REPORT

Town of Bruderheim

Master Services Plan

December 2015

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1 Introduction

1.1 BACKGROUND

The Town of Bruderheim is located along Highway 45, north of Highway 15, approximately 59 kilometres northeast of the City of Edmonton. Refer to **Figure 1.1** for location plan.

Associated Engineering has previously completed a Deep Utility Analysis of the existing water distribution and sanitary sewer systems, providing a final report in January 2010. Since then, the Town of Bruderheim has increased its corporate boundary by annexation and has recently updated its Municipal Development Plan. The Town has subsequently retained Associated Engineering to undertake a Master Services Plan to extend the water and sanitary systems into future growth areas, and expand the analysis to include the storm drainage and transportation systems. A Master Services Plan will assist administration and Council in planning and budgeting infrastructure upgrading and expansion, to achieve orderly and coordinated development.

The Master Services Plan will help to address the top ranking priority as identified in the 2014 Town of Bruderheim Municipal Sustainability Plan. Priority #1 of the Plan recognizes the importance that infrastructure plays in attracting and retaining residents as well as business and industry to the area.

1.2 STUDY AREA

The study area consists of the existing Town boundary as well as additional lands located to the south of the Town boundary, extending to Highway 15.

The topography of the study area generally falls from south to north, from Highway 15 to the north study area limits.

1.3 REPORT OBJECTIVES AND SCOPE

The Master Services Plan addresses the expansion and capacity upgrading of the following infrastructure components:

- Water Distribution System.
- Sanitary Sewerage System.
- Storm Drainage System.
- Transportation System.

The objectives of this report are as follows:

- Collect/review background data.
- Establish design criteria.
- Analyze the capability of the existing system to handle the current demands.

- Determine upgrading requirements to satisfy the existing system.
- Develop future servicing concepts for the study area.
- Provide cost estimates for proposed upgrading.

1.4 REFERENCES

.1 Town of Bruderheim, Existing Deep Utility Analysis, Associated Engineering, 2010.
.2 Town of Bruderheim, Municipal Development Plan, 2013.
.3 Town of Bruderheim, Infrastructure Plan – Tritek Engineering Consultants Ltd., September 1988.
.4 Town of Bruderheim, Record Drawings.
.5 Town of Bruderheim, Engineering Servicing Standards.

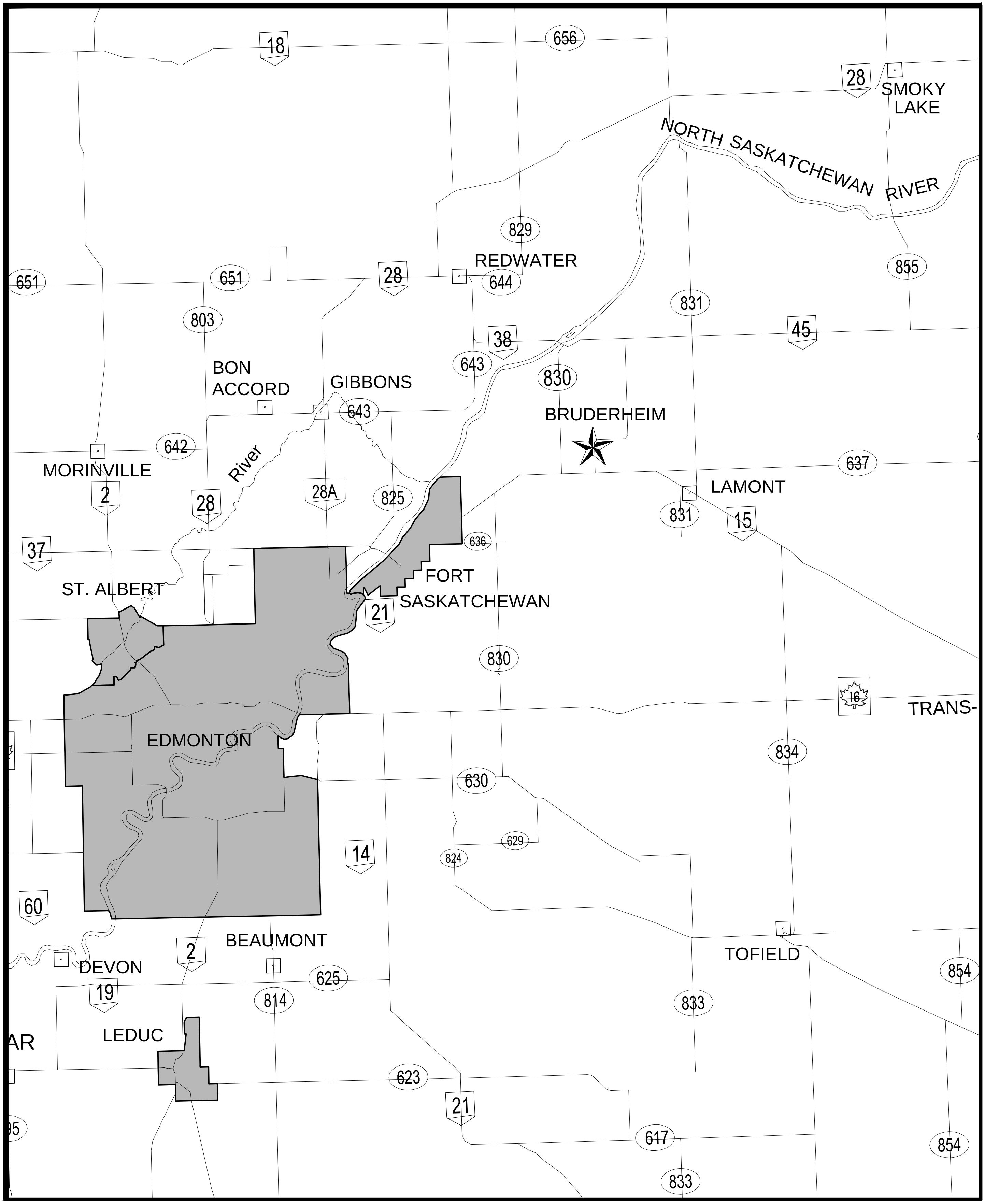
In addition to providing much of the above information, the Town of Bruderheim staff provided assistance on this project.

1.5 ABBREVIATIONS

AC	asbestos cement
fps	feet per second
ft^3/s	cubic feet per second
ft^3	cubic feet
ig	imperial gallons
igpcd	imperial gallons per capita day
igpm	imperial gallons per minute
km	kilometre
L/s	Litres per second
L	Litre
Lpcd	Litres per capita day
m	metre
m/s	metres per second
m^3/s	cubic metres per second
m^3	cubic metres
mig	million imperial gallons
mm	millimetre
PRV	Pressure reducing valve
PVC	polyvinyl chloride
AEAL	Associated Engineering Alberta Ltd.
USGPM	United States Gallons per Minute

1.6 METRIC CONVERSIONS

To Convert From	To	Multiple By
cubic metres (m^3)	cubic feet (ft^3)	35.31
cubic metres (m^3)	imp gal (ig)	219.97
cubic metres/hour (m^3/hr)	igpm	3.667
kilopascals (kPa)	psi	0.145
kilowatts (kw)	horsepower (hp)	1.341
litres/sec (L/s)	igpm	13.2
megalitres (ML)	imp gal (ig)	219974
metres (m)	ft	3.281
millimetres (mm)	inches	0.0394



This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

P:\20133816\00_Master_Services_P\Working_Dwgs\100_Civil\Figure 1.1.dwg
DATE: 2014-01-14, Kevin Grandish

PROJECT No.	2013-3618
DATE:	2013/12/16
APPROVED:	C. GOTTSTEIN
SCALE:	1: 500,000
DWG. No.	FIGURE 1.1

Associated Engineering

TOWN OF BRUDERHEIM

MASTER SERVICES PLAN

LOCATION PLAN

2 Design Criteria

2.1 GENERAL

The proposed design criteria identified below does not strictly adhere to those outlined within the Town of Bruderheim Engineering Standards, so as not to oversize transmission mains and trunk sewers. It is recommended that the Town of Bruderheim Engineering Standards be applied for all individual development areas to ensure that all localized infrastructure are adequately sized.

2.1.1 Population

One of the main variables in assessing a community's municipal servicing components is the population.

According to the Town's current Municipal Development Plan (MDP), the 2012 municipal census yielded a population of 1,298, while the 2011 federal census identified a population of 1,155. The 2013 MDP indicates that the Town believes the 2012 municipal census to be more accurate. For the purpose of this report, a projected population of 1,376 for 2014 will be applied, as identified in the MDP. The MDP also suggests a moderate future growth rate for the Town of 1.5 to 2.0%. In keeping with the MDP, a 2.0% annual growth rate will be utilized for this report.

A growth projection of 2.0% applied annually is presented in **Table 2.1**.

Table 2.1
Projected Population

Year	Population
2014	1,376
2019	1,519
2024	1,677
2029	1,852
2034	2,045
2039	2,257

2.1.2 Population Density

Population densities are utilized to estimate the population or equivalent population based on different land uses. These values are used in conjunction with the per capita daily water consumption/sewage generation rates to estimate the demands on the water and sewer systems.

The following population densities and equivalent population densities have been adopted from the Existing Deep Utility analysis for use in this report:

Table 2.2
Equivalent Population Densities

Description	Population Density Persons/ha
Residential (Single family)	35
Residential (Multi-family)	85
Residential (Apartment)	140
Commercial/Industrial/Institutional	25

An equivalent population density has been included for apartment buildings, which reflects recent development within the Town.

2.1.3 Land Use

Map 2 – Future Land Use as included in the Town of Bruderheim 2013 Municipal Development Plan prepared by Municipal Planning Services is attached for reference. The land uses identified on this drawing have been used in conjunction with the above population densities in the analysis of the existing and future systems. Where higher density locations are known to exist (i.e. multi family or apartment development), they have been applied accordingly.

2.1.4 Phasing Plan

Figure 2.1 presents the proposed phasing plan. The figure identifies three development phases, with the final phase divided into two ultimate development stages; development to the Town Boundary, and development to the Study Boundary. Table 2.3 presents the future population associated with the full build out of each stage. Assuming future single family residential development at 35 p/ha and a 2% annual growth rate, Phase 1 would not be fully occupied until far beyond the study period.

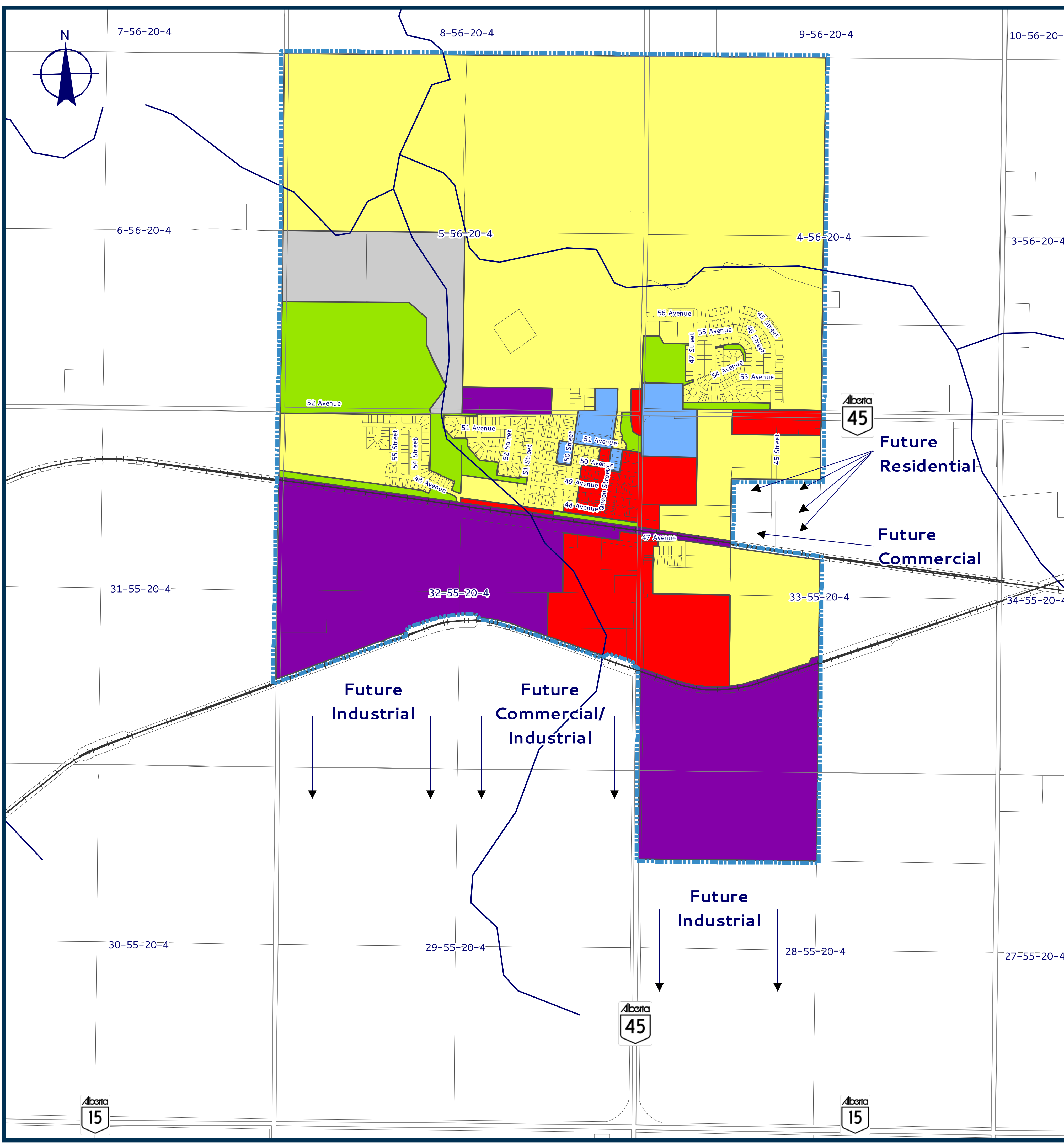
Table 2.3
Future Population per Development Phase

Phase	New Population	Total Population
Phase 1	3,090	4,466
Phase 2	2,460	6,926
Phase 3	6,755	13,681

Phase 3 is divided into 2 components, however the second component (ultimate development to study boundary) does not include any future residential development. As such, it can be developed as required. Additional residential development could be required in order to support future industrial and commercial development, if necessary.

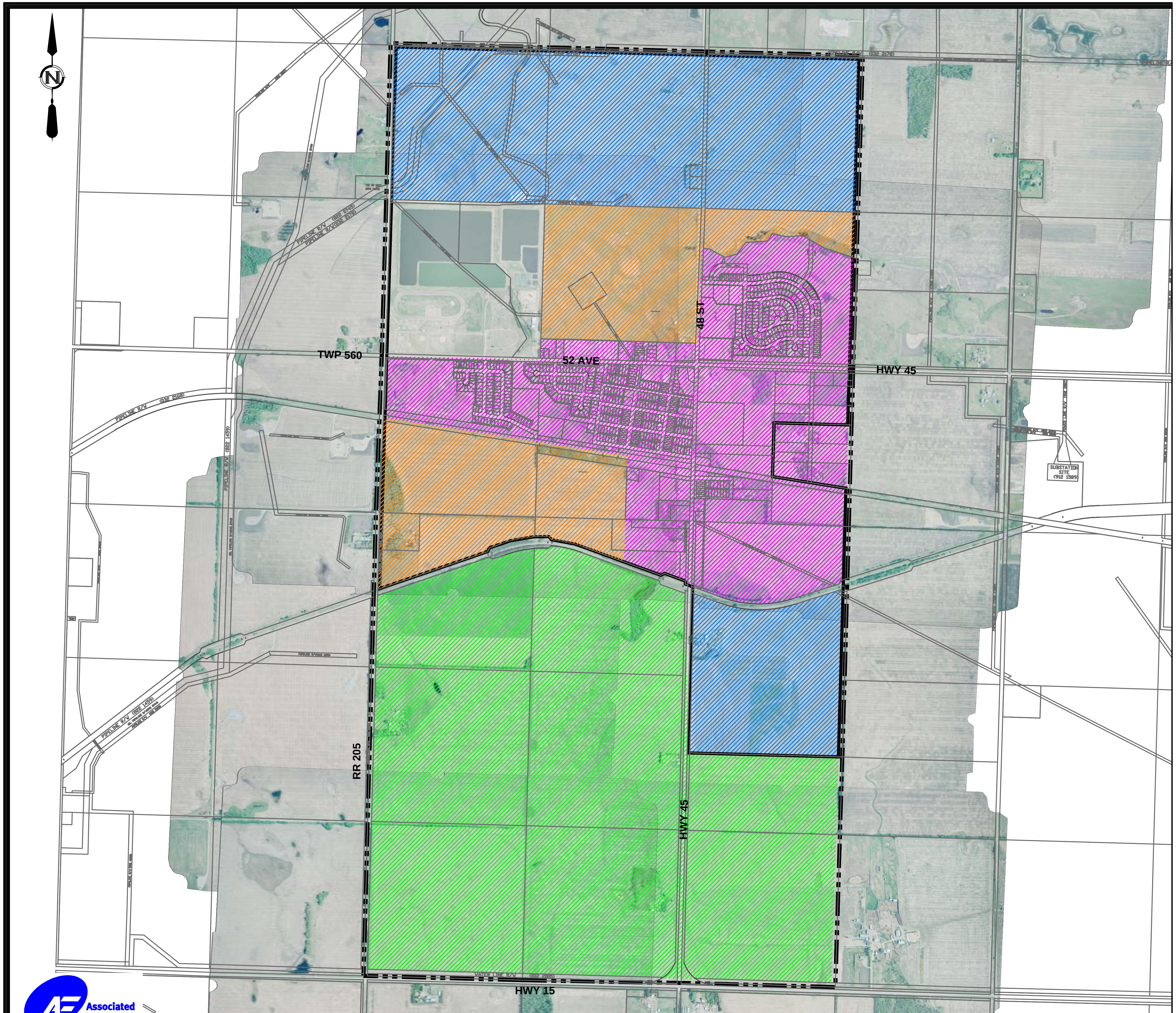
Town of Bruderheim

Map 2: Future Land Use



Digital Geographic Information: Canada National Topological Survey Geobase and Geogratis & Altalis
Geographic coordinate system and projection: UTM. NAD 83 Datum: Zone 12N
FOR MORE INFORMATION: www.munplan.ab.ca | #208, 1751-107 Avenue NW Edmonton, AB T5S 1E5 | 780.486.1991

MPS



the town of Bruderheim Alberta

MASTER SERVICES PLAN

PHASING PLAN

LEGEND:

- STUDY BOUNDARY
- TOWN BOUNDARY
- PHASE 1
- PHASE 2
- PHASE 3 (ULTIMATE TO TOWN BOUNDARY)
- PHASE 3 (ULTIMATE TO STUDY BOUNDARY)

SCALE : 1:20,000

DECEMBER, 2015

FIGURE 2.1

P:\20133816\00_Master_Services_P\Working_Dwgs\100_Civil\Figure 2.1.dwg
DATE: 12/1/2015, Kevin Grandish

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2.2 WATER SYSTEM

2.2.1 Water Demand

Water demand is critical in determining the distribution network, pumping capability and storage required for a water system. Three critical rates of demand, Average Day, Peak Day and Peak Hour Flow are normally used. Fire flows, in conjunction with the Peak Day flows are also used to test the water system's capability to deliver water and meet system demands.

