61 | 739.28 | 738.72 |

## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 9_025.04 | 9_025.04 | 9_025.03 | 0.04 | 250 | 0.004 | 0.005 | 0.005 | 0.005 | 250 | 65.9 | 0.41 | 739.55 | 739.28 |
| 9_026.00 | 9_026.00 | 9_025.00 | 0.033 | 300 | 0.009 | 0.013 | 0.013 | 0.013 | 300 | 74.4 | 0.14 | 737.82 | 737.72 |
| 9_027.00 | 9_027.00 | 9_026.00 | 0.041 | 300 | 0.007 | 0.01 | 0.01 | 0.01 | 300 | 87.8 | 0.22 | 738.01 | 737.82 |
| 9_028.00 | 9_028.00 | 9_027.00 | 0.037 | 300 | 0.002 | 0.002 | 0.002 | 0.002 | 300 | 111.0 | 0.18 | 738.22 | 738.01 |
| 9_029.02l1 | 9_029.02 | 9_012.27 | 0.045 | 200 | 0.031 | 0.033 | 0.033 | 0.034 | 200 | 21.1 | 1.96 | 739.06 | 738.65 |
| 9_029.03 | 9_029.03 | 9_029.02 | 0.04 | 300 | 0.027 | 0.027 | 0.027 | 0.029 | 300 | 119.5 | 0.21 | 739.32 | 739.07 |
| 9_029.04 | 9_029.04 | 9_029.03 | 0.031 | 250 | 0.027 | 0.029 | 0.029 | 0.029 | 250 | 119.5 | 0.33 | 739.71 | 739.32 |
| 9_100.00 | 9_100.00 | 9_101.00 | 0.019 | 200 | 0.004 | 0.006 | 0.006 | 0.006 | 200 | 122.4 | 0.42 | 741.63 | 741.12 |
| 9_101.00 | 9_101.00 | 9_102.00 | 0.02 | 200 | 0.008 | 0.01 | 0.01 | 0.01 | 200 | 121.7 | 0.43 | 741.12 | 740.59 |
| 9_102.00 | 9_102.00 | 9_103.00 | 0.019 | 200 | 0.011 | 0.014 | 0.014 | 0.014 | 200 | 121.6 | 0.40 | 740.59 | 740.11 |
| 9_103.00 | 9_103.00 | 9_104.00 | 0.019 | 200 | 0.017 | 0.026 | 0.026 | 0.026 | 200 | 121.6 | 0.41 | 740.11 | 739.61 |
| 9_104.00 | 9_104.00 | 9_105.00 | 0.019 | 200 | 0.018 | 0.028 | 0.028 | 0.028 | 200 | 121.5 | 0.42 | 739.61 | 739.10 |
| 9_105.00 | 9_105.00 | 9_106.00 | 0.018 | 200 | 0.022 | 0.033 | 0.033 | 0.033 | 200 | 107.4 | 0.36 | 739.10 | 738.71 |
| 9_106.00l2 | 9_106.00 | Intercept1 | Future | Future | Future | 0.016 | 0.016 | 0.016 | 450 | 12.5 | 0.40 | 738.91 | 738.86 |
| 9_106.00l1 | 9_106.00 | 9_107.00 | 0.02 | 200 | 0.025 | 0.022 | 0.022 | 0.025 | 200 | 96.0 | 0.47 | 738.71 | 738.26 |
| 9_107.00 | 9_107.00 | 9_108.00 | 0.026 | 200 | 0.026 | 0.023 | 0.023 | 0.026 | 200 | 96.1 | 0.76 | 738.26 | 737.53 |
| 9_108.00 | 9_108.00 | 9_109.00 | 0.023 | 200 | 0.027 | 0.023 | 0.023 | 0.027 | 200 | 122.0 | 0.60 | 737.49 | 736.76 |
| 9_109.00 | 9_109.00 | 9_018.00 | 0.021 | 200 | 0.029 | 0.026 | 0.026 | 0.029 | 200 | 122.0 | 0.39 | 736.73 | 736.26 |
| 9_200.00 | 9_200.00 | 9_201.00 | 0.029 | 250 | 0.016 | 0.02 | 0.02 | 0.02 | 250 | 89.0 | 0.29 | 741.34 | 741.08 |
| 9_200.01 | 9_200.01 | 9_200.02 | 0.029 | 250 | 0.008 | 0.009 | 0.009 | 0.009 | 250 | 94.5 | 0.29 | 741.98 | 741.70 |
| 9_200.02 | 9_200.02 | 9_200.00 | 0.033 | 250 | 0.008 | 0.009 | 0.009 | 0.009 | 250 | 94.5 | 0.37 | 741.70 | 741.35 |
| 9_200.07 | 9_200.07 | 9_200.20 | 0.031 | 250 | 0.021 | 0.023 | 0.023 | 0.023 | 250 | 123.5 | 0.26 | 740.55 | 740.23 |
| 9_200.08 | 9_200.08 | 9_200.07 | 0.025 | 250 | 0.018 | 0.02 | 0.02 | 0.02 | 250 | 143.3 | 0.40 | 741.13 | 740.55 |
| 9_200.09 | 9_200.09 | 9_200.08 | 0.023 | 250 | 0.015 | 0.015 | 0.015 | 0.015 | 250 | 126.3 | 0.34 | 741.56 | 741.13 |
| 9_200.10 | 9_200.10 | 9_200.09 | 0.023 | 250 | 0.015 | 0.015 | 0.015 | 0.015 | 250 | 72.3 | 0.36 | 741.82 | 741.56 |
| 9_200.11 | 9_200.11 | 9_200.10 | 0.035 | 250 | 0.015 | 0.015 | 0.015 | 0.015 | 250 | 18.5 | 0.81 | 741.97 | 741.82 |
| 9_200.12 | 9_200.12 | 9_200.11 | 0.021 | 250 | 0.015 | 0.015 | 0.015 | 0.015 | 250 | 120.7 | 0.30 | 742.33 | 741.97 |