The following briefly describes each of the critical flow conditions:

Average Day
The Average Day demand is determined by dividing the total annual consumption by 365 days. By dividing this rate by the population served, the per capita per day demand is derived. This rate is used primarily as a basis for the projection of the total water demand.

Peak Day
The Peak Day demand is determined by the single day of maximum consumption observed in the distribution system. In using the single day maximum flow, one must ensure that the record is not distorted by firefighting demand, equipment malfunction or watermain breaks. The peaking factor is determined by comparing the peak consumption day to the average day demand. The Peak Day demand is used in determining the delivery capacity required of supply mains, treatment facilities, storage facilities and pumping facilities. In conjunction with the fire flow, it is used to test the water system's capacity to supply the fire and peak day demand.

Peak Hour
The Peak Hour demand is the expected maximum demand observed during a short period of the day. Usually, most facilities are not equipped to record peak hour demands in such detail. Therefore, the rate is established based on experience and judgement. The Peak Hour rate is used in determining watermain sizing and pumping requirement.

An analysis of the historical water consumption was undertaken in the Deep Utility Analysis. The study recommended that a per capita water consumption of 280 L/c/d be adopted. It is recommended that this value be increased to 300 L/c/d in order to incorporate some conservatism in the design of the future water system, and ensure that it will meet the needs of the potential future users. The per capital consumption value of 375 L/c/d as identified in the Town of Bruderheim Engineering Servicing Standards may be too conservative for establishing future transmission main sizing, and analyzing pumping and storage requirements.

2.2.2 Peaking Factor

The Deep Utility Analysis established peaking values based on historical data, and subsequently recommended that a peak day factor of 1.8 times the average day demand be adopted. Although suitable for the analysis of the existing system, it is recommended that the higher value of 2.0 times the average day demand as identified in the Town of Bruderheim Engineering Standards, be adopted for the purpose of master planning.

A Peak Hour factor of 3 times the Average Daily Demand was applied in the Deep Utility Analysis and will also be adopted for this report.

The water consumption demands to be used in the Master Services Plan will be as shown in **Table 2.4**. This is based on the projected population of 1,376 in 2014, as per the 2013 Municipal Development Plan.

Table 2.4
2014 Projected System Demands

	Peaking Factor	Bruderheim (L/s)	2 inch Truckfill (L/s)	TOTAL (L/s)
Average Day Demand	1	4.8	9	13.8
Peak Day Demand	2	9.6	9	18.6
Peak Hour Demand	3	14.3	9	23.3

In addition to the Town demands, the flows shown in the above table also include the contribution from the existing 2 inch truckfill. The truckfill demand does not get peaked as it is either in operation, or not. There is also a second 4 inch truckfill connection; however this is supplied by a dedicated truckfill pump.

2.2.3 Design Water Demand

The water demands recommended to be used in this analysis are presented in **Table 2.5**. These are based on a per capita consumption of 300 L/c/d and peak day and peak hour factors of 2 times the average day, and 3 times the average day demand, respectively. Water demand projections are based on the populations presented in **Table 2.1**.

Table 2.5
Distribution System Water Demand Projections[1]

Year	Population	Average Day Demand (L/s)	Peak Day Demand (L/s)	Peak Hour Demand (L/s)
2014	1376	4.8	9.6	14.3
2019	1519	5.3	10.6	15.9
2024	1677	5.8	11.6	17.5
2029	1852	6.4	12.8	19.2
2034	2045	7.1	14.2	21.3
2039	2257	7.8	15.6	23.4
Ultimate Town2	13681	47.5	95.0	142.5
Ultimate Study3	13681	75.5	151	226.5

Notes: 1: The demands identified are for the distribution system and do not include the 9 L/s flow associated with the 2 inch truckfill.
2: The Ultimate demand presented is to the existing Town boundary.
3: Additional demand has been added to accommodate the expansion of industrial lands to the entire study boundary.

2.2.4 Fire Flow

The following table presents fire flows derived by the Fire Underwriters Survey guidelines.

Table 2.6
Fire Flows

Description	Recommended Fire Flow litres/minute
1. Single Family Residential Wood frame construction, two stories or less 100 m^3 to 150 m^2 150 m^2 to 275 m^2	 5,000 (83 L/s) 6,000 (100 L/s)
2. Multi Family Residential Wood frame construction c/w fire separator four units up to 100 m^2 each	 8,000 (133 L/s)
3. Walk-up Apartments Ordinary construction up to 3,200 m^2 (10-20 m separation)	 12,000 (200 L/s)

Description		Recommended Fire Flow litres/minute
4. Schools Non-combustible construction up to 3,300 m^2 up to 4,000 m^2 up to 12,000 m^2		 10,000 (167 L/s) 11,000 (183 L/s) 19,000 (317 L/s)
5. Institutional, Churches Ordinary construction (15% exposure)	 up to 850 m2	 6,000 (100 L/s)
6. Commercial Non-combustible construction (50% exposure) up to 2,900 m^2 up to 4,200 m^2		 11,000 (183 L/s) 14,000 (233 L/s)
7. Light Industry Non-combustible construction up to 2,900 m^2 (25% exposure) up to 2,900 m^2 (50% exposure)		 9,000 (150 L/s) 11,000 (183 L/s)
8. Low Density Rural Residential 2 stories or less over 30 m separation		 2,000 (33 L/s)
9. High Density Rural Residential 2 stories or less 10.1 to 30 m separation		3,000 (50 L/s)

The preceding flows, based on Fire Underwriter's Guidelines, are determined as follows:

F = 220 C√A where

F = required fire flow in litres per minute
C = 1.5 for wood frame construction
= 1.0 for ordinary construction
= 0.8 for non-combustible construction
= 0.6 for fire flow resistant construction (fully protected frame, floors, roof)
A = total floor area in square metres (including all storeys)

Other considerations when determining fire flow requirements are:

- occupancy hazard,
- automatic sprinkler protection, and
- exposure within 45 metres.

The following fire flows are recommended to be adopted by this study based on the table provided above:

Residential	Single Family	83 L/s
	Multi-family	133 L/s
	Apartment	200 L/s
Commercial	(standard)	183 L/s
Industrial		183 L/s
Schools		167 L/s
Institutional		100 L/s

2.2.5 Operating Pressures

The recommended normal operating system pressures are:

- Minimum system pressure 345 kPa (50 psi).
- Maximum system pressure 552 kPa (80 psi).

To achieve maximum user satisfaction, the recommended operating pressure in the system should be between 350 kPa (50 psi) and 550 kPa (80 psi) during the peak hour design flow, as per the Alberta Environment Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. The Town of Bruderheim Engineering Servicing Standards identifies a maximum pressure of 700 kPa (101 psi).

As per the Town of Bruderheim Engineering Standards, the minimum recommended system pressures during a fire event are:

- Residual pressure at demand hydrant 140 kPa (20 psi).
- Zone pressure 140 kPa (20 psi).

2.2.6 Pipe Roughness Coefficient (“C” Value)

The following "C" values for various pipes, are recommended to be used in the hydraulic model.

- PVC 120
- Asbestos Cement 120
- Steel 110

Any new proposed pipes will be assumed to be either PVC or HDPE pipe, and will have a “C” factor of 120 applied, as per the Town of Bruderheim Engineering Servicing Standards.

2.2.7 Treated Water Storage

It is good practice to provide adequate storage in a water system for operational needs (peak hours), supply interruption and fire flow demand. Design guidelines vary depending on the size of the community and the capital cost involved. The appropriate level of storage must consider how fast the system can be restored to be fully operational when impacted by an interruption such as power failure, plant failure, schedules plant shutdown, watermain breaks, etc.

Water systems with long supply lines or long distances from the source of water are at a higher risk of supply interruption (i.e. regional pipelines) than those which are located close to the source and water treatment plant. In these cases, the recommended storage is based on one peak day plus fire flow, as shown below:

· Equalization & Emergency Storage	One Peak Day
· Fire Storage	200 L/s for 2.5 hours duration (1,800 m^3)

As the Town receives water from the John S. Batiuk Regional Water Commission, it is recommended that a criterion of one peak day plus fire flow be used to assess the treated water storage requirements.

2.3 SANITARY SEWERAGE SYSTEM

2.3.1 Sewage Flow

2.3.1.1 Dry Weather Flows (DWF):

- Domestic Sanitary Flows:
  - Daily per capita flow: 300 L/c/d (100% of the design water consumption rate).

The Deep Utility Analysis utilized pump run hours to establish the dry weather flow rate and associated sewage generation rate. The analysis determined that a value of 200 L/c/d would be suitable for assessing the existing sewage collection system. For the current study, it is recommended that the value be increased to 100% of the design water consumption, in order to reflect possible future flow rates in both the existing and future development areas.

- Peaking Factor: based on Harmon Formula (maximum of 3.8)

$$\text{Peak Factor} = 1 + \frac{14}{(4 + p^{0.5})}$$

Where p = equivalent population in 1000's.

2.3.2.2 Wet Weather Flows (WWF)

Rainfall related Infiltration/Inflows (I/I) are based on current standards and reflect future performance expectations. The Town of Bruderheim Engineering Servicing Standards recommends that an I/I rate of 0.5 L/s/ha be applied. However, it is recommended that the criteria established in the Deep Utility Study be applied. These values are consistent with those applied to many other similar communities in Alberta, and are more conservative that the Engineering Servicing Standards in areas with suspected foundation drain connections. The recommended I/I design criteria are as follows:

Existing Development Areas

- General Infiltration Allowance:
  - Residential Area: 0.28 L/s/ha
  - Other Areas: 0.28 L/s/ha

- Foundation Drain:
  - Residential Areas: 0.60 L/s/ha
  - Other Areas: Nil

- Sag Manholes 0.4 L/s/sag manhole
  (20% of manholes will be assumed to be sag manholes, which results in a general allowance of 0.08 L/s to be applied to each manhole)

Foundation drains are assumed to be connected to the sanitary sewer system in Sunset Crescent and Brookside Park. Sunset Crescent was noted in a previous report as having suspected weeping tile connections to the sanitary sewer, and Brookside Park was indicated by Town staff.

Future Development Areas

- General Infiltration Allowance:
  - Residential Areas: 0.28 L/s/ha
  - Other Areas: 0.28 L/s/ha
- Foundation Drain: No allowance (not allowed)

2.3.2 Pipe Roughness

For gravity sewers, the coefficient of roughness in the Manning's formula shall be 0.015 for old pipes of which all existing pipes are believed to be vitrified clay tile pipes (VCT). New pipes will use a value of 0.013.

For PVC of HDPE sewage forcemains, the “C” value in the Hazen-Williams formula is assumed to be 120.

2.3.3 Velocity

Suggested velocities for the sanitary system are as follows:

Table 2.7
Minimum/Maximum Velocities

Gravity Mains	Minimum 0.6 m/s	Maximum 3 m/s
Forcemains	Minimum 0.76 m/s	Maximum 3.0 m/s (Optimum Maximum of 1.5 m/s)

2.3.4 Pipe Slope

Minimum slopes, as recommended by Alberta Environment and Parks (AEP), are required to achieve a 0.6 m/s minimum scour velocity. The minimum pipe slopes are as follows:

Table 2.8
Minimum Pipe Slopes

Sewer Diameter (mm)	Minimum Design Slope (m/100 m)
200	0.40
250	0.28
300	0.22
375	0.15
450	0.12
525	0.10
600 and greater	0.08

2.3.5 Pipe Cover

For the purpose of this assessment, a minimum depth of cover of 3.0 m above typical sewer mains has been applied in future development areas.

2.3.6 Sewage Treatment

The Town of Bruderheim currently utilizes a sewage lagoon system. The AEP 2013 Standards and Guidelines regulate sewage lagoon design criteria and Alberta Environment provides approvals to operate the system. Table 2.9 below shows the design criteria established in AEP 2013 Standards and Guidelines.

Table 2.9
Requirements for Wastewater Lagoons Set by AEP

Average Day Flow (m^3/day)	Number of Anaerobic Cells	Requirements for Facultative Cell(s)	Requirements for 12 Months Storage Cell(s)
<250	0 min. depth=3.0m	Yes max. depth=1.5m retention = 60 days	Yes max. depth=3.0m retention = 12 months
250 - 500	2 min. depth=3.0m retention = 2 days	Yes max. depth=1.5m retention = 60 days	Yes max. depth=3.0m retention = 12 months
>500	4 min. depth=3.0m retention = 2 days	Yes max. depth=1.5m retention = 60 days	Yes max. depth=3.0m retention = 12 months

AEP requires that sewage lagoons be setback a certain distance from public utilities and residences to buffer the effect of potential odours and also to provide a margin of public safety. The following table illustrates the setback distances as recommended by Alberta Environment:

Table 2.10
Setback Distances from Wastewater Lagoons Set by AEP

Minimum Setback Distance (m) from the "Working Area" of a Wastewater Lagoon to:		
.1	The property line of the land where the lagoon is located	30
.2	The designated right-of-way of a rural road or railway	30
.3	The designated right-of-way of a primary or secondary highway	100
.4	A "building site" for school, hospital, for establishment or residential use	300

Note:
"Working Area" means, those areas of a parcel of land that are currently being used or will be used for the processing of wastewater.
"Building Site" means a portion of the land on which a building exists, or can or may be constructed

2.3.7 Lagoon Flows

Town staff have indicated that the typical yearly discharge from the existing sewage lagoon is in the order of 25,000,000 imperial gallons/year (113,652 m^3/year). This equates to 311 m^3/day, which when based on the 2012 municipal census population of 1,298 people results in an average day contribution of 240 L/c/d. It is recommended that a design value equivalent to the sewage generation rate of 300 L/c/d be applied.

Based on a sewage generation rate of 300 L/c/d, the projected future Lagoon flows are as follows:

Table 2.11
Lagoon Flow Projections

Year	Population	Lagoon Flow (m^3/day)
2014	1,376	413
2019	1,519	456
2024	1,677	503
2029	1,852	556
2034	2,045	614
2039	2,257	677
Ultimate	**13,681**	**4,104**

2.3.8 Lift Station

The Lift Station pumping capacity has been based on conveying the design peak wet weather flow. This is calculated by adding the estimated wet weather flows with the peak dry weather flows. The peak dry weather flow is based on the population projection, sewage generation rate of 300 L/c/d and the Harmon's peaking factor.

The wet well size will be analyzed based on storing one half of the peak wet weather flow for five (5) minutes.

2.4 STORM DRAINAGE SYSTEM

Design criteria were adopted from the Town of Bruderheim Engineering Design Standards and Alberta Environment stormwater management guidelines. The following is a summary of the design criteria relevant to the Master Plan.

2.4.1 Design Storm

The design standard in the Town of Bruderheim requires that the minor system be designed to have capacity for the 1:5 year storm and the major drainage system be designed to accommodate the 1:100 year storm.

Upgrades will be proposed to meet the following criteria:

- Prevent storm sewer from surcharging to ground during a minor storm event (1:5 year storm event).
- Limit the potential for flooding of private property in a major event (1:100 year storm event).

The Intensity-duration-frequency (IDF) rainfall data from the Edmonton Municipal Airport (period 1914-1995) was used for the analysis of the existing system and proposed upgrades. Table 2.12 provides the IDF Curve constants for different return frequencies.

Table 2.13 provides a summary of the design storm events used in this study for the assessment of the existing drainage system.

Table 2.12
IDF Curve Parameters – Edmonton Municipal Airport (period 1914-1995)

	Return Frequency					
Constants	**2 year**	**5 year**	**10 year**	**25 year**	**50 year**	**100 year**
a=	221.51	335.29	410.83	505.47	576.99	647.86
b=	1.58	1.545	1.535	1.522	1.528	1.536
c=	0.647	0.654	0.656	0.658	0.66	0.661

Table 2.13
Design Storms for the Assessment of the Existing Storm Drainage System

Component	Return Period	Duration	Distribution	Design Objective
Existing Storm Sewers (Minor System)	1:5 years	4 hours	City of Edmonton "Chicago" type storm	- No Surcharge - No Flooding on streets
Existing ditches, channels, culvert/bridge Structures, Stormwater facilities (Major System)	1:100 year	4 hours	City of Edmonton "Chicago" type storm	- No Flooding - Maximum surcharging in the roadway gutter of 180 mm

Future storm sewers are sized for the 1:5 year storm as specified in the Town of Bruderheim Engineering Design Standards.

2.4.2 Runoff Coefficients

The following runoff coefficients were used for the conceptual sizing of the future stormwater management facilities using the Modified Rational Method, based on the Town of Bruderheim Engineering Design Standards.

Table 2.14
Runoff Coefficients (C)

Land Use	1:5 Year Storm	1:100 Year Storm
Parks, Reserves and School Grounds	0.15	0.19
Residential		
Single Family	0.4	0.50
Multi Family	0.6	0.75
High Density	Calculated*	Calculated*
Commercial	Calculated*	Calculated*
Industrial	Calculated*	Calculated*

*Calculated by using the following formula: $C = \frac{(0.95 \times \text{Impervious Area}) + 0.10(\text{Total Area} - \text{Impervious Area})}{\text{Total Area}}$

The Town of Bruderheim standards state that “for less frequency storms, the runoff coefficient must be increased accordingly to reflect the impact of antecedent moisture conditions”, however, it does not specify the percentage increase require for the assessment of existing system and future developments. The following Alberta Environment design guidelines were adopted for storms above the 1:5 year storm event:

The runoff coefficient “C” was increased as follows:

- 1:10 to 1:25 year – Add 10%
- 1:25 to 1:50 year – Add 20%
- 1:50 to 1:100 year – Add 25%

2.4.3 Model Development

The storm sewer system was modeled by using PCSWMM software to evaluate the capacity of the existing storm drainage system and alternatives to improve its performance. The PCSWMM is a fully dynamic computer model designed for simulating flows and water levels in sewer systems. It is capable of simulating real storm events, design flows, surcharging and backwater conditions, as wells as stormwater pond operation and reverse flows in complicated storm systems.

Table 2.15 outlines the model parameters used in the PCSWMM model for the storm drainage Master Plan.

Table 2.15
Model Parameters

Parameter	Value
Ground Slope	Actual catchment slope calculated based on DEM
Impervious Area Manning's n	0.015
Pervious Area Manning's n	0.25 – 0.50*
Impervious Depression Storage	2 mm – 7 mm *
Pervious Depression Storage	5 mm – 7 mm *
Percent of area with zero detention	25%
Maximum Infiltration Rate	75 mm/hr
Minimum Infiltration Rate	5 mm/hr
Decay Constant	4 (1/hr)

*Higher values were used on the model to better represent flows from agricultural/undeveloped areas outside of the Town boundary.

Table 2.16 provides the imperviousness values used in the computer modeling of the existing storm drainage system.

Table 2.16
Imperviousness Values

Land use Code	Land use Description	Percentage Impervious
C-1	Downtown Commercial	90
C-2	General Commercial	90
GI	General Industrial	70
IPS	Institutional and Public Service	40
MHP	Manufactured Home Park	50
MHS	Manufactured Home Subdivision	40
P	Parks and Recreation	0
R-1	Single Detached Residential	30
R-2	General Residential	40
R-3	Multiple Residential	70
R-3	Multiple Residential	60
U	Utilities	100
UR	Urban Reserve	0

The percent imperviousness refers to the anticipated amount of surface runoff generated based on the land use of an area. Development of land (paving, buildings, etc.) increases the imperviousness of an area, meaning that less surface runoff infiltrates into the ground. The increased volume and rate of runoff produces larger peak flood discharges in developed watersheds than would have occurred before development. The percent imperviousness values provided in **Table 2.16** are typical values for the land uses are applicable to the Town of Bruderheim. The higher the percent imperviousness the more runoff is generated.

Note that the percent imperviousness is different than the runoff coefficient “C” used in the rational method (**Table 2.14**).

The following Manning’s n values are used in the assessment of the storm drainage system:

· Impervious Areas	0.015
· Pervious Areas	0.250 – 0.50 (typical for agricultural/undeveloped areas)
· PCV pipes	0.013
· Concrete Pipes	0.011
· Corrugated Steel Pipe (CSP culverts)	0.024
· Grassed ditches	0.035 to 0.050

Manning’s n describes the resistance of the bed of a channel (or the surface of a pipe) to the flow of water in it.

2.4.4 Model Catchments

Catchment areas were delineated from the available DEM data using Manifold GIS. Catch basins locations were obtained from the Town´s built drawings and formed the basis for determining the catchment areas. Catchment slopes was calculated using the Manifold software, as the average slope for each catchment. The impervious percentage for each catchment was calculated by overlaying the land-use map over the catchment map in PCSWMM and calculating the weighted impervious area based on land-use.

2.4.5 Stormwater Management Storage Facilities

In general, stormwater management (SWM) ponds will be required for all new developments to control flows and prevent flooding of the downstream system. Storm ponds also provide benefits in improving stormwater quality.

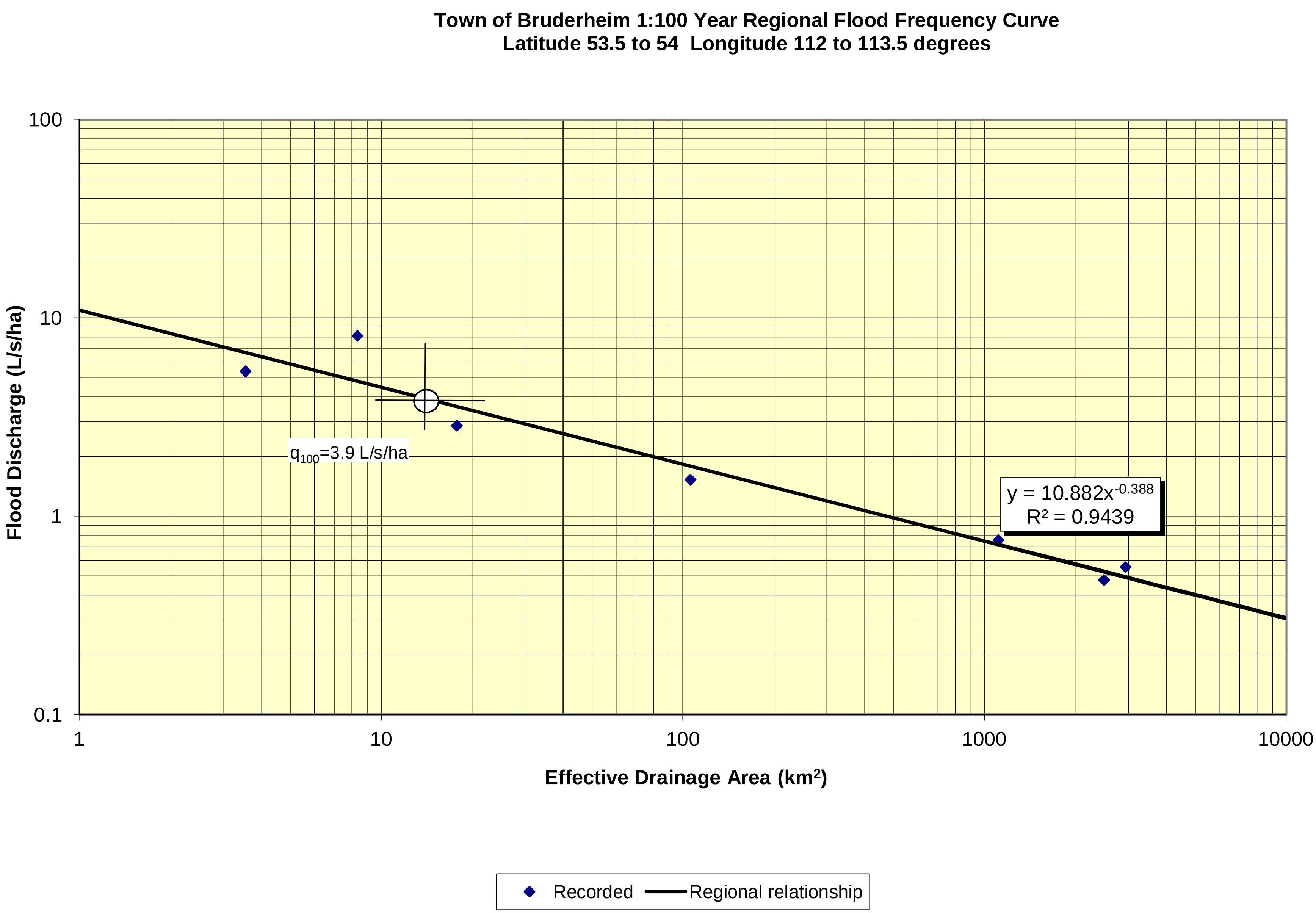
A maximum outflow rate of 3.9 l/s/ha is proposed for pond design in the Town of Bruderheim based on the Regional Analysis of various streams, such as Beaverhill Creek, Sturgeon River,Pointe-Aux-Pins Creek, and Redwater River, as shown in **Figure 2.2**.

2.5 TRANSPORTATION SYSTEM

The design criteria for the components of the Transportation system include:

- **Town of Bruderheim Engineering Servicing Standards**: The Town of Bruderheim Engineering Service Standards were used to identify the required cross sections for future arterial and collector roads, as well as basic roadway geometric information.
- **Geometric Design Guide for Canadian Roads, Transportation Association of Canada**: This guide contains industry standards for recommended geometric design criteria for roadways, including recommended alignments and cross-section information.
- **Manual of Uniform Traffic Control Devices, Transportation Association of Canada**: This guide provides recommended standards for the design, dimensions and application of devices and signs for the control of traffic and road users. These standards should be implemented for all upgrades to roadways.
- **Guide for the Design of Roadway Lighting, Transportation Association of Canada**: This guide provides best practice recommended guidelines for when and where roadways may require lighting, the design standards and codes for that lighting and warranting criteria to identify lighting requirements. These standards should be implemented for new and upgraded roadways as required.

Figure 2.2: Regional Analysis



3 Water System

3.1 EXISTING FACILITIES

The Town of Bruderheim's water system consists of:

- Treated Water Supply Line
- Reservoir and Pumphouse
- Water Distribution System

3.1.1 Treated Water Supply Line

City of Edmonton treated water is supplied from the John S. Batiuk Regional Water Commission via a 350 mm diameter steel main at the Bruderheim connection. The supply pressures and reservoir levels are monitored at the On-Line Station. The Commission assesses the capacity of the line, and the ability to serve the various communities and industrial users.

3.1.2 Reservoir and Pumphouse

The pumphouse currently consists of two distribution pumps and one diesel engine driven stand-by (fire) pump. These pumps supply water to the distribution system and, a 50 mm (2 inch) truck fill. A separate truck fill pump supplies water to the 100 mm (4 inch) truckfill via a separate header.

The existing pumps are as follows:

- There are two variable speed 30 HP American-Marsh vertical turbine pumps, model 10HS type 480. They are 4 stage pumps with 184 mm (7.25 inch) impellers. They are rated at 39 L/s and 42.6 m TDH.
- There is one constant speed 30 HP American-Marsh vertical turbine Standby (Fire) pump, model 12XS, type 480. It is a 3 stage pump with a 236 mm (9.3125 inch) impeller and is rated at 103 L/s and 42.3 m of head.
- There is also one 7.5 HP Grundfos submersible Truckfill pump rated at 22.7 L/s at 15.5 m TDH.

The pump setpoints are based on 42 m of head, and it is understood that all pumps can operate simultaneously, if required. The pumphouse outgoing pressure is controlled by a Pressure Control Valve also to 42 m or 60 psi. The 50 mm (2 inch) truckfill operates directly off of the header of the distribution and stand-by pumps. The 100 mm (4 inch) truckfill operates off the separate header and pump.

According to previous reports, the existing water storage totals 3,060 m^3 in two interconnected compartments.

3.1.3 Distribution System

The existing distribution system is comprised of asbestos cement (AC) pipe. Most of the distribution system was constructed in the 1960's and 1970's, and the system has not grown significantly since this time. The pipe sizes range in diameter from 150 mm to 350 mm. **Figure 3.1** presents the pipe sizes within the distribution system.

3.2 EXISTING SYSTEM ASSESSMENT

3.2.1 Distribution System

The existing distribution system was analyzed using the computer modelling software WaterCAD, by Bentley. The system was analyzed based on satisfying the average day, peak hour and peak day plus fire flow requirements. Although the average day run is not generally used in analyzing the capacity of the system, it is included in this section to illustrate how the system functions under regular conditions. The following describes each scenario in detail:

Average Day

The average day demand of 4.8 L/s (refer to **Table 2.5**) can easily be supplied by one of the two 39 L/s distribution pumps. The highest pressure in the system (based on assumptions relating to reservoir elevations) is 648 kPa (67.9 psi) and the lowest is 342 kPa (49.7 psi). The results are the same whether or not the 50 mm truckfill is in operation. These pressures are essentially within the recommended design pressures.

Peak Hour

The peak hour design flow is 14.3 L/s and again is easily supplied by one of the two distribution pumps. Even if the small truckfill is operating at 9.0 L/s, the total outflow of 23.3 L/s is much less than the pump can handle at its design setpoint. As the pumps are variable speed, it is understood that they will reduce their speed in order to provide the required flow at the desired head of 42 m TDH.

The maximum pressure within the distribution system is 468 kPa (67.9 psi), and the minimum is 342 kPa (49.7 psi), identical to the Average Day Scenario. The minimum pressure is very close (within rounding) of the recommended minimum pressure. The Peak Hour pressure results are shown in **Figure 3.1**.

Peak Day plus Fire

Figure 3.2 shows the ability of the distribution system to meet the recommended fire flows under existing conditions. The Peak Day plus Fire scenario assumes that one distribution pump and the standby (fire) pump are operating (reserving the second distribution pump as 100% back-up). **Figure 3.2** identifies the fire flow availability throughout the Town. Those nodes which do not meet the recommended fire flow levels are still capable of drawing water, however it may not be at the quantity or pressure identified within the design criteria section of this report.

3.2.2 Pump Capacity

Table 3.1 presents the pumping capacity analysis. Based on one distribution pump operating (reserving the second pump as 100% backup), there is ample pumping capacity to accommodate the current and projected future Peak Hour demand.

Table 3.1
Pumping Capacity Analysis

Year	2014	2019	2024	2029	2034	2039
Population	1376	1519	1677	1852	2045	2257
Peak Hour Analysis						
Peak Hour Demand (L/s)	14.3	15.8	17.5	19.3	21.3	23.5
Distribution Pump (L/s)[1]	39	39	39	39	39	39
Surplus/Deficit (L/s)	24.7	23.2	21.5	19.7	17.7	15.5
Peak Day + Fire Flow Analysis						
Peak Day Demand (L/s)	10	11	12	13	14	16
Fire Flow Demand (L/s)	200	200	200	200	200	200
Peak Day + Fire Flow Demand (L/s)	210	211	212	213	214	216
Standby Pump (L/s)	103	103	103	103	103	103
Surplus/Deficit (L/s)	-107	-108	-109	-110	-111	-113

Notes: 1: Based on the operation of 1 distribution pump, allowing the other pump to remain as 100% backup

As described in the Deep Utility Study, a total of 181 L/s can be provided if the distribution pumps and standby pump operate together. However, this is not enough to satisfy the current design fire flow of 200 L/s plus the existing Peak Day Demand of 9.6 L/s, or 210 L/s demand flow. In addition, it is recommended that the standby pump be sized to provide the peak day plus fire flow on its own, in case of power interruption or distribution pump failure.

3.2.3 Water Storage

Table 3.2 presents the existing and projected storage capacity based on a Peak Day plus Fire storage requirement.

Table 3.2
Storage Capacity Analysis

Year	Population	Existing Storage (m^3)	Bruderheim Peak Day Flow (m^3/d)	Truck Fill Peak Day Flow (m^3/d)	Fire Flow (m^3)	Total Required Storage (m^3)	Storage Surplus/Deficit (m^3)
2014	1,376	3,060	826	870	1,800	3,496	-436
2019	1,519	3,060	911	870	1,800	3,581	-521
2024	1,677	3,060	1,006	870	1,800	3,676	-616
2029	1,852	3,060	1,111	870	1,800	3,781	-721
2034	2,045	3,060	1,227	870	1,800	3,897	-837
2039	2,257	3,060	1,354	870	1,800	4,024	-964
Ultimate	13,681	3,060	8,209	870	1,800	10,879	-7,819

The fire storage component is based on the largest demand allowed for in the distribution system, which in this study is 200 L/s required for the apartment building which was recently constructed. A fire flow of 200 L/s is required to be maintained for 2.5 hours, in accordance to Fire Underwriters Survey.