| 9_200.13 | 9_200.13 | 9_200.12 | 0.023 | 250 | 0.015 | 0.015 | 0.015 | 0.015 | 250 | 119.7 | 0.34 | 742.74 | 742.33 |
| 9_200.20 | 9_200.20 | 9_200.21 | 0.034 | 250 | 0.021 | 0.023 | 0.023 | 0.023 | 250 | 110.0 | 0.30 | 740.18 | 739.85 |
| 9_200.21 | 9_200.21 | 9_029.04 | 0.022 | 250 | 0.027 | 0.029 | 0.029 | 0.029 | 250 | 19.4 | 0.17 | 739.77 | 739.74 |
| 9_201.00 | 9_201.00 | 9_202.00 | 0.024 | 250 | 0.015 | 0.02 | 0.02 | 0.02 | 250 | 106.7 | 0.20 | 741.08 | 740.86 |
| 9_202.00 | 9_202.00 | 9_203.00 | 0.032 | 250 | 0.017 | 0.024 | 0.024 | 0.024 | 250 | 106.7 | 0.36 | 740.86 | 740.48 |
| 9_203.00 | 9_203.00 | 9_204.00 | 0.045 | 250 | 0.02 | 0.027 | 0.027 | 0.027 | 250 | 106.7 | 0.68 | 740.86 | 740.14 |
| 9_204.00 | 9_204.00 | 9_205.00 | 0.03 | 250 | 0.022 | 0.03 | 0.03 | 0.03 | 250 | 106.7 | 0.32 | 740.14 | 739.80 |
| 9_205.00 | 9_205.00 | 9_206.00 | 0.028 | 250 | 0.021 | 0.03 | 0.03 | 0.03 | 250 | 107.0 | 0.26 | 739.80 | 739.52 |
| 9_206.00l1 | 9_206.00 | Intercept2 | Future | Future | Future | 0.024 | 0.024 | 0.024 | 450 | 15.1 | 0.40 | 739.77 | 739.71 |
| 9_206.00 | 9_206.00 | 9_207.00 | 0.046 | 300 | 0.023 | 0.023 | 0.023 | 0.023 | 300 | 125.3 | 0.24 | 739.52 | 739.22 |
| 9_207.00 | 9_207.00 | 9_208.00 | 0.019 | 200 | 0.023 | 0.019 | 0.019 | 0.023 | 200 | 121.8 | 0.40 | 739.19 | 738.70 |
| 2_208.00 | 9_208.00 | 9_209.00 | 0.019 | 200 | 0.024 | 0.018 | 0.018 | 0.024 | 200 | 100.5 | 0.42 | 738.70 | 738.27 |
| 9_209.00 | 9_209.00 | 9_210.00 | 0.019 | 200 | 0.026 | 0.02 | 0.02 | 0.026 | 200 | 121.9 | 0.40 | 738.24 | 737.76 |
| 9_210.00 | 9_210.00 | 9_211.00 | 0.019 | 200 | 0.028 | 0.022 | 0.022 | 0.028 | 200 | 121.5 | 0.42 | 737.76 | 737.24 |
| 9_211.00 | 9_211.00 | 9_021.00 | 0.018 | 200 | 0.03 | 0.024 | 0.024 | 0.03 | 200 | 122.2 | 0.34 | 737.21 | 736.79 |
| 9_300.00 | 9_300.00 | 9_301.00 | 0.026 | 250 | 0.006 | 0.006 | 0.006 | 0.006 | 250 | 46.7 | 0.24 | 740.87 | 740.76 |
| 9_301.00 | 9_301.00 | 9_302.00 | 0.029 | 250 | 0.008 | 0.009 | 0.009 | 0.009 | 250 | 98.0 | 0.29 | 740.75 | 740.46 |
| 9_302.00 | 9_302.00 | 9_303.00 | 0.03 | 250 | 0.008 | 0.009 | 0.009 | 0.009 | 250 | 59.1 | 0.31 | 740.45 | 740.26 |
| 9_303.00 | 9_303.00 | 9_304.00 | 0.042 | 300 | 0.012 | 0.012 | 0.012 | 0.012 | 300 | 14.3 | 0.22 | 740.26 | 740.23 |
| 9_304.00 | 9_304.00 | 9_305.00 | 0.054 | 300 | 0.012 | 0.012 | 0.012 | 0.012 | 300 | 117.0 | 0.29 | 740.23 | 739.89 |
| 9_305.00 | 9_305.00 | 9_305.01 | 0.127 | 300 | 0.014 | 0.015 | 0.015 | 0.015 | 300 | 10.0 | 2.10 | 739.89 | 739.68 |
| 9_306.00 | 9_305.01 | 9_307.00 | 0.074 | 380 | 0.02 | 0.038 | 0.038 | 0.038 | 375 | 122.6 | 0.19 | 739.65 | 739.42 |
| 9_306.01 | 9_306.01 | 9_305.01 | 0.02 | 200 | 0.006 | 0.023 | 0.023 | 0.023 | 200 | 85.1 | 0.45 | 740.29 | 739.90 |
| 9_306.02 | 9_306.02 | 9_306.01 | 0.016 | 200 | 0.006 | 0.023 | 0.023 | 0.023 | 200 | 84.9 | 0.28 | 740.53 | 740.29 |
| 9_306.03 | 9_306.03 | 9_306.02 | 0.02 | 200 | 0.006 | 0.023 | 0.023 | 0.023 | 200 | 64.8 | 0.34 | 740.75 | 740.53 |
| 9_306.04 | 9_306.04 | 9_306.03 | 0.069 | 300 | 0.006 | 0.023 | 0.023 | 0.023 | 300 | 96.9 | 0.47 | 741.21 | 740.75 |

### Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| 9_306.05 | 9_306.05 | 9_306.04 | 0.048 | 300 | 0.005 | 0.024 | 0.024 | 0.024 | 300 | 129.9 | 0.23 | 741.51 | 741.21 |
| 9_306.06 | 9_306.06 | 9_306.05 | 0.053 | 300 | 0.001 | 0.018 | 0.018 | 0.018 | 300 | 127.7 | 0.27 | 741.86 | 741.51 |
| 9_306.07 | 9_306.07 | 9_306.06 | 0.022 | 200 | 0 | 0.017 | 0.017 | 0.017 | 200 | 93.1 | 0.40 | 742.27 | 741.89 |
| 9_307.00 | 9_307.00 | 9_308.00 | 0.079 | 380 | 0.022 | 0.039 | 0.039 | 0.039 | 375 | 120.5 | 0.20 | 739.42 | 739.18 |
| 9_308.00 | 9_308.00 | 9_019.00 | 0.273 | 380 | 0.025 | 0.042 | 0.042 | 0.042 | 375 | 122.9 | 2.38 | 739.18 | 736.25 |
| 9_507.00l1 | 9_507.00 | 8_001.65 | Future | 300 | Future | 0.082 | 0.019 | 0.082 | 300 | 24.9 | 1.03 | 740.11 | 739.85 |
| 9_508.00l1 | 9_508.00 | 9_507.00 | Future | 300 | Future | 0.082 | 0.019 | 0.082 | 300 | 20.4 | 0.39 | 740.21 | 740.13 |
| 9_509.00l1 | 9_509.00 | 9_508.00 | Future | 300 | Future | 0.082 | 0.019 | 0.082 | 300 | 73.7 | 0.50 | 740.60 | 740.23 |
| 9_510.00l1 | 9_510.00 | 9_509.00 | Future | 300 | Future | 0.077 | 0.015 | 0.077 | 300 | 73.7 | 0.37 | 740.90 | 740.63 |
| 9_511.00l1 | 9_511.00 | 9_510.00 | Future | 300 | Future | 0.077 | 0.015 | 0.077 | 300 | 90.5 | 0.29 | 741.20 | 740.94 |
| 9_512.00l1 | 9_512.00 | 9_511.00 | Future | 300 | Future | 0.075 | 0.013 | 0.075 | 300 | 54.6 | 0.33 | 741.41 | 741.22 |
| 9_513.00l1 | 9_513.00 | 9_512.00 | Future | 300 | Future | 0.075 | 0.013 | 0.075 | 300 | 57.8 | 0.22 | 741.63 | 741.51 |
| 9_514.00l1 | 9_514.00 | 8_001.66 | Future | 300 | Future | 0.044 | 0.044 | 0.044 | 300 | 15.5 | 1.16 | 741.89 | 741.71 |
| 9_515.00l1 | 9_515.00 | 9_514.00 | Future | 300 | Future | 0.044 | 0.044 | 0.044 | 300 | 62.6 | 0.21 | 742.06 | 741.93 |
| 9_516.00l1 | 9_516.00 | 9_513.00 | Future | 300 | Future | 0.075 | 0.013 | 0.075 | 300 | 65.9 | 0.22 | 741.83 | 741.68 |
| 9_517.00l1 | 9_517.00 | 9_516.00 | Future | 300 | Future | 0.075 | 0.013 | 0.075 | 300 | 43.4 | 0.22 | 741.97 | 741.88 |
| AIR VALVEl1 | AIR VALVE | AIR VALVE_A | 0.255 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 829.0 | 0.42 | 740.60 | 737.09 |
| AIR VALVE_Al | AIR VALVE_A | AIR VALVE_B | 0.418 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 96.0 | 1.13 | 737.09 | 736.00 |
| AIR VALVE_Bl | AIR VALVE_B | AIR VALVE_C | 0.466 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 35.5 | -1.41 | 736.00 | 736.50 |
| AIR VALVE_Cl | AIR VALVE_C | AIR VALVE_D | 0.377 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 43.5 | -0.92 | 736.50 | 736.90 |
| AIR VALVE_Dl | AIR VALVE_D | VALVE | 0.609 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 79.0 | -2.41 | 736.90 | 738.80 |
| Creekside-2l1 | Creekside-1 | Creekside-2 | Future | 380 | Future | 0.124 | 0.123 | 0.124 | 375 | 109.7 | 1.10 | 731.16 | 729.95 |
| Creekside-2l2 | Creekside-2 | Creekside-3 | Future | 380 | Future | 0.124 | 0.124 | 0.124 | 375 | 74.3 | 1.10 | 729.95 | 729.13 |
| Creekside-3l1 | Creekside-3 | T_223.00 | Future | 380 | Future | 0.123 | 0.123 | 0.123 | 375 | 43.0 | 1.54 | 729.13 | 728.47 |
| Creekside-4l2 | Creekside-4 | 12_044.00 | Future | Future | Future | 0 | 0 | 0 | 250 | 66.1 | 1.91 | 731.89 | 730.63 |
| EnvInt-1l1 | EnvInt-1 | EnvInt-2 | Future | Future | Future | 0.082 | 0.082 | 0.082 | 450 | 131.0 | 0.60 | 742.47 | 741.68 |
| EnvInt-2l1 | EnvInt-2 | 8_082.22 | Future | Future | Future | 0.082 | 0.082 | 0.082 | 450 | 395.0 | 0.59 | 741.68 | 739.36 |