The quantity of storage required for the truck fill operation has been estimated at 870 m^3. This assumes operation of the larger truckfill (100 mm), as it is assumed that the two truckfill's do not operate simultaneously. It is based on a Peak day of filling for 16 hours straight (6 am to 10 pm). If the trucks are estimated to hold 13.6 cubic metres/load (3,602 USgal/load), then based on the average existing filling rate of 25 L/s, it would take approximately 9 minutes to fill each truck. Assuming on the average, it takes about 15 minutes to load a 13.6 m^3 truck (complete cycle of parking, hose adjustment and fill), 4 trucks could be filled per hour. Over 16 hours this could result in an estimated total of 64 loads, which at 13.6 m^3 per load totals 870 m^3.

Ensuring significant truckfill storage capacity is appropriate in the Bruderheim area, where the reservoir has been used to support grass firefighting efforts.

From **Table 3.3** it appears that there is not sufficient available storage to accommodate the anticipated 2014 demand. This differs from the Deep Utility Analysis, as the previous analysis based the fire flow storage requirements on commercial/industrial fire flows. With the construction of the apartment building, it is recommended that a larger fire flow be provided for, and subsequently larger fire flow volume must be stored. Increased per capita consumption design rates and peaking factor rates also contribute to the deficit.

3.2.4 Hydrant Coverage

Figure 3.3 indicates the current level of hydrant coverage within the Town. The coverage is based on a 75 m radius for hydrants within single family residential areas, and 60 m for all other locations. The figure also recommends locations of future hydrants in areas without sufficient coverage. Most of the areas which require additional hydrants can be easily serviced off of existing watermains. The exception is at the school, church and residences north of Highway 45, where hydrants may be adequately placed along the existing waterline, however may not extend deep enough into the existing properties in order to provide protection to all buildings.

3.3 UPGRADES TO EXISTING SYSTEM

3.3.1 Distribution System Upgrades

The existing water distribution system requires upgrading in order to satisfy fire flow requirements. These upgrades are identified in **Figure 3.4**. Although the Deep Utility Study identified all upgrades (including those to meet minimum recommended sizes), the current plan identifies only those upgrades required to meet the recommended fire flows. It is recommended that watermains be upsized to meet minimum recommended sizes during planned neighbourhood rehabilitation, when it may occur. The proposed upgrades are as follows:

- A 350 mm watermain is recommended to be installed along 48 Street from 52 Avenue to south of the Canadian National Railway. This watermain will greatly increase the fire flow capacity of the distribution system by looping watermains along 48 Street and conveying additional flow to the extreme south.
- A 250 mm diameter pipe is recommended to be installed from the southeast corner of West Woodlands Subdivision along 48 Avenue. This improves fire flows to the southeast area of the Town.
- A 300 mm diameter watermain is proposed from the existing pumphouse to connect to the existing 250 mm diameter pipe in the Brookside Subdivision. This pipe improves fire flow in the Brookside area, and greatly improves zone pressure throughout the Town during a potential fire flow scenario. It is recommended that an easement be secured to allow for the installation of this waterline.
- A 200 mm diameter watermain to loop existing mains on 47 and 46 Avenues.
- Interconnect mains on 52 Avenue at Queen Street to improve flow to the downtown area.

It is recommended that when watermain replacements are scheduled to occur, that a minimum of 200 mm mains to be installed in the residential locations. The existing 150 mm diameter watermains in the downtown commercial area are recommended to be replaced with a minimum of 250 mm diameter mains at such time as main replacements are undertaken. Larger pipes could be required in commercial or industrial areas depending on the recommended fire flows and availability of watermain looping, etc.

It should also be noted that it is not the responsibility of the Municipality to provide fire flow. The above analysis has been provided to assist the Town if they choose to provide fire flow based on the Fire Underwriters Survey.

Although all proposed upgrades will be necessary in order to fully meet the recommended fire flows, it is understood that some of these upgrades will occur as development of adjacent lands proceed.

3.3.2 Pumping Upgrades

It is recommended that the existing standby pump be upgraded in order to accommodate the 10 year peak day plus fire flow demands, projected at 212 L/s. The distribution pumps will not require upgrading to beyond the 25 year study period.

3.3.3 Storage Upgrades

Additional storage is recommended to be constructed at the existing Reservoir site (refer to **Table 3.2**). This is required in order to provide 1 Peak Day plus fire flow, however, also includes a truck fill storage component. As the truck fill storage volume has been calculated based on assumptions regarding truck size and quantity, the Town may or may not feel that there is flexibility in this particular design value. It is recommended that any storage constructed consider the 25 year projected demands, and therefore an expansion of 964 m^3 would be in order.

Additional storage capacity could potentially be constructed as a separate truckfill facility to be located along Highway 45. This would address concerns regarding the strength of the existing road structure along 52 Avenue, through relocation of the existing truckfill.

3.4 ULTIMATE SYSTEM

The ultimate water distribution system is presented in **Figure 3.5**. As shown in the figure, it is anticipated that four separate pressure zones will ultimately be required to service the entire study boundary, due to the rise in topography towards the south. The current pressure zone (Zone 1) which encompasses the entire existing development area, is proposed to be increased from a pressure of 60 psi (669.6 m HGL) to 75 psi (680 m HGL). This will be necessary in order to provide minimum pressure to the future development area bounded by the Canadian National and Canadian Pacific Railways. The model results indicate that the minimum pressure during the peak hour demand will be 342 kPa (47 psi) and the maximum pressure during low demand periods will be 572 kPa (83 psi) within the Zone 1 area. These pressures are minimally below and above the optimum/recommended pressures.

Pressure Zone 2 is envisioned south of the CP Railway to 800 m north of Highway 15. The concept shown in **Figure 3.5** identifies a future Reservoir and Pumphouse which will supply operating pressure and fire flows to the proposed Industrial development in this area. The concept is based on an ultimate peak day demand of 62 L/s provided to the proposed reservoir. Typical design flows as well as fire flows for the Zone 2 area will be provided from the proposed Reservoir and Pumphouse at a proposed HGL of 701 m. This

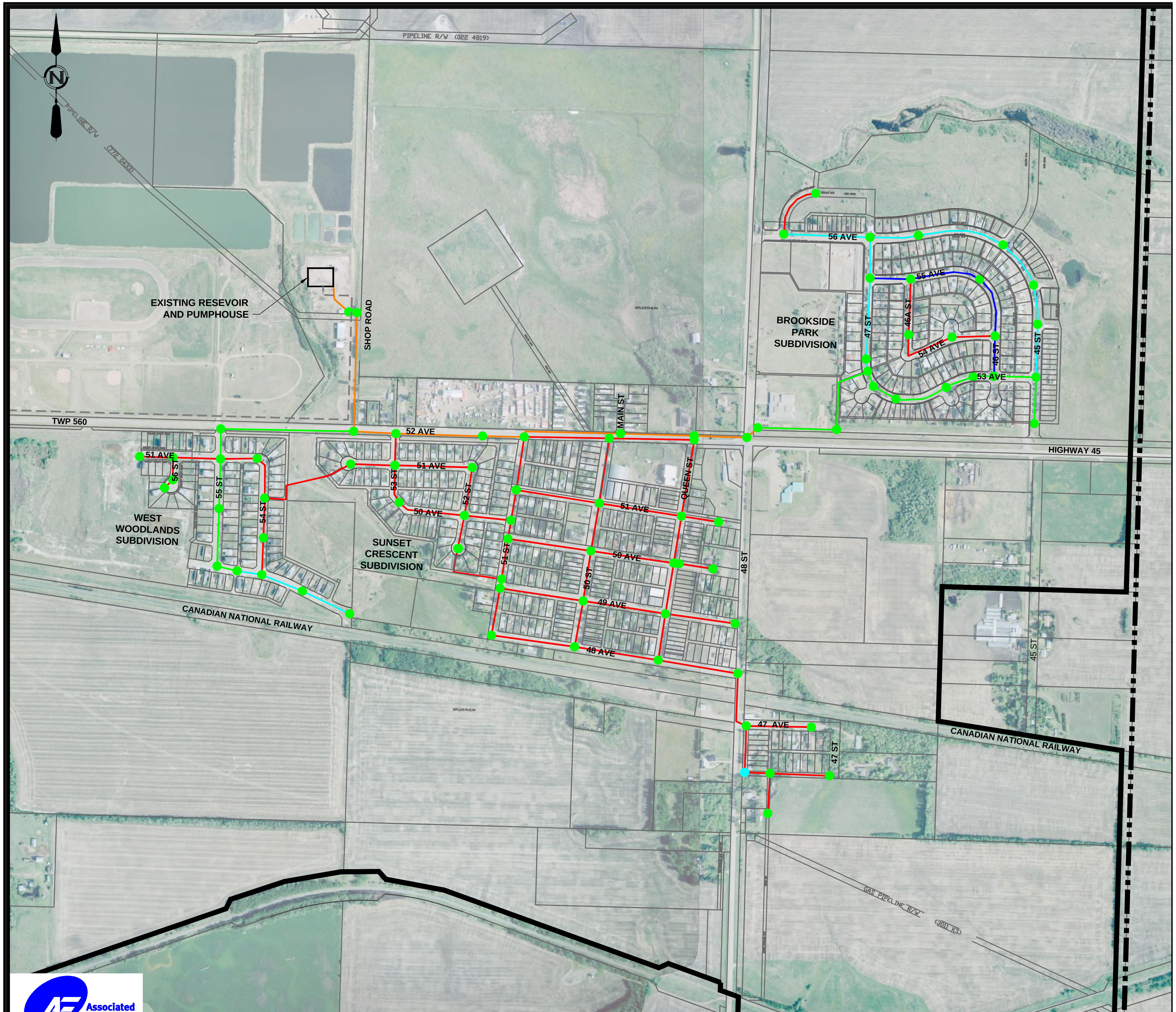
Reservoir and Pumphouse can be designed to flow back to the Zone 1 area to provide additional support during high flow/low pressure scenarios, or if the existing Reservoir and Pumphouse is momentarily taken offline.

Pressure Zone 3 is located in the most southern portion of the study area and is anticipated to be serviced by a booster station or potentially an additional Reservoir and Pumphouse to an HGL of approximately 720 m.

A rise in pressure at the main Reservoir and Pumphouse will result in pressures up to 88 psi in the far northeast corner. Although this pressure does fall within the maximum pressure range identified within the Town of Bruderheim Engineering Standards, it exceeds that recommended by Alberta Environment. Future pressure reducing valve (PRV) stations are therefore recommended in order to reduce pressures to an HGL of 670 m (Zone 4). Pressures are anticipated to slightly exceed 80 psi between the reservoir and Brookside due to the fairly low topography.

Figure 3.5 presents the proposed future servicing concept in terms of the watermain transmission mains. These watermains have been sized in order to meet the associated fire flows within each future land use. In terms of the future residential land use areas, a fire flow of 200 L/s has been applied in order to allow for flexibility in locating future high density residential developments. This will also accommodate future school sites and neighbourhood commercial developments.

Additional storage will be required at the existing Reservoir and Pumphouse in order to service the entirety of the Zone 1/Zone 4 area. It is anticipated that the storage requirements for the proposed Zone 2/Zone 3 area will be provided by the proposed Reservoir and Pumphouse to be located south of the CP Railway.



the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING WATER DISTRIBUTION SYSTEM: PEAK HOUR PRESSURE

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING JOHN S. BATIUK REGIONAL WATER COMMISSION PIPELINE
- EXISTING RESERVOIR AND PUMPHOUSE

PIPE SIZES:

- EXISTING 150mm
- EXISTING 200mm
- EXISTING 250mm
- EXISTING 300mm
- EXISTING 350mm

PEAK HOUR PRESSURE:

- LESS THAN 50 psi (345 KPa)
- 50 psi (345 KPa) to 80 psi (552 KPa)
- 80 psi (345 KPa) to 90 psi (620 KPa)
- OVER 90 psi (620 KPa)

SCALE : 1:8,000

DECEMBER, 2015

Associated Engineering

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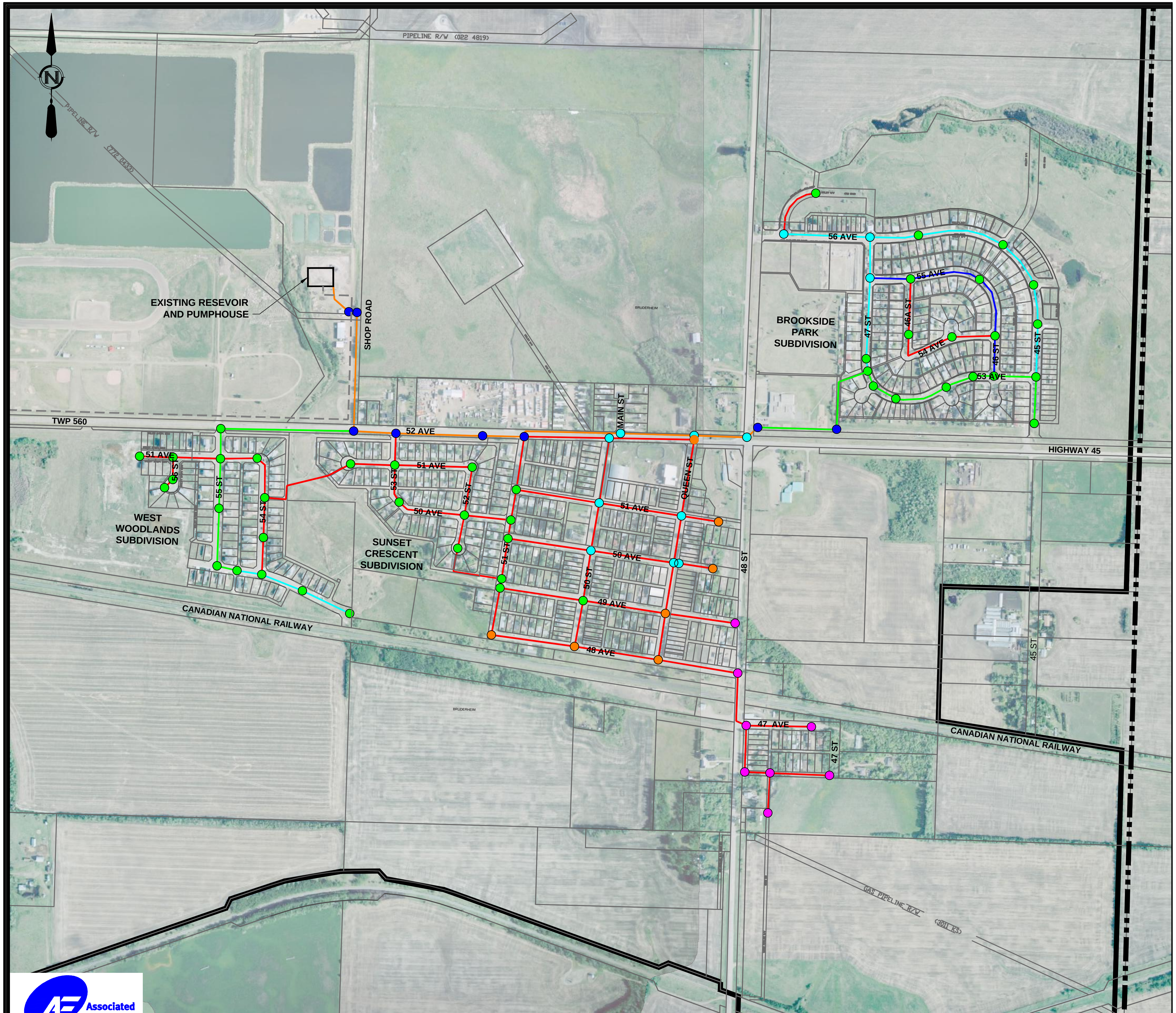
DATE: 12/1/2015, Kevin Grandish

FIGURE 3.1



the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING WATER DISTRIBUTION SYSTEM: FIRE FLOW ANALYSIS

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING JOHN S. BATIUK REGIONAL WATER COMMISSION PIPELINE
- EXISTING RESERVOIR AND PUMPHOUSE

PIPE SIZES:

- EXISTING 150mm
- EXISTING 200mm
- EXISTING 250mm
- EXISTING 300mm
- EXISTING 350mm

FIRE FLOW AVAILABILITY:

- MEETS / EXCEEDS FIRE FLOW
- MEETS 80% OR MORE
- MEETS 60 - 80%
- MEETS 40 - 60%
- MEETS LESS THAN 40%

SCALE : 1:8,000

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FIGURE 3.2

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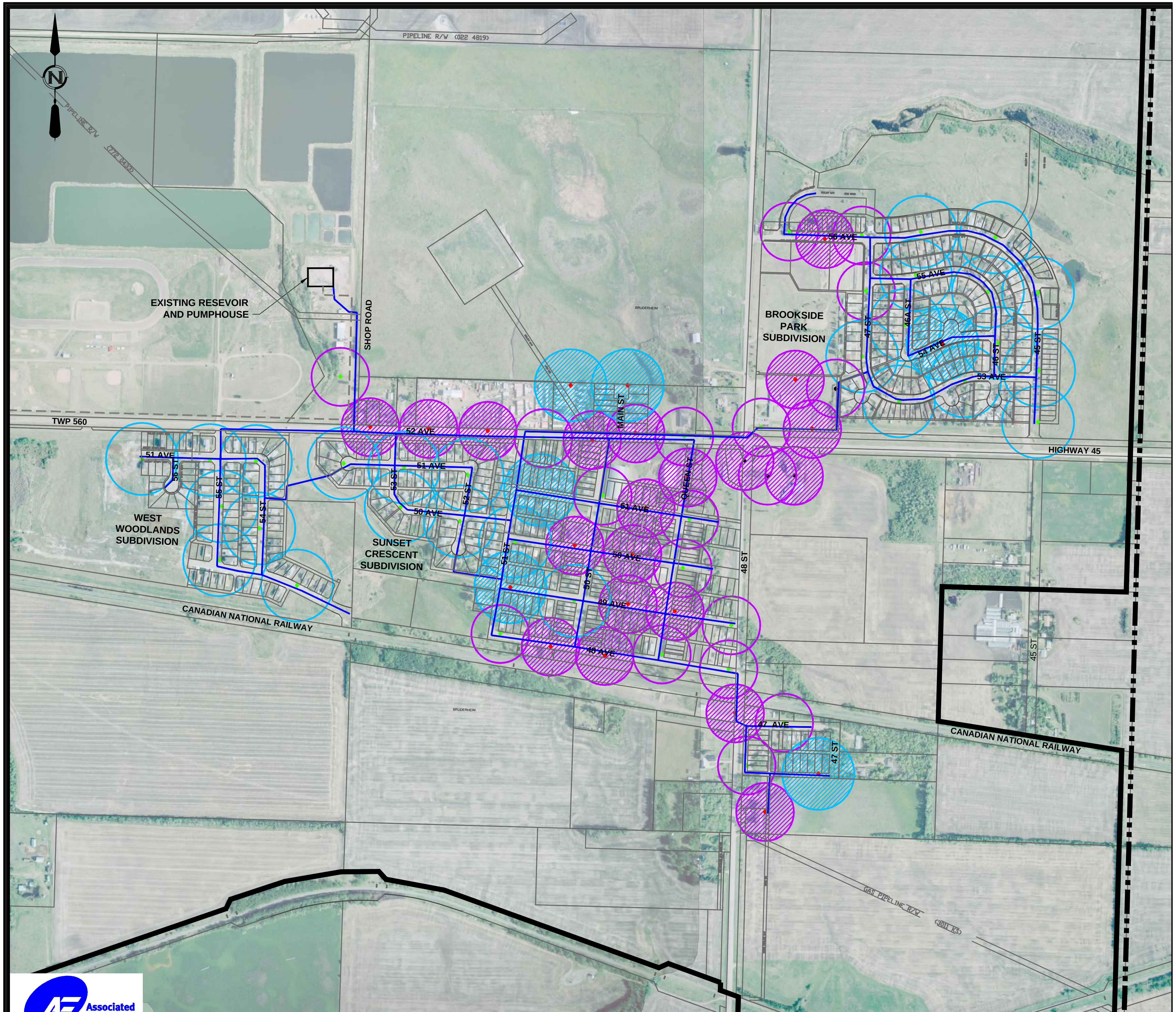

the town of **Bruderheim** Alberta

MASTER SERVICES PLAN

EXISTING WATER DISTRIBUTION SYSTEM: HYDRANT ANALYSIS

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING JOHN S. BATIUK REGIONAL WATER COMMISSION PIPELINE
- EXISTING RESERVOIR AND PUMPHOUSE
- EXISTING WATERMAIN
- EXISTING HYDRANT LOCATION
- EXISTING HYDRANT COVERAGE IN RESIDENTIAL AREAS (75m RADIUS)
- EXISTING HYDRANT COVERAGE IN ALL OTHER AREAS (60m RADIUS)
- PROPOSED HYDRANT LOCATION
- PROPOSED HYDRANT COVERAGE IN RESIDENTIAL AREAS (75m RADIUS)
- PROPOSED HYDRANT COVERAGE IN ALL OTHER AREAS (60m RADIUS)

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 3.3

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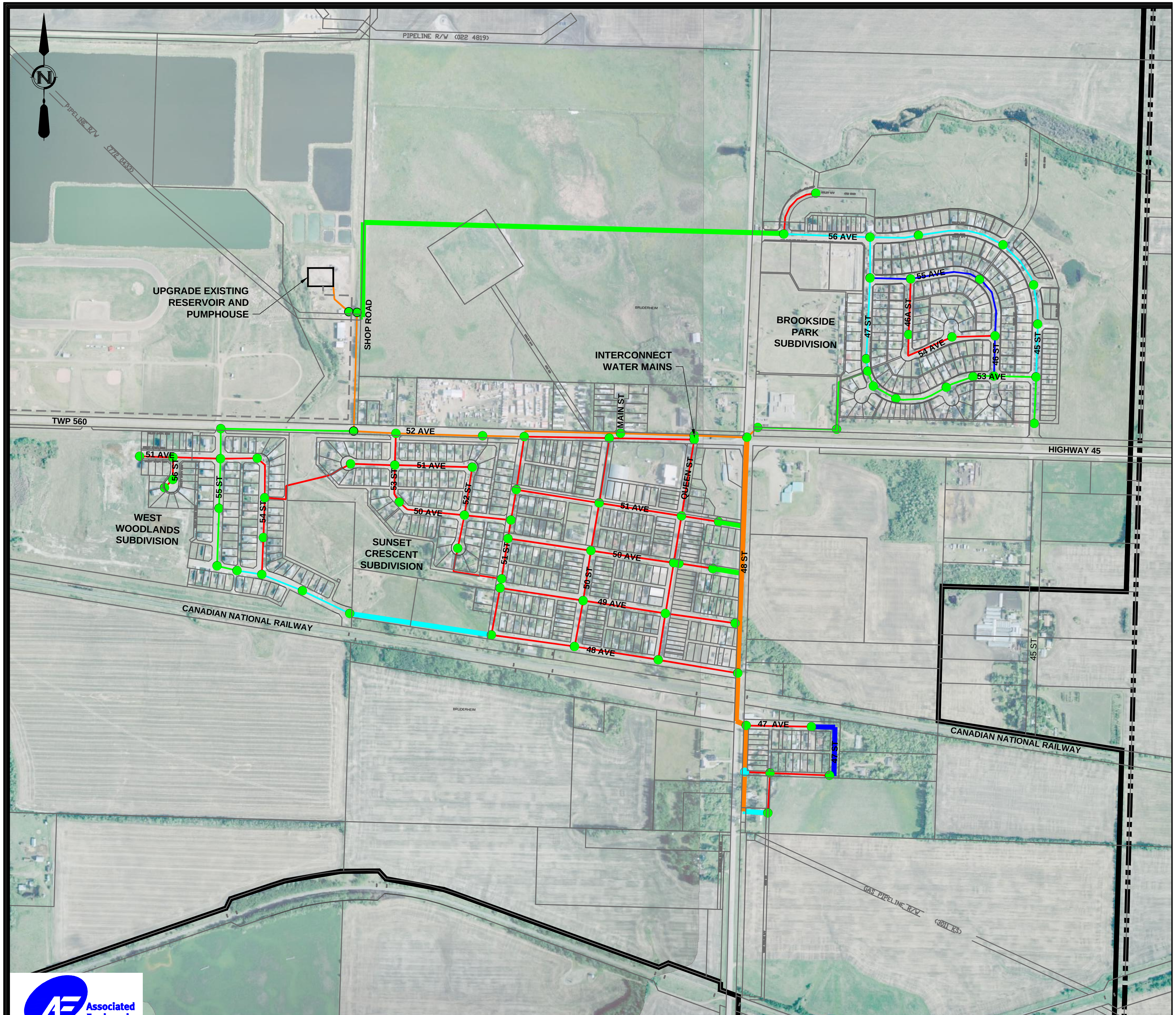


the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING WATER DISTRIBUTION SYSTEM WITH UPGRADES

LEGEND:

STUDY AREA BOUNDARY
TOWN BOUNDARY
EXISTING JOHN S. BATIUK REGIONAL WATER COMMISSION PIPELINE
EXISTING RESERVOIR AND PUMPHOUSE

PIPE SIZES:

EXISTING 150mm
EXISTING 200mm
EXISTING 250mm
EXISTING 300mm
EXISTING 350mm
PROPOSED 200mm
PROPOSED 250mm
PROPOSED 300mm
PROPOSED 350mm

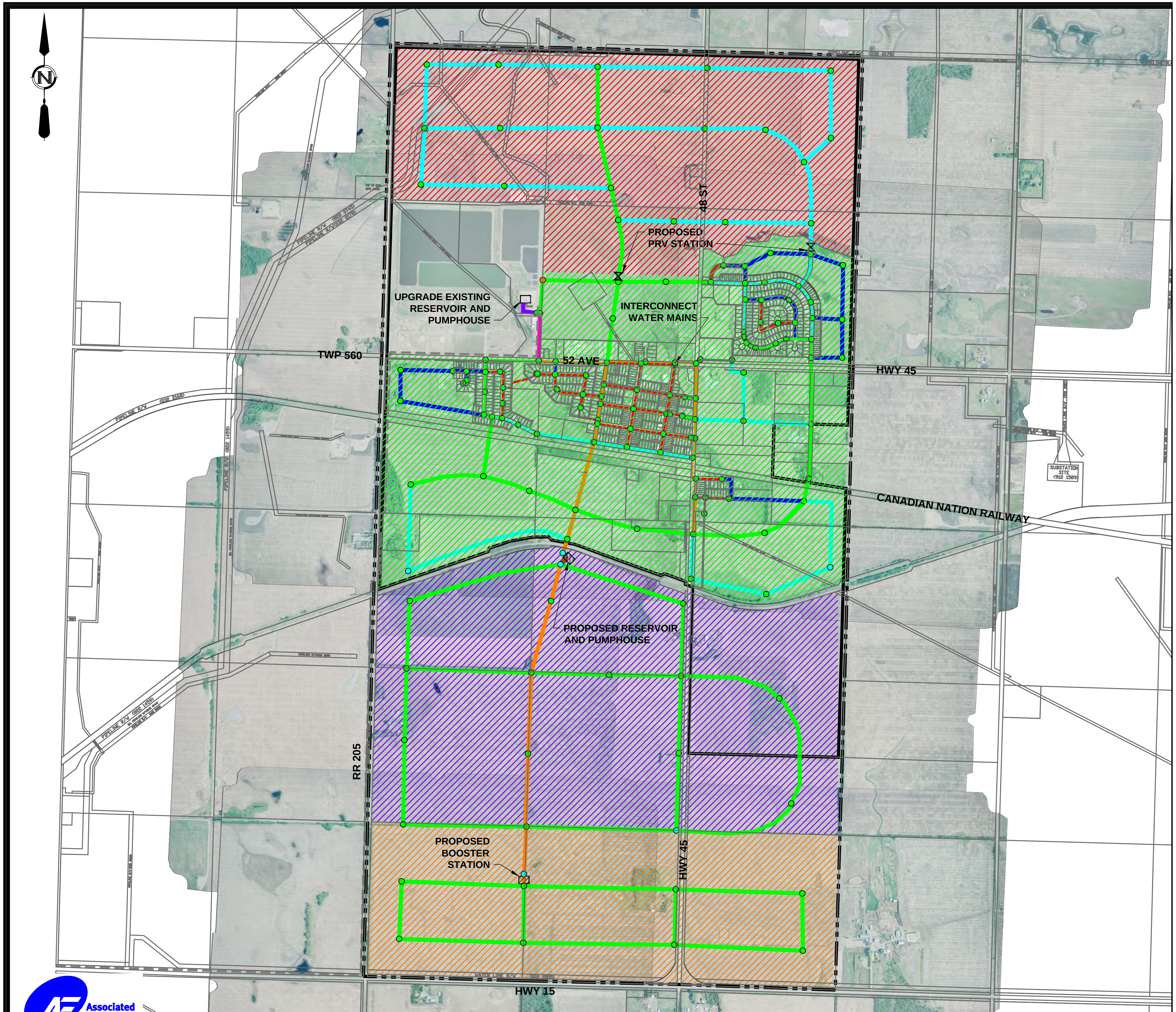
PEAK HOUR PRESSURE:

LESS THAN 50 psi (345 KPa)
50 psi (345 KPa) to 80 psi (552 KPa)
80 psi (345 KPa) to 90 psi (620 KPa)
OVER 90 psi (620 KPa)

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 3.4



P:\20133816\00_Master_Services_P\Working_Dwgs\100_Civil\Figure 3.5.dwg
DATE: 12/1/2015, Kevin Grandish

Associated Engineering

the town of Bruderheim Alberta

MASTER SERVICES PLAN

ULTIMATE WATER DISTRIBUTION SYSTEM

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING JOHN S. BATIUK REGIONAL WATER COMMISSION PIPELINE
- EXISTING RESERVOIR AND PUMPHOUSE
- PROPOSED RESERVOIR AND PUMPHOUSE
- PROPOSED PRV STATION
- ZONE 1 (HGL = 680m)
- ZONE 2 (HGL = 701m)
- ZONE 3 (HGL = 720m)
- ZONE 4 (HGL = 670m)

PIPE SIZES:

- EXISTING 150mm
- EXISTING 200mm
- EXISTING 250mm
- EXISTING 300mm
- EXISTING 350mm
- PROPOSED 200mm
- PROPOSED 250mm
- PROPOSED 300mm
- PROPOSED 350mm
- PROPOSED 400mm
- PROPOSED 450mm
- PROPOSED 500mm

PEAK HOUR PRESSURE:

- LESS THAN 50 psi (345 KPa)
- 50 psi (345 KPa) to 80 psi (552 KPa)
- 80 psi (345 KPa) to 90 psi (620 KPa)
- OVER 90 psi (620 KPa)

SCALE : 1:20,000

DECEMBER, 2015

FIGURE 3.5

4 Sanitary Sewer System

4.1 EXISTING FACILITIES

The sanitary system consists of:

- Collection System
- Lift Station and Forcemain from Brookside Park Subdivision
- Lagoons

4.1.1 Collection System

The existing collection system is comprised of sewer mains varying in size from 200 mm to 450 mm in diameter (refer to **Figure 4.1**). The system is essentially divided into three major areas: Brookside Park, West Woodlands, and the remainder (Sunset Crescent and the Main area of Town).

Brookside Park is serviced by a lift station and 200 mm forcemain which outlets into a 250 mm diameter sewer at a location approximately 1,100 m downstream. Recently, the forcemain collapsed in the vicinity of 51 Street and 52 Avenue. The discharge was subsequently re-routed to Manhole 205, and the remainder of the forcemain is assumed to have been abandoned.

West Woodlands Subdivision is serviced by a 375 mm diameter sewer from the subdivision. These flows are combined with flows from the rest of the Town into a 450 mm diameter main, and outlets to the existing sewage lagoon.

Sewers from both Sunset Crescent and the Main section of the Town enter an existing 250 mm diameter trunk sewer which travels along Highway 45, and then runs north toward the lagoon. A site inspection undertaken on October 10, 2013, has identified that the 375 mm and the 250 mm diameter trunk mains do not interconnect on 51 Street, however, do interconnect at Manhole 102, upstream of the lagoon (refer to Sanitary Index Drawing A1).

Record drawings were provided for West Woodlands, Brookside Park and Sunset Crescent, however, drawings were not available for much of the central portion of the Town. As such, Associated Engineering undertook a partial site survey and manhole inspection program in order to ascertain pipe inverts at select locations.

It is recommended that the Town undertake a program to gather the missing manhole data including locations, rims and invert information, when practical. Survey data will be required during the preliminary design of recommended upgrades.

4.1.2 Lift Stations and Forcemains

There is one lift station located north of the Brookside Park Subdivision which pumps flows from the subdivision to Manhole 205, as shown in **Figure 4.2,** (manhole location identified on Sanitary Index Drawing A1).

The sewage lift station is comprised of a dry well and wet well. The dry well is 2.74 m in diameter, and the wet well is 2.44 m in diameter. The dry well is outfitted with two identical Flygt sewage pumps, and there is a provision for a third pump. They are model CT3152.181, 20 HP pumps with a 454 impeller. The Tritek report indicates that the setpoint for the pumps is 41.6 L/s at 20 m TDH. Both barrels are 7.16 m deep. Although drawings have been provided for the lift station, the actual operating elevations are unknown.

The existing sewage forcemain is comprised of 200 mm asbestos cement pipe.

4.1.3 Lagoons

The existing sewage lagoon is comprised of the following treatment cells, as identified in the Tritek Report:

- Anaerobic cells:
  - 4 small cells at 1,000 m^3 each
  - 2 large cells at 2,550 m^3 each
- Facultative cell:
  - 78,500 m^3
- Storage cell:
  - 464,000 m^3

The lagoon discharges to an outfall ditch, which has recently been improved. The lagoon is typically discharged within a 3 to 4 week period; once per year in the spring beginning after April 1.

4.2 EXISTING SYSTEM ASSESSMENT

4.2.1 Collection System Assessment

A partial site survey and manhole inspection program was undertaken on October 10, 2013. Key manholes were surveyed and invert elevations measured. Manholes which were not surveyed and were missing record data were interpolated as necessary in order to establish missing invert data. Upstream manholes for which data was not available were assumed to have been installed with minimum recommended slopes. Further information including a detailed site survey will be necessary prior to undertaking preliminary design of the recommended upgrades.

Previous reports have indicated that weeping tile connections from residences to the sanitary sewer may exist in the Sunset Crescent Subdivision. As mentioned in the design criteria section of the report, the sanitary model assumes that such connections also may also occur throughout Brookside Park Subdivision.

Although Town staff have indicated that the number of weeping tile connecting may be in the order of 90%, the model has been analyzed based on 100% weeping tile connections in these areas, in order to be conservative.