| Intercept1l1 | Intercept1 | 9_012.20 | Future | Future | Future | 0.284 | 0.284 | 0.284 | 600 | 14.0 | 0.07 | 737.36 | 737.35 |
| Intercept2l1 | Intercept2 | 9_012.24 | Future | Future | Future | 0.27 | 0.27 | 0.27 | 600 | 37.5 | 0.13 | 737.97 | 737.92 |
| Mohler Pumpl1 | Mohler Pump | 2012 | Future | Future | Future | 0.445 | 0.445 | 0.445 | 600 | 1100.0 | -0.50 | 734.00 | 739.45 |
| OF-pumpl1 | OF-pump | Overflow | 0.221 | 450 | 0.993 | 0 | 0 | 1.495 | 900 | 18.0 | -0.56 | 711.00 | 711.10 |
| 1204 | PUMP1 | 1204A | Future | Future | Future | 0.095 | 0.094 | 0.095 | 375 | 602.3 | -0.42 | 732.58 | 735.10 |
| 2310 | PUMP3 | 2311 | Future | Future | Future | 0.579 | 1.749 | 1.749 | 1000 | 214.1 | -5.56 | 731.85 | 743.75 |
| 3008 | Pump-NE | 4207 | Future | Future | Future | 0.066 | 0.311 | 0.311 | 500 | 1078.4 | -0.56 | 728.45 | 734.45 |
| 2005 | Pump-SE | 2006 | Future | Future | Future | 0.262 | 0.285 | 0.285 | 450 | 546.7 | -0.74 | 739.22 | 743.25 |
| 8_001.65 | SAN.VALVE | 8_001.64 | 0.032 | 250 | 0.055 | 0.15 | 0.088 | 0.15 | 250 | 728.0 | -0.27 | 743.00 | 744.97 |
| STRUCT_1l1 | STRUCT_1 | OUTFALL | 5.377 | 900 | 0.342 | 0 | 0 | 0.342 | 900 | 19.0 | 8.16 | 742.30 | 740.75 |
| T5_217.00 | T_217.00 | T5_216.00 | 0.121 | 600 | 0.179 | 0.998 | 1.006 | 1.006 | 1200 | 152.6 | 0.09 | 727.29 | 727.15 |
| T5_218.00 | T_218.00 | T_217.00 | 0.188 | 600 | 0.179 | 0.999 | 1.007 | 1.007 | 1200 | 152.8 | 0.10 | 727.44 | 727.29 |
| T5_219.00 | T_219.00 | T_218.00 | 0.158 | 600 | 0.179 | 1 | 1.008 | 1.008 | 1200 | 128.8 | 0.07 | 727.54 | 727.45 |
| T5_220.00 | T_220.00 | T_219.00 | 0.162 | 600 | 0.178 | 1.002 | 1.01 | 1.01 | 1200 | 150.3 | 0.07 | 727.67 | 727.56 |
| T5_221.00 | T_221.00 | T_220.00 | 0.076 | 600 | 0.176 | 1.003 | 1.011 | 1.011 | 1200 | 62.3 | 0.02 | 727.73 | 727.72 |
| T5_222.00 | T_222.00 | T_221.00 | 0.155 | 530 | 0.172 | 0.997 | 1.006 | 1.006 | 1200 | 100.0 | 0.13 | 727.87 | 727.74 |
| T5_223.00 | T_223.00 | T_222.00 | 0.137 | 530 | 0.172 | 0.999 | 1.008 | 1.008 | 1200 | 147.4 | 0.10 | 728.02 | 727.87 |
| T5_224.00 | T_224.00 | T_223.00 | 0.127 | 530 | 0.136 | 0.879 | 0.89 | 0.89 | 1200 | 136.5 | 0.09 | 728.14 | 728.02 |
| T5_225.00 | T_225.00 | T_224.00 | 0.118 | 530 | 0.136 | 0.88 | 0.892 | 0.892 | 1200 | 145.2 | 0.08 | 728.25 | 728.14 |
| T5_226.00 | T_226.00 | T_225.00 | 0.163 | 530 | 0.136 | 0.541 | 0.311 | 0.541 | 1050 | 83.2 | 0.14 | 728.37 | 728.25 |
| T5_227.00 | T_227.00 | T_226.00 | 0.184 | 530 | 0.112 | 0.542 | 0.315 | 0.542 | 1050 | 71.2 | 0.18 | 728.50 | 728.37 |
| T5_228.00 | T_228.00 | T_227.00 | 0.09 | 300 | 0.107 | 0.118 | 0.118 | 0.125 | 300 | 117.0 | 0.91 | 729.70 | 728.64 |
| T5_229.00 | T_229.00 | T_228.00 | 0.092 | 300 | 0.105 | 0.117 | 0.117 | 0.124 | 300 | 118.5 | 0.96 | 730.89 | 729.75 |
| T5_230.00 | T_230.00 | T_229.00 | 0.118 | 300 | 0.083 | 0.083 | 0.084 | 0.085 | 300 | 21.9 | 1.56 | 731.23 | 730.89 |
| T5_231.00 | T_231.00 | T_230.00 | 0.082 | 300 | 0.081 | 0.082 | 0.082 | 0.084 | 300 | 132.7 | 0.76 | 732.24 | 731.23 |
| T5_232.00 | T_232.00 | T_231.00 | 0.053 | 300 | 0.077 | 0.078 | 0.079 | 0.08 | 300 | 97.9 | 0.32 | 732.57 | 732.26 |

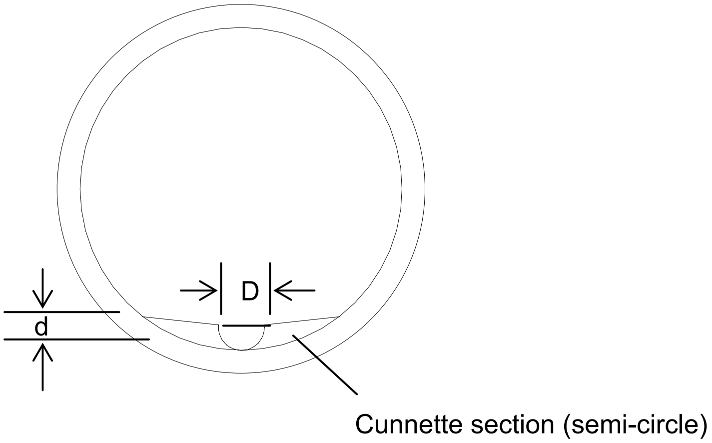
## Appendix C: System Ugrade and Expansion Requirements

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| T5_233.00 | T_233.00 | T_232.00 | 0.052 | 300 | 0.072 | 0.075 | 0.076 | 0.078 | 300 | 100.8 | 0.35 | 732.92 | 732.56 |
| T5_234.00 | T_234.00 | T_233.00 | 0.055 | 300 | 0.052 | 0.058 | 0.058 | 0.068 | 300 | 118.1 | 0.34 | 733.31 | 732.91 |
| T5_235.00 | T_235.00 | T_234.00 | 0.05 | 300 | 0.052 | 0.058 | 0.058 | 0.068 | 300 | 114.4 | 0.28 | 733.63 | 733.31 |
| T5_236.00 | T_236.00 | T_235.00 | 0.062 | 300 | 0.047 | 0.052 | 0.052 | 0.061 | 300 | 114.6 | 0.43 | 734.12 | 733.63 |
| T5_237.00 | T_237.00 | T_236.00 | 0.039 | 300 | 0.015 | 0.013 | 0.013 | 0.015 | 300 | 117.1 | 0.20 | 734.35 | 734.12 |
| 8_001.06 | T_502.00 | 8_001.19 | 1.197 | 1050 | 0.588 | 1.576 | 1.57 | 1.576 | 1350 | 62.9 | 0.20 | 719.04 | 718.91 |
| 8_001.05 | T_503.00 | T_502.00 | 1.19 | 1050 | 0.588 | 1.575 | 1.569 | 1.575 | 1350 | 158.7 | 0.20 | 719.38 | 719.06 |
| 8_001.04 | T_504.00 | T_503.00 | 1.189 | 1050 | 0.588 | 1.575 | 1.568 | 1.575 | 1350 | 62.2 | 0.20 | 719.53 | 719.40 |
| 8_001.02 | T_505.00 | T_98A.00 | 1.202 | 900 | 0.588 | 1.566 | 1.56 | 1.566 | 1350 | 58.2 | 0.46 | 720.09 | 719.82 |
| 8_001.01 | T_506.00 | T_505.00 | 0.876 | 1050 | 0.588 | 1.567 | 1.56 | 1.567 | 1350 | 55.5 | 0.11 | 720.15 | 720.09 |
| T7_101.00 | T_507.00 | T_506.00 | 0.885 | 1050 | 0.577 | 1.558 | 1.551 | 1.558 | 1350 | 122.3 | 0.11 | 720.31 | 720.17 |
| T7_102.00 | T_508.00 | T_507.00 | 1.032 | 1050 | 0.577 | 1.558 | 1.551 | 1.558 | 1350 | 132.4 | 0.15 | 720.53 | 720.33 |
| T7_103.00 | T_509.00 | T_508.00 | 1.065 | 1050 | 0.564 | 1.539 | 1.532 | 1.539 | 1350 | 134.4 | 0.16 | 720.77 | 720.56 |
| T7_104.00 | T_510.00 | T_509.00 | 0.885 | 1050 | 0.564 | 1.539 | 1.532 | 1.539 | 1350 | 48.9 | 0.11 | 720.85 | 720.80 |
| T7_105.00 | T_511.00 | T_510.00 | 0.882 | 1050 | 0.564 | 1.539 | 1.533 | 1.539 | 1350 | 73.8 | 0.11 | 720.96 | 720.88 |
| T7_105.01 | T_512.00 | T_511.00 | 0.927 | 1050 | 0.564 | 1.539 | 1.533 | 1.539 | 1350 | 43.8 | 0.12 | 721.04 | 720.98 |
| T_72.00I1 | T_72.00 | T_72A.00 | 0.124 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 340.9 | -0.10 | 736.47 | 736.81 |
| T_72A.00I1 | T_72A.00 | T_72B.00 | 0.138 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 154.0 | -0.12 | 736.81 | 737.00 |
| T_72B.00I1 | T_72B.00 | T_72C.00 | 0.309 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 443.6 | -0.62 | 737.00 | 739.75 |
| T_72C.00I1 | T_72C.00 | AIR VALVE | 0.299 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 146.8 | -0.58 | 739.75 | 740.60 |
| T_73.00I1 | T_73.00 | T_73A.00 | 0.489 | 500 | 0.343 | 0 | 0 | 0.343 | 500 | 90.7 | 1.55 | 714.70 | 713.29 |
| T_73A.00I1 | T_73A.00 | T_73B.00 | 0.422 | 500 | 0.343 | 0 | 0 | 0.343 | 500 | 49.3 | 1.16 | 713.29 | 712.72 |
| T_73B.00I1 | T_73B.00 | T_73C.00 | 0.413 | 500 | 0.343 | 0 | 0 | 0.343 | 500 | 65.0 | 1.11 | 712.72 | 712.00 |
| T_73C.00I1 | T_73C.00 | T_73D.00 | 1.607 | 500 | 0.343 | 0 | 0 | 0.343 | 500 | 127.2 | -19.06 | 712.00 | 736.25 |
| T_73D.00I1 | T_73D.00 | T_73E.00 | 0.433 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 21.7 | -1.38 | 736.25 | 736.55 |
| T_73E.00I1 | T_73E.00 | T_72.00 | 0.339 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 10.8 | 0.74 | 736.55 | 736.47 |