Table 4.1 presents the spreadsheet model results for the existing system hydraulic assessment, which is also presented in **Figure 4.2**. The model identifies that the majority of the pipes have ample spare capacity. As shown in the Figure, undersized mains are found at the following locations:

- 50 Street from 50 Avenue to 51 Avenue.
- 52 Avenue from 51 Street to the Shop Road.
- Eastern trunk sewer (250 mm diameter) from 52 Avenue to lagoon.

These results are somewhat different that those presented in the Deep Utility Study. This is a result of significantly more invert data available due to the partial site survey and additional record drawings which were provided. As well, the per capita sewage generation rate has been increased to 300 L/c/d from the previous study, in order to incorporate conservatism in the design of future mains.

As a result, the sewer main located from Manhole 205 to 102 (refer to **Appendix A** for manhole location plans), is significantly undersized due to the contribution from the lift station. The sewer main downstream of Manhole 202 remains somewhat undersized when the lift station is not operating (based on the current design criteria).

Figures Sanitary Index A1 and A2 are enclosed in **Appendix A**, and identify the sanitary catchments included in the spreadsheet models for the existing and ultimate systems. Manhole numbering is also identified on the drawings.

4.2.2 Lift Station and Forcemain Assessment

The Deep Utility Study reviewed the operation of the Lift Station and found that based on the design flows and pump run hours, that it was unlikely that both pumps would operate simultaneously based on the design wet weather flow requirements. At the time of the Deep Utility Study, Town staff indicated that the pumps have run together during wet weather conditions. It is recommended that a lift station drawdown test be undertaken in order to confirm the existing flow rate. If the expected pumping rate is confirmed, as well as the sustained operation of two pumps, then significantly more inflow and/or infiltration is being conveyed by this sanitary system than would be expected. This could be due to a higher infiltration rate than 0.28 L/s/ha or an additional point of infiltration.

Each pump is believed to have a setpoint of 41.6 L/s at 20 m TDH, although it is recommended that a drawdown test be performed in order to confirm the actual pump flows. As per **Table 4.1**, the total estimated wet weather flow for Brookside Park is 32.4 L/s, which is much lower than the capacity of one pump.

It appears that the existing pumps are more than adequately sized, and were designed to accommodate a larger catchment area.

At the design flow of 41.6 L/s, the velocity through the 200 mm forcemain is 1.3 m/s, which is within the recommended velocity identified in the design criteria.

Table 4-1
Existing Sanitary Sewer System

General		Existing Areas
Per Capita Flow Generation		300 L/c/day
Peaking Factor		Harmons
General Infiltration		0.28 L/s/ha
Foundation Drain Allowance*		0.60 L/s/ha
Sag Manhole Allowance**		0.08 L/s
Manning's n	Old VCT Pipe	0.015
	New PVC Pipe	0.013

Other	Residential	MD Residential	Com/Ind/Inst
Population Density	35 people/ha	85 people/ha	25 people/ha
Area Flow Generation	0.122 L/s/ha	0.295 L/s/ha	0.09 L/s/ha

Lift Station pumping rate =	41.60 L/s

Pipes with zero remaining capacity	0.00
Pipes with 0 to 20% remaining capacity	10.00

Note: *Foundation Drain Allowance is applied to Sunset Crescent and Brookside Park only.
Foundation drains in the Main Area and West Woodlands are assumed to be connected to the storm sewer.
** Sag Manhole Allowance is applied to existing manholes only

		Design Flows										Pipe Data					Pipe Capacity	
From MH	**To MH**	**Total DWF (L/s)**	**Accum DWF (L/s)**	**Harmon's Peaking Factor**	**Peak DWF (L/s)**	**General I/I (L/s)**	**Fnd Drain I/I (L/s)**	**Sag MH (L/s)**	**Total I/I (L/s)**	**Accum I/I (L/s)**	**Accum WWF (L/s)**	**Length**	**Diameter**	**Slope**	**Velocity**	**Capacity**	**Spare Capacity (L/s)**	**Spare Capacity (%)**
												Estimated						
314	313	0.046	0.046	3.800	0.175	0.106	0.228	0.080	0.414	0.414	0.590	45.90	250	1.37%	1.244	63.045	62.5	99.1
313	312	0.055	0.101	3.800	0.383	0.126	0.270	0.080	0.476	0.890	1.274	49.95	250	2.04%	1.515	76.759	75.5	98.3
312	311	0.036	0.137	3.800	0.522	0.084	0.180	0.080	0.344	1.234	1.756	32.08	300	0.65%	0.963	70.283	68.5	97.5
311	310	0.081	0.219	3.800	0.831	0.188	0.402	0.080	0.670	1.904	2.735	78.96	300	0.53%	0.875	63.813	61.1	95.7
310	309	0.090	0.309	3.800	1.173	0.207	0.444	0.080	0.731	2.635	3.808	86.95	300	0.43%	0.787	57.404	53.6	93.4
309	308	0.107	0.416	3.800	1.579	0.246	0.528	0.080	0.854	3.490	5.069	97.20	300	0.44%	0.794	57.924	52.9	91.2
308	307	0.146	0.561	3.800	2.134	0.336	0.720	0.080	1.136	4.626	6.759	139.72	300	0.35%	0.706	51.493	44.7	86.9
307	306	0.061	0.622	3.800	2.364	0.140	0.300	0.080	0.520	5.146	7.510	62.64	300	0.50%	0.844	61.596	54.1	87.8
306	305	0.097	0.719	3.800	2.734	0.224	0.480	0.080	0.784	5.930	8.663	87.29	300	0.45%	0.804	58.680	50.0	85.2
337	336	0.000	0.000	3.800	0.000	0.000	0.000	0.080	0.080	0.080	0.080	52.68	200	0.63%	0.726	23.542	23.5	99.7
335	336	0.096	0.096	3.800	0.365	0.221	0.474	0.080	0.775	0.775	1.140	59.03	200	0.87%	0.852	27.626	26.5	95.9
336	334	0.061	0.157	3.800	0.596	0.140	0.300	0.080	0.520	1.375	1.971	105.51	200	0.61%	0.716	23.207	21.2	91.5
333	334	0.081	0.081	3.800	0.309	0.188	0.402	0.080	0.670	0.670	0.979	37.27	200	2.30%	1.386	44.955	44.0	97.8
334	332	0.061	0.299	3.800	1.136	0.140	0.300	0.080	0.520	2.565	3.701	76.43	200	0.71%	0.770	24.981	21.3	85.2
332	331	0.066	0.365	3.800	1.385	0.151	0.324	0.080	0.555	3.120	4.505	86.24	200	0.63%	0.727	23.591	19.1	80.9
330	331	0.081	0.081	3.800	0.309	0.188	0.402	0.080	0.670	0.670	0.979	41.97	200	3.54%	1.722	55.827	54.8	98.2
331	329	0.058	0.504	3.800	1.916	0.134	0.288	0.080	0.502	4.292	6.208	37.77	200	0.38%	0.563	18.259	12.1	66.0
328	329	0.156	0.156	3.800	0.594	0.504	1.080	0.080	1.664	1.664	2.258	68.70	200	0.71%	0.768	24.906	22.6	90.9
329	327	0.085	0.746	3.800	2.834	0.196	0.420	0.080	0.696	6.652	9.486	74.41	200	0.47%	0.628	20.352	10.9	53.4
327	315	0.102	0.848	3.800	3.221	0.235	0.504	0.080	0.819	7.471	10.693	113.16	200	0.37%	0.559	18.139	7.4	41.1
320	319	0.088	0.088	3.800	0.333	0.202	0.432	0.080	0.714	0.714	1.046	111.97	200	0.45%	0.611	19.812	18.8	94.7
319	318	0.083	0.170	3.800	0.647	0.190	0.408	0.080	0.678	1.392	2.039	81.52	200	0.68%	0.752	24.395	22.4	91.6
318	317	0.077	0.247	3.800	0.937	0.176	0.378	0.080	0.634	2.026	2.964	72.65	200	0.73%	0.779	25.257	22.3	88.3
317	316	0.080	0.327	3.800	1.242	0.185	0.396	0.080	0.661	2.687	3.929	80.55	200	0.47%	0.624	20.234	16.3	80.6

Table 4-1
Existing Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
326	325	0.039	0.039	3.800	0.148	0.090	0.192	0.080	0.362	0.362	0.509	78.63	200	0.69%	0.757	24.563	24.1	97.9
324	325	0.081	0.081	3.800	0.309	0.188	0.402	0.080	0.670	0.670	0.979	35.61	200	1.03%	0.927	30.053	29.1	96.7
325	323	0.028	0.148	3.800	0.563	0.064	0.138	0.080	0.282	1.314	1.877	56.71	200	0.55%	0.680	22.066	20.2	91.5
323	322	0.041	0.190	3.800	0.720	0.095	0.204	0.080	0.379	1.693	2.413	40.94	200	0.50%	0.646	20.944	18.5	88.5
322	321	0.088	0.277	3.800	1.053	0.202	0.432	0.080	0.714	2.406	3.459	80.67	200	0.55%	0.677	21.950	18.5	84.2
321	316	0.061	0.338	3.800	1.284	0.140	0.300	0.080	0.520	2.926	4.210	80.81	200	0.58%	0.697	22.601	18.4	81.4
316	315	0.044	0.709	3.800	2.692	0.101	0.216	0.080	0.397	6.010	8.703	84.79	200	0.49%	0.637	20.654	12.0	57.9
315	305	0.000	1.556	3.800	5.914	0.000	0.000	0.080	0.080	13.562	19.475	86.07	200	0.90%	0.865	28.063	8.6	30.6
305	304	0.124	2.400	3.800	9.121	0.361	0.774	0.080	1.215	20.706	29.827	109.60	300	1.40%	1.417	103.406	73.6	71.2
304	303	0.118	2.518	3.800	9.568	0.342	0.732	0.080	1.154	21.860	31.428	69.38	300	1.56%	1.494	109.033	77.6	71.2
303	302	0.057	2.575	3.800	9.786	0.171	0.366	0.080	0.617	22.477	32.263	77.53	300	0.64%	0.956	69.776	37.5	53.8
302	301	0.000	2.575	3.800	9.786	0.000	0.000	0.080	0.080	22.557	32.343	42.48	300	0.75%	1.035	75.527	43.2	57.2
301	LS	0.000	2.575	3.800	9.786	0.000	0.000	0.080	0.080	22.637	32.423	8.00	300	0.65%	0.964	70.353	37.9	53.9
LS	201	0.0	0.000	0.000	0.0	0.000	0.000	0.000	0.000	41.600	41.6							
545	544	0.070	0.070	3.800	0.267	0.227	0.000	0.080	0.307	0.307	0.574	124.95	200	1.37%	1.071	34.722	34.1	98.3
604	603	0.040	0.040	3.800	0.152	0.092	0.000	0.080	0.172	0.172	0.325	78.18	200	0.28%	0.481	15.587	15.3	97.9
603	544	0.034	0.074	3.800	0.282	0.078	0.000	0.080	0.158	0.331	0.613	122.74	200	0.28%	0.481	15.585	15.0	96.1
544	543	0.058	0.203	3.800	0.770	0.188	0.000	0.080	0.268	0.905	1.675	101.65	200	0.39%	0.572	18.556	16.9	91.0
602	601	0.118	0.118	3.800	0.448	0.272	0.000	0.080	0.352	0.352	0.800	105.87	200	0.40%	0.578	18.753	18.0	95.7
601	543	0.000	0.118	3.800	0.448	0.000	0.000	0.080	0.080	0.432	0.880	65.65	200	0.40%	0.578	18.744	17.9	95.3
543	542	0.117	0.438	3.800	1.663	0.378	0.000	0.080	0.458	1.795	3.458	103.78	200	0.40%	0.575	18.662	15.2	81.5
542	541	0.030	0.468	3.800	1.779	0.098	0.000	0.080	0.178	1.973	3.751	72.31	200	0.50%	0.648	21.011	17.3	82.1
541	540	0.022	0.490	3.800	1.861	0.070	0.000	0.080	0.150	2.123	3.984	101.50	200	0.50%	0.648	21.000	17.0	81.0
540 high	530	0.052	0.052	3.800	0.198	0.168	0.000	0.080	0.248	0.248	0.446	102.30	200	1.17%	0.990	32.104	31.7	98.6
529	530	0.085	0.085	3.800	0.323	0.274	0.000	0.080	0.354	0.354	0.678	109.16	200	0.40%	0.579	18.763	18.1	96.4
530 through	527	0.052	0.189	3.800	0.719	0.168	0.000	0.080	0.248	0.850	1.569	102.29	200	0.79%	0.813	26.356	24.8	94.0
527 high	516	0.095	0.095	3.800	0.363	0.308	0.000	0.080	0.388	0.388	0.751	102.38	200	1.10%	0.958	31.058	30.3	97.6
515	516	0.042	0.042	3.800	0.158	0.134	0.000	0.080	0.214	0.214	0.373	86.44	200	0.40%	0.579	18.762	18.4	98.0
516 high	514	0.124	0.124	3.800	0.470	0.171	0.000	0.080	0.251	0.251	0.721	81.16	200	0.43%	0.601	19.474	18.8	96.3
514	212	0.145	0.145	3.800	0.552	0.347	0.000	0.080	0.427	0.427	0.979	79.52	200	0.44%	0.607	19.674	18.7	95.0
213	212	0.175	0.175	3.800	0.666	0.566	0.000	0.080	0.646	0.646	1.312	97.80	250	0.28%	0.562	28.459	27.1	95.4
212	211	0.088	0.408	3.800	1.551	0.283	0.000	0.080	0.363	1.436	2.987	96.32	250	0.36%	0.637	32.272	29.3	90.7
211	210	0.000	0.408	3.800	1.551	0.000	0.000	0.080	0.080	1.516	3.067	56.14	250	0.36%	0.636	32.252	29.2	90.5
216	210	0.137	0.137	3.800	0.522	0.316	0.000	0.080	0.396	0.396	0.918	105.30	200	0.40%	0.578	18.751	17.8	95.1

Table 4-1
Existing Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
210	209	0.000	0.545	3.800	2.073	0.000	0.000	0.080	0.080	1.992	4.065	23.54	250	0.35%	0.630	31.926	27.9	87.3
540 through	539	0.026	0.516	3.800	1.960	0.084	0.000	0.080	0.164	2.287	4.247	70.43	200	0.56%	0.682	22.123	17.9	80.8
539	538	0.051	0.567	3.800	2.155	0.165	0.000	0.080	0.245	2.532	4.687	103.78	200	0.56%	0.683	22.150	17.5	78.8
537	538	0.044	0.044	3.800	0.168	0.123	0.000	0.080	0.203	0.203	0.371	88.17	200	0.40%	0.578	18.737	18.4	98.0
538	532	0.136	0.747	3.800	2.839	0.314	0.000	0.080	0.394	3.129	5.968	102.30	200	0.84%	0.837	27.158	21.2	78.0
530 high	531	0.069	0.069	3.800	0.264	0.224	0.000	0.080	0.304	0.304	0.568	86.15	200	0.52%	0.662	21.456	20.9	97.4
531	532	0.030	0.099	3.800	0.376	0.095	0.000	0.080	0.175	0.479	0.855	88.53	200	0.51%	0.653	21.189	20.3	96.0
534	533	0.095	0.095	3.800	0.360	0.218	0.000	0.080	0.298	0.298	0.659	76.17	200	0.40%	0.578	18.734	18.1	96.5
533	532	0.043	0.137	3.800	0.522	0.098	0.000	0.080	0.178	0.476	0.998	88.16	200	0.40%	0.579	18.765	17.8	94.7
532	525	0.137	1.121	3.800	4.259	0.316	0.000	0.080	0.396	4.481	8.740	102.21	200	0.36%	0.547	17.745	9.0	50.7
528	527	0.077	0.077	3.800	0.294	0.249	0.000	0.080	0.329	0.329	0.623	116.84	200	0.40%	0.578	18.748	18.1	96.7
527 through	526	0.088	0.354	3.800	1.345	0.168	0.000	0.080	0.248	1.428	2.773	86.14	200	0.22%	0.427	13.854	11.1	80.0
526	525	0.106	0.460	3.800	1.749	0.134	0.000	0.080	0.214	1.642	3.391	88.51	200	0.22%	0.427	13.847	10.5	75.5
523	524	0.096	0.096	3.800	0.365	0.221	0.000	0.080	0.301	0.301	0.666	76.22	200	0.40%	0.578	18.759	18.1	96.4
524	525	0.035	0.131	3.800	0.499	0.081	0.000	0.080	0.161	0.462	0.961	88.10	200	0.40%	0.578	18.744	17.8	94.9
525	518	0.138	1.851	3.800	7.032	0.258	0.000	0.080	0.338	6.923	13.955	102.38	200	0.14%	0.339	11.005	-2.9	0.0
516 through	517	0.092	0.229	3.800	0.870	0.134	0.000	0.080	0.214	0.817	1.686	101.27	200	0.04%	0.182	5.894	4.2	71.4
517	518	0.092	0.320	3.800	1.218	0.134	0.000	0.080	0.214	1.031	2.249	73.35	200	0.04%	0.182	5.896	3.6	61.9
520	519	0.103	0.103	3.800	0.393	0.238	0.000	0.080	0.318	0.318	0.711	76.15	200	0.40%	0.579	18.767	18.1	96.2
519	518	0.038	0.141	3.800	0.536	0.087	0.000	0.080	0.167	0.485	1.020	88.12	200	0.40%	0.578	18.742	17.7	94.6
518	513	0.108	2.420	3.800	9.197	0.134	0.000	0.080	0.214	8.653	17.850	58.75	250	0.68%	0.872	44.198	26.3	59.6
521	511	0.049	0.049	3.800	0.185	0.112	0.000	0.080	0.192	0.192	0.377	91.81	200	0.37%	0.553	17.940	17.6	97.9
509	511	0.022	0.022	3.800	0.083	0.050	0.000	0.080	0.130	0.130	0.214	44.62	200	0.34%	0.535	17.365	17.2	98.8
511	510	0.000	0.070	3.800	0.268	0.000	0.000	0.080	0.080	0.402	0.670	10.18	200	0.21%	0.415	13.469	12.8	95.0
510	512	0.121	0.191	3.800	0.728	0.115	0.000	0.080	0.195	0.597	1.325	76.29	200	0.21%	0.420	13.623	12.3	90.3
512	513	0.059	0.251	3.800	0.952	0.056	0.000	0.080	0.136	0.733	1.685	88.13	200	0.21%	0.419	13.587	11.9	87.6
513	209	0.148	2.819	3.800	10.713	0.230	0.000	0.080	0.310	9.696	20.409	79.35	250	0.68%	0.872	44.190	23.8	53.8
209	208	0.000	3.365	3.800	12.785	0.000	0.000	0.080	0.080	11.768	24.553	26.79	250	0.39%	0.664	33.661	9.1	27.1
208	207	0.000	3.365	3.800	12.785	0.000	0.000	0.080	0.080	11.848	24.633	9.96	250	0.41%	0.681	34.497	9.9	28.6
207	206	0.000	3.365	3.800	12.785	0.000	0.000	0.080	0.080	11.928	24.713	39.12	250	0.41%	0.679	34.386	9.7	28.1
215	206	0.103	0.103	3.800	0.393	0.238	0.000	0.080	0.318	0.318	0.711	101.04	200	0.40%	0.580	18.798	18.1	96.2
206	205	0.000	3.468	3.800	13.178	0.000	0.000	0.080	0.080	12.326	25.504	69.84	250	0.41%	0.679	34.407	8.9	25.9
205	204	0.000	3.468	3.800	13.178	0.000	0.000	0.080	0.080	54.006	67.184	95.38	250	0.41%	0.679	34.425	-32.8	0.0
204	203	0.248	3.716	3.800	14.121	0.801	0.000	0.080	0.881	54.887	69.008	100.97	250	0.35%	0.625	31.656	-37.4	0.0