| T_75A.00I1 | T_75A.00-CC | T_74.00-LS | 3.548 | 1200 | 0.453 | 0 | 0 | 0.453 | 1200 | 10.0 | 1.00 | 713.40 | 713.30 |
| T_75A.00I2 | T_75A.00-CC | OF-pump | 1.173 | 450 | 0.993 | 0 | 0 | 1.496 | 900 | 30.0 | 15.67 | 716.30 | 711.60 |
| T_78.00I1 | T_78.00 | DISC | 2.242 | 1200 | 1.343 | 3.625 | 2.585 | 3.625 | 1500 | 26.2 | 0.35 | 713.59 | 713.50 |
| T_79.00I1 | T_79.00 | 62 | 3.441 | 1500 | 1.343 | 3.448 | 2.518 | 3.448 | 1500 | 23.5 | 0.24 | 713.90 | 713.84 |
| 408 | T_80.00 | T_79.00 | 3.449 | 1500 | 1.343 | 3.448 | 2.518 | 3.448 | 1500 | 51.1 | 0.25 | 714.02 | 713.90 |
| 407 | T_81.00 | T_80.00 | 3.44 | 1500 | 1.344 | 3.449 | 2.519 | 3.449 | 1500 | 106.8 | 0.25 | 714.29 | 714.02 |
| 406 | T_82.00 | T_81.00 | 3.437 | 1500 | 1.344 | 3.449 | 2.519 | 3.449 | 1500 | 152.8 | 0.25 | 714.67 | 714.29 |
| 409 | T_83.00 | T_82.00 | 3.435 | 1500 | 1.344 | 3.449 | 2.519 | 3.449 | 1500 | 34.6 | 0.25 | 714.76 | 714.67 |
| 405 | T_84.00 | T_83.00 | 3.433 | 1500 | 1.345 | 3.449 | 2.519 | 3.449 | 1500 | 132.2 | 0.25 | 715.08 | 714.76 |
| 404 | T_85.00 | T_84.00 | 3.441 | 1500 | 1.345 | 3.449 | 2.518 | 3.449 | 1500 | 107.5 | 0.25 | 715.35 | 715.08 |
| 9_402.00 | T_85A.00 | T_85B.00 | 3.437 | 1500 | 1.347 | 3.45 | 2.519 | 3.45 | 1500 | 96.9 | 0.25 | 715.73 | 715.49 |
| T_85B.00I1 | T_85B.00 | T_85.00 | 3.431 | 1500 | 1.346 | 3.449 | 2.518 | 3.449 | 1500 | 54.5 | 0.25 | 715.49 | 715.35 |
| 9_401.00 | T_86.00 | T_85A.00 | 3.439 | 1500 | 1.352 | 3.449 | 2.518 | 3.449 | 1500 | 63.1 | 0.25 | 715.88 | 715.73 |
| 9_400.00 | T_86A.00 | T_86.00 | 3.748 | 1500 | 1.363 | 3.45 | 2.519 | 3.45 | 1500 | 56.8 | 0.30 | 716.05 | 715.88 |
| 9_398.00 | T_87.00 | T_87A.00 | 1.033 | 900 | 1.379 | 3.45 | 2.519 | 3.45 | 1500 | 37.9 | 0.34 | 716.65 | 716.52 |
| 9_399.00 | T_87A.00 | T_86A.00 | 3.436 | 1500 | 1.374 | 3.45 | 2.519 | 3.45 | 1500 | 55.5 | 0.25 | 716.19 | 716.05 |
| 8_001.13 | T_88.00 | T_88A.00 | 0.165 | 610 | 0.277 | -0.017 | -0.009 | 0.277 | 610 | 14.3 | -0.07 | 716.76 | 716.77 |
| 8_001.57 | T_88A.00 | T_88B.00 | 3.087 | 900 | 0.277 | -0.012 | -0.011 | 0.277 | 900 | 10.0 | -3.06 | 716.77 | 717.08 |
| 8_001.14 | T_88B.00 | T_87.00 | 1.122 | 900 | 1.217 | 2.341 | 2.276 | 2.341 | 1350 | 138.1 | 0.40 | 717.08 | 716.52 |
| 8_001.12 | T_89.00 | T_88.00 | 0.248 | 610 | 0.277 | -0.009 | -0.007 | 0.277 | 610 | 107.9 | 0.16 | 716.93 | 716.76 |
| 8_001.11 | T_90.00 | T_89.00 | 0.639 | 610 | 0.277 | -0.004 | -0.002 | 0.277 | 610 | 52.7 | 1.04 | 717.48 | 716.93 |
| 8_001.10 | T_91.00 | T_90.00 | 0.601 | 610 | 0.277 | 0.002 | -0.001 | 0.277 | 610 | 37.9 | 0.92 | 717.83 | 717.48 |
| 8_001.09 | T_92.00 | T_91.00 | 0.558 | 610 | 0.277 | 0 | 0 | 0.277 | 610 | 64.1 | 0.80 | 718.34 | 717.83 |
| 8_001.08 | T_94.00 | T_92.00 | 0.329 | 610 | 0.278 | 0 | 0 | 0.278 | 610 | 162.4 | 0.28 | 718.79 | 718.34 |
| 8_001.07 | T_95.00 | T_94.00 | 0.217 | 610 | 0.278 | 0 | 0 | 0.278 | 610 | 107.8 | 0.12 | 718.92 | 718.79 |
| 8_001.03 | T_98A.00 | T_504.00 | 0.662 | 900 | 0.588 | 1.566 | 1.56 | 1.566 | 1350 | 99.6 | 0.14 | 719.82 | 719.68 |
| T3_121.00 | T3_120.00 | T7_122.00 | 0.163 | 380 | 0.112 | 0.117 | 0.117 | 0.117 | 375 | 64.0 | 1.05 | 727.64 | 726.97 |

**Appendix C: System Ugrade and Expansion Requirements**

| Link ID | U/S Node | D/S Node | Existing Pipe Capacity (m3/s) | Existing Diameter (mm) | Peak Flow (m3/s) | | | | Proposed Diameter (mm) | Length (m) | Slope (%) | Upstream Invert | Downstream Invert |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Future scenario 1 | Future Scenario 2 | Design Discharge | | | | | |
| T7_147.00 | T3_147.00 | T7_146.00 | 0.067 | 300 | 0.058 | 0.06 | 0.06 | 0.06 | 300 | 60.5 | 0.58 | 726.74 | 726.39 |
| T3_148.00 | T3_148.00 | T3_147.00 | 0.036 | 300 | 0.057 | 0.059 | 0.059 | 0.059 | 300 | 52.4 | 0.17 | 726.83 | 726.74 |
| T5_209.00 | T5_209.00 | T7_208.00 | 0.29 | 600 | 0.21 | 1.044 | 1.05 | 1.05 | 1200 | 115.3 | 0.23 | 726.40 | 726.13 |
| T5_210.00 | T5_210.00 | T5_209.00 | 0.084 | 600 | 0.209 | 1.044 | 1.05 | 1.05 | 1200 | 150.9 | 0.02 | 726.43 | 726.40 |
| T5_211.00 | T5_211.00 | T5_210.00 | 0.236 | 600 | 0.209 | 1.044 | 1.051 | 1.051 | 1200 | 154.5 | 0.16 | 726.67 | 726.43 |
| T5_212.00 | T5_212.00 | T5_211.00 | 0.119 | 600 | 0.209 | 1.044 | 1.051 | 1.051 | 1200 | 151.0 | 0.04 | 726.73 | 726.67 |
| T5_213.00 | T5_213.00 | T5_212.00 | 0.255 | 600 | 0.209 | 1.045 | 1.051 | 1.051 | 1200 | 49.5 | 0.18 | 726.82 | 726.73 |
| T5_214.00 | T5_214.00 | T5_213.00 | 0.147 | 600 | 0.18 | 0.996 | 1.004 | 1.004 | 1200 | 104.1 | 0.06 | 726.89 | 726.82 |
| T5_215.00 | T5_215.00 | T5_214.00 | 0.104 | 600 | 0.18 | 0.997 | 1.004 | 1.004 | 1200 | 136.4 | 0.03 | 726.93 | 726.89 |
| T5_216.00 | T5_216.00 | T5_215.00 | 0.259 | 600 | 0.18 | 0.997 | 1.005 | 1.005 | 1200 | 113.0 | 0.19 | 727.14 | 726.93 |
| T7_106.00 | T7_106.00 | T_512.00 | 0.252 | 600 | 0.564 | 1.539 | 1.533 | 1.539 | 1350 | 106.0 | 0.18 | 721.69 | 721.50 |
| T7_107.00 | T7_107.00 | T7_106.00 | 0.225 | 600 | 0.564 | 1.539 | 1.533 | 1.539 | 1350 | 157.7 | 0.14 | 721.92 | 721.69 |
| T7_108.01 | T7_108.00 | T7_108A.00 | 0.113 | 600 | 0.475 | 1.519 | 1.512 | 1.519 | 1350 | 10.0 | 0.08 | 722.33 | 722.32 |
| T7_108.00 | T7_108A.00 | T7_107.00 | 0.33 | 600 | 0.45 | 1.519 | 1.513 | 1.519 | 1350 | 107.4 | 0.35 | 722.32 | 721.95 |
| T7_109.00 | T7_109.00 | T7_108.00 | 0.677 | 600 | 0.542 | 1.519 | 1.512 | 1.519 | 1350 | 20.3 | 1.28 | 722.59 | 722.33 |
| T7_111.00 | T7_111.00 | T7_172.00 | 0.41 | 600 | 0.308 | 1.315 | 1.315 | 1.315 | 1350 | 12.8 | 0.47 | 723.54 | 723.48 |
| T7_112.00 | T7_112.00 | T7_111.00 | 0.266 | 600 | 0.293 | 1.277 | 1.278 | 1.278 | 1200 | 109.5 | 0.20 | 723.72 | 723.50 |
| T7_119.00 | T7_119.00 | T7_218.00 | 0.193 | 380 | 0.17 | 0.177 | 0.177 | 0.177 | 375 | 27.9 | 1.47 | 724.73 | 724.32 |
| T7_120.00 | T7_120.00 | T7_119.00 | 0.177 | 380 | 0.112 | 0.117 | 0.117 | 0.117 | 375 | 39.6 | 1.24 | 725.22 | 724.73 |
| T7_121.00 | T7_121.00 | T7_120.00 | 0.175 | 380 | 0.112 | 0.117 | 0.117 | 0.117 | 375 | 109.1 | 1.21 | 726.54 | 725.22 |
| T3_122.00 | T7_122.00 | T7_121.00 | 0.146 | 380 | 0.112 | 0.117 | 0.117 | 0.117 | 375 | 34.8 | 0.83 | 726.83 | 726.54 |
| T7_138.00 | T7_138.00 | T7_111.00 | 0.104 | 300 | 0.048 | 0.048 | 0.048 | 0.048 | 300 | 10.0 | 1.40 | 723.96 | 723.82 |
| T7_139.00 | T7_139.00 | T7_138.00 | 0.129 | 300 | 0.048 | 0.048 | 0.048 | 0.048 | 300 | 91.6 | 2.15 | 725.93 | 723.96 |
| T7_140.00 | T7_140.00 | T7_140A.00 | 0.053 | 300 | 0.048 | 0.048 | 0.048 | 0.048 | 300 | 101.7 | 0.36 | 725.49 | 725.13 |
| T7_140A.00 | T7_140A.00 | T7_139.00 | 0.053 | 300 | 0.048 | 0.048 | 0.048 | 0.048 | 300 | 102.1 | 0.36 | 725.13 | 724.76 |