Table 4-1
Existing Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
203	202	0.000	3.716	3.800	14.121	0.000	0.000	0.080	0.080	54.967	69.088	101.11	250	0.35%	0.625	31.679	-37.4	0.0
537	536	0.074	0.074	3.800	0.282	0.190	0.000	0.080	0.270	0.270	0.553	86.53	200	0.87%	0.855	27.718	27.2	98.0
536	535	0.029	0.103	3.800	0.393	0.067	0.000	0.080	0.147	0.418	0.811	125.34	200	0.49%	0.641	20.772	20.0	96.1
535	522	0.069	0.173	3.800	0.656	0.160	0.000	0.080	0.240	0.657	1.314	117.87	200	0.88%	0.860	27.882	26.6	95.3
521	522	0.024	0.024	3.800	0.092	0.056	0.000	0.080	0.136	0.136	0.228	103.13	200	0.17%	0.382	12.389	12.2	98.2
522	507	0.000	0.197	3.800	0.749	0.000	0.000	0.080	0.080	0.873	1.622	95.82	200	0.80%	0.817	26.493	24.9	93.9
506	507	0.067	0.067	3.800	0.254	0.154	0.330	0.080	0.564	0.564	0.818	31.76	200	1.29%	1.038	33.652	32.8	97.6
508	507	0.132	0.132	3.800	0.503	0.305	0.654	0.080	1.039	1.039	1.543	78.19	200	0.60%	0.710	23.040	21.5	93.3
507	504	0.122	0.518	3.800	1.968	0.280	0.600	0.080	0.960	3.436	5.404	121.70	200	0.52%	0.658	21.351	15.9	74.7
504	503	0.063	0.581	3.800	2.208	0.146	0.312	0.080	0.538	3.974	6.182	38.78	200	0.50%	0.649	21.055	14.9	70.6
503	502	0.000	0.581	3.800	2.208	0.000	0.000	0.080	0.080	4.054	6.262	64.66	200	0.50%	0.646	20.956	14.7	70.1
506	505	0.096	0.096	3.800	0.365	0.221	0.474	0.080	0.775	0.775	1.140	74.04	200	0.74%	0.787	25.521	24.4	95.5
505	502	0.101	0.197	3.800	0.748	0.232	0.498	0.080	0.810	1.586	2.334	86.87	200	0.22%	0.432	14.014	11.7	83.3
501	502	0.168	0.168	3.800	0.637	0.386	0.828	0.080	1.294	1.294	1.932	106.70	200	0.52%	0.658	21.329	19.4	90.9
502	202	0.000	0.946	3.800	3.594	0.000	0.000	0.080	0.080	7.014	10.608	72.55	200	0.40%	0.575	18.638	8.0	43.1
202	201	0.105	4.767	3.762	17.931	0.339	0.000	0.080	0.419	62.400	80.330	88.46	250	0.35%	0.625	31.675	-48.7	0.0
201	109	0.000	4.767	3.762	17.931	0.000	0.000	0.080	0.080	62.480	80.410	96.00	250	0.41%	0.682	34.532	-45.9	0.0
109	107	0.000	4.767	3.762	17.931	0.000	0.000	0.080	0.080	62.560	80.490	96.00	250	0.41%	0.683	34.620	-45.9	0.0
107	105	0.000	4.767	3.762	17.931	0.000	0.000	0.080	0.080	62.640	80.570	120.00	250	0.41%	0.683	34.602	-46.0	0.0
105	103	0.000	4.767	3.762	17.931	0.000	0.000	0.080	0.080	62.720	80.650	57.77	250	0.42%	0.684	34.655	-46.0	0.0
103	102	0.000	4.767	3.762	17.931	0.000	0.000	0.080	0.080	62.800	80.730	3.00	250	2.07%	1.525	77.295	-3.4	0.0
412	408	0.029	0.029	3.800	0.111	0.067	0.000	0.080	0.147	0.147	0.258	53.52	200	0.40%	0.577	18.721	18.5	98.6
415	408	0.000	0.000	3.800	0.000	0.000	0.000	0.080	0.080	0.080	0.080	80.52	250	0.40%	0.669	33.899	33.8	99.8
408	407	0.022	0.051	3.800	0.194	0.050	0.000	0.080	0.130	0.358	0.552	40.49	250	0.50%	0.748	37.892	37.3	98.5
407	406	0.166	0.218	3.800	0.827	0.384	0.000	0.080	0.464	0.821	1.648	117.97	250	0.50%	0.749	37.969	36.3	95.7
406	405	0.120	0.338	3.800	1.284	0.277	0.000	0.080	0.357	1.178	2.462	112.17	250	0.50%	0.750	38.025	35.6	93.5
417	416	0.092	0.092	3.800	0.351	0.213	0.000	0.080	0.293	0.293	0.644	73.55	200	0.92%	1.012	32.828	32.2	98.0
416	405	0.123	0.215	3.800	0.817	0.283	0.000	0.080	0.363	0.656	1.473	65.47	200	0.54%	0.774	25.089	23.6	94.1
414	413	0.044	0.044	3.800	0.166	0.101	0.000	0.080	0.181	0.181	0.347	73.55	200	0.40%	0.577	18.704	18.4	98.1
413	412	0.060	0.103	3.800	0.393	0.137	0.000	0.080	0.217	0.398	0.791	65.47	200	0.40%	0.579	18.766	18.0	95.8
412	411	0.100	0.203	3.800	0.771	0.230	0.000	0.080	0.310	0.708	1.479	113.37	200	0.40%	0.579	18.769	17.3	92.1
411	410	0.156	0.359	3.800	1.362	0.358	0.000	0.080	0.438	1.146	2.508	121.92	200	0.40%	0.578	18.757	16.2	86.6
410	409	0.000	0.359	3.800	1.362	0.000	0.000	0.080	0.080	1.226	2.588	9.63	200	0.41%	0.587	19.042	16.5	86.4
409	405	0.083	0.441	3.800	1.676	0.190	0.000	0.080	0.270	1.496	3.173	86.46	200	0.40%	0.577	18.713	15.5	83.0
405	404	0.022	1.016	3.800	3.861	0.050	0.000	0.080	0.130	3.461	7.321	64.92	300	0.35%	0.706	51.512	44.2	85.8

Table 4-1
Existing Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
404	403	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	3.541	7.401	91.44	375	0.24%	0.682	77.756	70.4	90.5
403	402	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	3.621	7.481	91.44	375	0.24%	0.684	77.933	70.5	90.4
402	401	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	3.701	7.561	91.66	375	0.24%	0.681	77.663	70.1	90.3
401	108	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	3.781	7.641	100.90	375	0.24%	0.681	77.634	70.0	90.2
108	106	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	3.861	7.721	96.00	375	0.24%	0.685	78.097	70.4	90.1
106	104	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	3.941	7.801	120.00	375	0.24%	0.686	78.197	70.4	90.0
104	102	0.000	1.016	3.800	3.861	0.000	0.000	0.080	0.080	4.021	7.881	57.77	375	0.25%	0.689	78.593	70.7	90.0
102	101 Lagoon	0.000	5.783	3.704	21.418	0.000	0.000	0.080	0.080	66.900	88.318	74.77	450	0.12%	0.536	87.930	-0.4	0.0

The wet well capacity has been estimated at 5.7 m^3, as the pumping set points are not known. This is purely a rough estimate and requires verification. The wet well would be required to be over 4.9 m^3 in order to store half of the peak flow for five minutes. It therefore appears that the wet well may be sufficiently sized for the current design flows.

4.2.3 Lagoons

Table 4.2 presents the Sewage Lagoon Capacity Assessment. As shown on the table, there appears to be ample available storage to accommodate the existing design flows, and beyond the 25 year study period.

4.3 UPGRADES TO EXISTING SYSTEM

There are two upgrades recommended to the existing sanitary collection system, as identified in Figure 4.3. The first is to install a new 250 mm sewage forcemain from the Lift Station directly west to the sewage lagoon. This recommendation addresses Town concerns over the condition of the existing forcemain which has collapsed due to age and condition in recent years. This will also address capacity concerns in the downstream system during peak flow periods in which the lift station is in operation. It is recommended that the Town secure an easement for the construction of the forcemain.

The second recommendation is to interconnect the 375 mm and 250 mm trunk sewers at MH 201 and MH 401 (at the Shop Road and 52 Avenue). This will allow for the incoming flow to be split between the two trunks, reducing the risk of surcharging in the smaller, eastern main.

This will not eliminate all areas of potential surcharge. As mentioned, the trunk main from MH 202 to MH 201 will continue to be somewhat overloaded after removing the contribution from the lift station; however, the model results indicate that surcharging will be limited to 0.18 m above the top of pipe. However, this will not accommodate any future expansion, and is anticipated to require upgrading if/when additional area is to be serviced. The final combined, downstream section of trunk main is also minimally overloaded; however, the proposed forcemain could be routed to the discharge manhole.

There is also a section of pipe on 50 Street from 50 Avenue to 51 Avenue with a very flat slope which cannot easily be addressed without replacing additional mains. As the related surcharge is anticipated to be within 0.1 m above the top of pipe, it is not recommended for upgrading at this time.

The installation of the forcemain is recommended to occur prior to servicing further development.

The recommended upgrades reflect a capacity analysis only, and do not consider upgrades required due to condition, other than for the sewage forcemain. It is recommended that regular CCTV inspections continue be undertaken in order to identify condition related upgrading requirements.

There are no upgrades recommended for the lift station or sewage lagoon to accommodate the existing design flows.

Table 4-2
Town of Bruderheim - Master Services Plan

Sewage Lagoon Capacity Assessment

Item	Units	Existing 2014	5 Year 2019	10 Year 2024	15 Year 2029	20 Year 2034	25 Year 2039	Phase 1	Phase 2	Ultimate
Population		1,376	1,519	1,677	1,852	2,045	2,257	4,466	6,926	13,681
Avg. Day Flow	m^3/d	413	456	503	556	614	677	1,340	2,078	4,104
Anaerobic Cells										
Number of Cells Required[a]	each	2	2	4	4	4	4	4	4	4
Number of Cells Existing	each	6	6	6	6	6	6	6	6	6
Retention Required, ea	days	2	2	2	2	2	2	2	2	2
Retention Available, ea[b]	days	4	4	3	3	3	2	1	0	0
Additional Retention Required	days	-	-	-	-	-	-	1	2	2
Volume Required, each cell	m^3	825.6	911.4	1006.2	1111.2	1227	1354.2	2679.6	4155.6	8208.6
Volume Available, each cell[c]	m^3	2000	2000	2000	2000	2000	2000	2000	2000	2000
Additional Volume Required, each cell	m^3	-	-	-	-	-	-	679.6	2155.6	6208.6
Facultative Cell										
Retention Required	days	60	60	60	60	60	60	60	60	60
Retention Available	days	190	172	156	141	127	115	58	37	19
Additional Retention Required	days	-	-	-	-	-	-	2	23	41
Volume Required	m^3	24,768	27,342	30,186	33,336	36,810	40,626	80,388	124,668	246,258
Volume Available	m^3	78,500	78,500	78,500	78,500	78,500	78,500	78,500	78,500	78,500
Additional Volume Required	m^3	-	-	-	-	-	-	1888	46168	167758
Storage Cell										
Retention Required	days	365	365	365	365	365	365	365	365	365
Retention Available	days	1,124	1,018	922	835	756	685	346	223	113
Additional Retention Required	days	-	-	-	-	-	-	19	142	252
Volume Required	m^3	150,672	166,331	183,632	202,794	223,928	247,142	489,027	758,397	1,498,070
Volume Available	m^3	464,000	464,000	464,000	464,000	464,000	464,000	464,000	464,000	464,000
Additional Volume Required	m^3	-	-	-	-	-	-	25,027	294,397	1,034,070

[a] AENV standards indicate no anaerobic cells are required when the average day design flow is less than 250 m^3/d.

2 anaerobic cells are required when the average day design flow is between 250 to 500 m^3/d

4 anaerobic cells are required when the average day design flow is more than 500 m^3/d

[b] Based on series operation

[c] assumes 2x1000 m^3 combined storage for each of two cells and 2550 m^3 each for remaining 2 cells (actual total is 6 cells at 9,100 m^3)

4.4 ULTIMATE SYSTEM

The ultimate sanitary collection system is presented over a number of figures in order to clearly present the proposed phasing of the system.

4.4.1 Phase 1

Figure 4.4 presents the proposed servicing concept for the Phase 1 development area. As shown in the Figure, new mains are anticipated to be constructed in the southeast, in order to accommodate future residential and commercial development. The most easterly development area, (including the existing greenhouse) can be accommodated through the Brookside development via the existing 250 mm diameter sewer.

The lands south of the existing Church site are anticipated to be serviced off of the 52 Avenue sewer main. Other development areas can be serviced off of extensions to existing mains, such as:

- Commercial lands located along Highway 45, south of the CN Railway.
- Area west of West Woodlands.
- Area east of West Woodlands.
- Areas north and east of Brookside Park.

As a result of servicing the full Phase 1 development area (refer to **Figure 2.1**), the following upgrades will be required (in addition to those upgrades already identified to the existing system):

- Upgrade 52 Avenue from 50 Street to the Shop Road.
- Upsize the lift station inlet pipe to 375 mm.
- Upsize sewer on 50 Street from 49 Avenue to 51 Avenue.

The lift station will require an expansion in order to increase the wet well and pumping capacity in order to accommodate the associated catchment area.

The existing sewage lagoon will require expansion in order to service the entire Phase 1 boundary buildout. It should be noted, however, that this lagoon expansion will not be required for over 25 years.

4.4.2 Phase 2

Figure 4.5 presents the proposed servicing concept for the Phase 2 development area. This involves servicing land between the CN and CP Railways, located west of Highway 45. A 250 mm and 450 mm sewer main are proposed to service these areas. The 450 mm main will eventually continue south and east, in order to service additional land. This main is proposed to tie into the exiting sewer at the south end of 51 Street, and will require that a small portion of sewer at Sunset Crescent be upgraded to a 250 mm diameter in order to convey the peak design flows.

Lands immediately north of the existing Town are also included in the Phase 2 area. A new lift station is proposed east of the sewage lagoon in order to service lands north of 52 Avenue, as well as north of Brookside. It is proposed that the lift station be installed at a depth sufficient to service lowlands further to the north (in the Ultimate servicing scenario). A 250 mm forcemain will be required in order to convey the design flows from the ultimate catchment area.

The existing 250 mm trunk main located on the Shop Road will require upgrading to a 375 mm diameter in order to accommodate the peak design flows.

The existing sewage lagoon will require expansion in order to service the Phase 2 boundary.

4.4.3 Ultimate System

Figure 4.6 presents the proposed servicing concept for the Ultimate development area. As shown in the Figure, the proposed 450 mm trunk main is envisioned to extend both south and east in order to service lands as far south as Highway 15. Lands north to the Town/Study Boundary are proposed to flow by gravity to the Lift Station proposed east of the existing lagoon. The far northeast portion of these lands will require an additional lift station and forcemain.

The existing sewage lagoon will require a significant expansion in order to service the entire study boundary.

The Ultimate System spreadsheet model is enclosed as **Table 4.2**. Sanitary Index Figure A2 is located in **Appendix A** and identifies the sanitary catchments and manhole numbering referenced in the spreadsheet.