| T7_141.00 | T7_141.00 | T7_140.00 | 0.098 | 250 | 0.048 | 0.048 | 0.048 | 0.048 | 250 | 44.3 | 6.39 | 728.35 | 725.52 |
| T7_145.00 | T7_145.00 | T7_119.00 | 0.127 | 250 | 0.058 | 0.06 | 0.06 | 0.06 | 250 | 22.6 | 5.49 | 726.11 | 724.87 |
| T7_146.00 | T7_146.00 | T7_145.00 | 0.052 | 300 | 0.058 | 0.06 | 0.06 | 0.06 | 300 | 64.9 | 0.35 | 726.39 | 726.16 |
| T7_171.00 | T7_171.00 | T7_109.00 | 0.686 | 600 | 0.31 | 1.315 | 1.315 | 1.315 | 1350 | 56.9 | 1.31 | 723.34 | 722.59 |
| T7_172.00 | T7_172.00 | T7_171.00 | 0.269 | 600 | 0.309 | 1.315 | 1.315 | 1.315 | 1350 | 68.7 | 0.20 | 723.48 | 723.34 |
| T7_174.00 | T7_173.00 | T7_174.00 | 0.133 | 450 | 0.272 | 1.105 | 1.109 | 1.109 | 1200 | 10.0 | 0.20 | 724.33 | 724.31 |
| T7_173.00 | T7_174.00 | T7_219.00 | 0 | 450 | 0.272 | 1.105 | 1.109 | 1.109 | 1200 | 34.0 | 0.00 | 724.31 | 724.31 |
| T7_200.00 | T7_200.00 | T7_173.00 | 0.266 | 600 | 0.271 | 1.103 | 1.108 | 1.108 | 1200 | 91.4 | 0.20 | 724.49 | 724.31 |
| T7_201.00 | T7_201.00 | T7_200.00 | 0.323 | 600 | 0.272 | 1.103 | 1.108 | 1.108 | 1200 | 82.2 | 0.29 | 724.75 | 724.51 |
| T7_203.00 | T7_203.00 | T7_201.00 | 0.238 | 600 | 0.272 | 1.104 | 1.108 | 1.108 | 1200 | 88.6 | 0.16 | 724.93 | 724.79 |
| T7_204.00 | T7_204.00 | T7_203.00 | 0.821 | 600 | 0.272 | 1.104 | 1.108 | 1.108 | 1200 | 25.0 | 1.88 | 725.40 | 724.93 |
| T7_205.00 | T7_205.00 | T7_204.00 | 0.266 | 600 | 0.272 | 1.104 | 1.108 | 1.108 | 1200 | 106.4 | 0.20 | 725.61 | 725.40 |
| T7_206.00 | T7_206.00 | T7_205.00 | 0.238 | 600 | 0.272 | 1.104 | 1.108 | 1.108 | 1200 | 56.9 | 0.16 | 725.70 | 725.61 |
| T7_207.00 | T7_207.00 | T7_206.00 | 0.289 | 600 | 0.272 | 1.104 | 1.108 | 1.108 | 1200 | 74.0 | 0.23 | 725.87 | 725.70 |
| T7_208.00 | T7_208.00 | T7_207.00 | 0.329 | 600 | 0.272 | 1.104 | 1.108 | 1.108 | 1200 | 85.6 | 0.30 | 726.13 | 725.87 |
| T7_213.00 | T7_213.00 | T7_112.00 | 0.218 | 600 | 0.292 | 1.276 | 1.278 | 1.278 | 1200 | 138.2 | 0.13 | 723.90 | 723.72 |
| T7_214.00 | T7_214.00 | T7_213.00 | 0.193 | 600 | 0.291 | 1.276 | 1.278 | 1.278 | 1200 | 44.4 | 0.10 | 723.95 | 723.90 |
| T7_215.00 | T7_215.00 | T7_214.00 | 0.266 | 600 | 0.289 | 1.276 | 1.278 | 1.278 | 1200 | 61.8 | 0.20 | 724.07 | 723.95 |
| T7_216.00 | T7_216.00 | T7_215.00 | 0.252 | 600 | 0.288 | 1.277 | 1.278 | 1.278 | 1200 | 61.0 | 0.18 | 724.18 | 724.07 |
| T7_117.00 | T7_217.00 | T7_216.00 | 0.226 | 600 | 0.288 | 1.277 | 1.278 | 1.278 | 1200 | 75.4 | 0.14 | 724.29 | 724.18 |
| T7_219.00 | T7_218.00 | T7_219.00 | 0 | 600 | 0.17 | 0.177 | 0.177 | 0.177 | 600 | 10.0 | 0.00 | 724.31 | 724.31 |
| T7_218.00 | T7_219.00 | T7_217.00 | 0.112 | 600 | 0.442 | 1.27 | 1.271 | 1.271 | 1200 | 71.5 | 0.04 | 724.31 | 724.29 |
| VALVEI1 | VALVE | STRUCT_1 | 1.09 | 500 | 0.342 | 0 | 0 | 0.342 | 500 | 70.0 | -7.72 | 738.80 | 744.20 |

In-line storage tank (superpipe)



Minimum Pipe Slopes for cunette section
(1/2 circular section or circular pipe flowing 1/2 full)
For: V=1.0 m/s
n=0.013
d=0.5*D

| **Design Flow*<br>(L/s)** | **D<br>(mm)** | **Minimum Slope<br>(%)** |
|---|---|---|
| 25 | 250 | 0.65 |
| 35 | 300 | 0.54 |
| 55 | 375 | 0.4 |
| 75 | 450 | 0.3 |
| 150 | 600 | 0.2 |

FIGURE 3
Cunette Section for In-line Storage

cunette.xls Sheet1

# D Appendix D - G.I.S. Database (Supplied Separately)