Table 4-3
Ultimate Sanitary Sewer System

General	Existing Areas
Per Capita Flow Generation	300 L/c/day
Peaking Factor	Harmons
General Infiltration	0.28 L/s/ha
Foundation Drain Allowance*	0.60 L/s/ha
Sag Manhole Allowance**	0.08 L/s
Manning's n Old VCT Pipe	0.015
New PVC Pipe	0.013

Other	Residential	MD Residential	Com/Ind/Inst
Population Density	35 people/ha	85 people/ha	25 people/ha
Area Flow Generation	0.122 L/s/ha	0.295 L/s/ha	0.09 L/s/ha

Lift Station pumping rate =	41.60 L/s

Pipes with zero remaining capacity	0.00
Pipes with 0 to 20% remaining capacity	10.00

Note: *Foundation Drain Allowance is applied to Sunset Crescent and Brookside Park only.
Foundation drains in the Main Area and West Woodlands are assumed to be connected to the storm sewer.
** Sag Manhole Allowance is applied to existing manholes only

		Design Flows										Pipe Data					Pipe Capacity	
From MH	To MH	Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
B4	B3	1.832	1.832	3.800	6.960	5.908	0.000	0.000	5.908	5.908	12.868	200.00	200	0.40%	0.667	21.640	8.8	40.5
B3	B2	2.127	3.958	3.763	14.894	4.900	0.000	0.000	4.900	10.808	25.702	600.00	250	0.40%	0.774	39.237	13.5	34.5
B2	B1	2.175	6.134	3.627	22.247	5.012	0.000	0.000	5.012	15.820	38.067	460.00	250	0.60%	0.948	48.055	10.0	20.8
B1	314	0.000	6.134	3.627	22.247	0.000	0.000	0.000	0.000	15.820	38.067	60.00	250	0.60%	0.948	48.055	10.0	20.8
314	313	0.046	6.180	3.625	22.400	0.106	0.228	0.080	0.414	16.234	38.634	45.90	250	1.37%	1.244	63.045	24.4	38.7
313	312	0.055	6.235	3.622	22.580	0.126	0.270	0.080	0.476	16.710	39.290	49.95	250	2.04%	1.515	76.759	37.5	48.8
312	311	0.036	6.271	3.620	22.700	0.084	0.180	0.080	0.344	17.054	39.754	32.08	300	0.65%	0.963	70.283	30.5	43.4
311	310	0.081	6.352	3.616	22.968	0.188	0.402	0.080	0.670	17.724	40.692	78.96	300	0.53%	0.875	63.813	23.1	36.2
310	309	0.637	6.989	3.584	25.047	1.467	0.444	0.080	1.991	19.715	44.762	86.95	300	0.43%	0.787	57.404	12.6	22.0
309	308	0.301	7.291	3.569	26.022	0.694	0.528	0.080	1.302	21.018	47.040	97.20	300	0.44%	0.794	57.924	10.9	18.8
308	307	0.146	7.436	3.562	26.492	0.336	0.720	0.080	1.136	22.154	48.646	139.72	300	0.35%	0.706	51.493	2.8	5.5
307	306	0.061	7.497	3.560	26.688	0.140	0.300	0.080	0.520	22.674	49.361	62.64	300	0.50%	0.844	61.596	12.2	19.9
306	305	0.097	7.594	3.555	27.000	0.224	0.480	0.080	0.784	23.458	50.458	87.29	300	0.45%	0.804	58.680	8.2	14.0
				3.800														
337	336	0.000	0.000	3.800	0.000	0.000	0.000	0.080	0.080	0.080	0.080	52.68	200	0.63%	0.726	23.542	23.5	99.7
				3.800														
335	336	0.096	0.096	3.800	0.365	0.221	0.474	0.080	0.775	0.775	1.140	59.03	200	0.87%	0.852	27.626	26.5	95.9
336	334	0.061	0.157	3.800	0.596	0.140	0.300	0.080	0.520	1.375	1.971	105.51	200	0.61%	0.716	23.207	21.2	91.5
				3.800														
333	334	0.081	0.081	3.800	0.309	0.188	0.402	0.080	0.670	0.670	0.979	37.27	200	2.30%	1.386	44.955	44.0	97.8
334	332	0.061	0.299	3.800	1.136	0.140	0.300	0.080	0.520	2.565	3.701	76.43	200	0.71%	0.770	24.981	21.3	85.2
332	331	0.066	0.365	3.800	1.385	0.151	0.324	0.080	0.555	3.120	4.505	86.24	200	0.63%	0.727	23.591	19.1	80.9
				3.800														
330	331	0.081	0.081	3.800	0.309	0.188	0.402	0.080	0.670	0.670	0.979	41.97	200	3.54%	1.722	55.827	54.8	98.2
331	329	0.058	0.504	3.800	1.916	0.134	0.288	0.080	0.502	4.292	6.208	37.77	200	0.38%	0.563	18.259	12.1	66.0
				3.800														
328	329	0.156	0.156	3.800	0.594	0.504	1.080	0.080	1.664	1.664	2.258	68.70	200	0.71%	0.768	24.906	22.6	90.9
329	327	0.085	0.746	3.800	2.834	0.196	0.420	0.080	0.696	6.652	9.486	74.41	200	0.47%	0.628	20.352	10.9	53.4
327	315	0.102	0.848	3.800	3.221	0.235	0.504	0.080	0.819	7.471	10.693	113.16	200	0.37%	0.559	18.139	7.4	41.1
				3.800														

Table 4-3
Ultimate Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
320	319	0.088	0.088	3.800	0.333	0.202	0.432	0.080	0.714	0.714	1.046	111.97	200	0.45%	0.611	19.812	18.8	94.7
319	318	0.083	0.170	3.800	0.647	0.190	0.408	0.080	0.678	1.392	2.039	81.52	200	0.68%	0.752	24.395	22.4	91.6
318	317	0.077	0.247	3.800	0.937	0.176	0.378	0.080	0.634	2.026	2.964	72.65	200	0.73%	0.779	25.257	22.3	88.3
317	316	0.080	0.327	3.800	1.242	0.185	0.396	0.080	0.661	2.687	3.929	80.55	200	0.47%	0.624	20.234	16.3	80.6
				3.800														
326	325	0.039	0.039	3.800	0.148	0.090	0.192	0.080	0.362	0.362	0.509	78.63	200	0.69%	0.757	24.563	24.1	97.9
				3.800														
324	325	0.081	0.081	3.800	0.309	0.188	0.402	0.080	0.670	0.670	0.979	35.61	200	1.03%	0.927	30.053	29.1	96.7
325	323	0.028	0.148	3.800	0.563	0.064	0.138	0.080	0.282	1.314	1.877	56.71	200	0.55%	0.680	22.066	20.2	91.5
323	322	0.041	0.190	3.800	0.720	0.095	0.204	0.080	0.379	1.693	2.413	40.94	200	0.50%	0.646	20.944	18.5	88.5
322	321	0.088	0.277	3.800	1.053	0.202	0.432	0.080	0.714	2.406	3.459	80.67	200	0.55%	0.677	21.950	18.5	84.2
321	316	0.061	0.338	3.800	1.284	0.140	0.300	0.080	0.520	2.926	4.210	80.81	200	0.58%	0.697	22.601	18.4	81.4
316	315	0.044	0.709	3.800	2.692	0.101	0.216	0.080	0.397	6.010	8.703	84.79	200	0.49%	0.637	20.654	12.0	57.9
315	305	0.000	1.556	3.800	5.914	0.000	0.000	0.080	0.080	13.562	19.475	86.07	200	0.90%	0.865	28.063	8.6	30.6
305	304	0.124	9.275	3.485	32.322	0.361	0.774	0.080	1.215	38.234	70.556	109.60	300	1.40%	1.417	103.406	32.8	31.8
304	303	0.118	9.393	3.480	32.689	0.342	0.732	0.080	1.154	39.388	72.077	69.38	300	1.56%	1.494	109.033	37.0	33.9
303	302	0.057	9.450	3.478	32.868	0.171	0.366	0.080	0.617	40.005	72.873	77.53	300	0.64%	0.956	69.776	-3.1	0.0
302	301	0.000	9.450	3.478	32.868	0.000	0.000	0.080	0.080	40.085	72.953	42.48	300	0.75%	1.035	75.527	2.6	3.4
301	LS	1.349	10.799	3.429	37.031	3.108	0.000	0.080	3.188	43.273	80.304	8.00	375	0.65%	1.291	147.184	66.9	45.4
				3.800														
LS	201	0.0	0.000	3.800	0.0				80.3	0.000	0.0	RELOCATE						
				3.800														
G5	G4	5.642	5.642	3.654	20.618	18.200	0.000	0.000	18.200	18.200	38.818	400.00	200	2.20%	1.565	50.751	11.9	23.5
G4	G3	2.821	8.464	3.517	29.770	9.100	0.000	0.000	9.100	27.300	57.070	400.00	250	2.00%	1.731	87.736	30.7	35.0
G3	G2	5.469	13.932	3.332	46.424	17.640	0.000	0.000	17.640	44.940	91.364	700.00	300	2.00%	1.955	142.669	51.3	36.0
G2	G1	0.000	13.932	3.332	46.424	0.000	0.000	0.000	0.000	44.940	91.364	420.00	375	0.40%	1.015	115.683	24.3	21.0
G1	G0	0.000	13.932	3.332	46.424	0.000	0.000	0.000	0.000	44.940	91.364	330.00	375	1.00%	1.604	182.911	91.5	50.0
G0	F0	0.564	14.497	3.317	48.080	1.820	0.000	0.000	1.820	46.760	94.840	650.00	450	0.15%	0.702	115.195	20.4	17.7
				3.800														
545	544	0.661	0.661	3.800	2.510	2.131	0.000	0.080	2.211	2.211	4.721	124.95	200	1.37%	1.071	34.722	30.0	86.4
				3.800														
C1	604	0.741	0.741	3.800	2.817	1.708	0.000	0.000	1.708	1.708	4.525	210.00	200	0.40%	0.667	21.640	17.1	79.1
604	603	0.040	0.781	3.800	2.969	0.092	0.000	0.080	0.172	1.880	4.850	78.18	200	0.28%	0.481	15.587	10.7	68.9
603	544	0.034	0.815	3.800	3.099	0.078	0.000	0.080	0.158	2.039	5.138	122.74	200	0.28%	0.481	15.585	10.4	67.0
544	543	0.527	2.003	3.800	7.611	1.700	0.000	0.080	1.780	6.029	13.640	101.65	200	0.39%	0.572	18.556	4.9	26.5
				3.800														
602	601	0.118	0.118	3.800	0.448	0.272	0.000	0.080	0.352	0.352	0.800	105.87	200	0.40%	0.578	18.753	18.0	95.7
601	543	0.000	0.118	3.800	0.448	0.000	0.000	0.080	0.080	0.432	0.880	65.65	200	0.40%	0.578	18.744	17.9	95.3
543	542	0.117	2.238	3.800	8.504	0.378	0.000	0.080	0.458	6.919	15.423	103.78	200	0.40%	0.575	18.662	3.2	17.4
542	541	0.065	2.303	3.800	8.752	0.210	0.000	0.080	0.290	7.209	15.961	72.31	200	0.50%	0.648	21.011	5.1	24.0
541	540	0.022	2.325	3.800	8.834	0.070	0.000	0.080	0.150	7.359	16.193	101.50	200	0.50%	0.648	21.000	4.8	22.9
540 high	530	0.052	0.052	3.800	0.198	0.168	0.000	0.080	0.248	0.248	0.446	102.30	200	1.17%	0.990	32.104	31.7	98.6
				3.800														
529	530	0.085	0.085	3.800	0.323	0.274	0.000	0.080	0.354	0.354	0.678	109.16	200	0.40%	0.579	18.763	18.1	96.4
530 through	527	0.052	0.189	3.800	0.719	0.168	0.000	0.080	0.248	0.850	1.569	102.29	200	0.79%	0.813	26.356	24.8	94.0

Table 4-3
Ultimate Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
				3.800														
527 high	516	0.095	0.095	3.800	0.363	0.308	0.000	0.080	0.388	0.388	0.751	102.38	200	1.10%	0.958	31.058	30.3	97.6
				3.800														
515	516	0.042	0.042	3.800	0.158	0.134	0.000	0.080	0.214	0.214	0.373	86.44	200	0.40%	0.579	18.762	18.4	98.0
516 high	514	0.124	0.124	3.800	0.470	0.171	0.000	0.080	0.251	0.251	0.721	81.16	200	0.43%	0.601	19.474	18.8	96.3
514	212	0.145	0.145	3.800	0.552	0.347	0.000	0.080	0.427	0.427	0.979	79.52	200	0.44%	0.607	19.674	18.7	95.0
				3.800														
A2	A1	2.976	2.976	3.800	11.308	7.504	0.000	0.000	7.504	7.504	18.812	400.00	200	0.39%	0.657	21.320	2.5	11.8
A1	213	0.000	2.976	3.800	11.308	0.000	0.000	0.000	0.000	7.504	18.812	270.00	250	0.28%	0.648	32.828	14.0	42.7
213	212	0.175	3.151	3.800	11.974	0.566	0.000	0.080	0.646	8.150	20.124	97.80	250	0.28%	0.562	28.459	8.3	29.3
212	211	0.088	3.384	3.800	12.859	0.283	0.000	0.080	0.363	8.940	21.798	96.32	250	0.36%	0.637	32.272	10.5	32.5
211	210	0.000	3.384	3.800	12.859	0.000	0.000	0.080	0.080	9.020	21.878	56.14	250	0.36%	0.636	32.252	10.4	32.2
				3.800														
216	210	0.137	0.137	3.800	0.522	0.316	0.000	0.080	0.396	0.396	0.918	105.30	200	0.40%	0.578	18.751	17.8	95.1
210	209	0.000	3.521	3.796	13.367	0.000	0.000	0.080	0.080	9.496	22.863	23.54	250	0.35%	0.630	31.926	9.1	28.4
				3.800														
540 through	539	0.026	2.351	3.800	8.933	0.084	0.000	0.080	0.164	7.523	16.456	70.43	200	0.56%	0.682	22.123	5.7	25.6
539	538	0.051	2.402	3.800	9.128	0.165	0.000	0.080	0.245	7.768	16.896	103.78	200	0.56%	0.683	22.150	5.3	23.7
				3.800														
536	522	0.098	46.539	2.827	131.587	0.227	0.000	0.000	0.227	150.027	281.613	243.210	525	0.65%	1.619	361.719	80.1	22.1
522	H1	0.095	46.634	2.827	131.813	0.218	0.000	0.000	0.218	150.245	282.058	269.560	525	0.65%	1.619	361.719	79.7	22.0
H1	Lagoon	0.000	46.634	2.827	131.813	0.000	0.000	0.000	0.000	150.245	282.058	600.000	525	0.57%	1.522	340.112	58.1	17.1
				3.800														
537	538	0.044	0.044	3.800	0.168	0.123	0.000	0.080	0.203	0.203	0.371	88.17	200	0.40%	0.578	18.737	18.4	98.0
538	532	0.136	2.582	3.800	9.813	0.314	0.000	0.080	0.394	8.365	18.178	102.30	200	0.84%	0.837	27.158	9.0	33.1
				3.800														
530 high	531	0.069	0.069	3.800	0.264	0.224	0.000	0.080	0.304	0.304	0.568	86.15	200	0.52%	0.662	21.456	20.9	97.4
531	532	0.030	0.099	3.800	0.376	0.095	0.000	0.080	0.175	0.479	0.855	88.53	200	0.51%	0.653	21.189	20.3	96.0
				3.800														
534	533	0.095	0.095	3.800	0.360	0.218	0.000	0.080	0.298	0.298	0.659	76.17	200	0.40%	0.578	18.734	18.1	96.5
533	532	0.043	0.137	3.800	0.522	0.098	0.000	0.080	0.178	0.476	0.998	88.16	200	0.40%	0.579	18.765	17.8	94.7
532	525	0.137	2.956	3.800	11.232	0.316	0.000	0.080	0.396	9.717	20.949	102.21	250	0.36%	0.733	37.124	16.2	43.6
				3.800														
528	527	0.077	0.077	3.800	0.294	0.249	0.000	0.080	0.329	0.329	0.623	116.84	200	0.40%	0.578	18.748	18.1	96.7
527 through	526	0.088	0.354	3.800	1.345	0.168	0.000	0.080	0.248	1.428	2.773	86.14	200	0.22%	0.427	13.854	11.1	80.0
526	525	0.106	0.460	3.800	1.749	0.134	0.000	0.080	0.214	1.642	3.391	88.51	200	0.22%	0.427	13.847	10.5	75.5
				3.800														
523	524	0.096	0.096	3.800	0.365	0.221	0.000	0.080	0.301	0.301	0.666	76.22	200	0.40%	0.578	18.759	18.1	96.4
524	525	0.035	0.131	3.800	0.499	0.081	0.000	0.080	0.161	0.462	0.961	88.10	200	0.40%	0.578	18.744	17.8	94.9
525	518	0.138	3.686	3.783	13.943	0.258	0.000	0.080	0.338	12.159	26.102	102.38	250	0.25%	0.612	31.019	4.9	15.9
				3.800														
516 through	517	0.092	0.229	3.800	0.870	0.134	0.000	0.080	0.214	0.817	1.686	101.27	200	0.04%	0.182	5.894	4.2	71.4
517	518	0.092	0.320	3.800	1.218	0.134	0.000	0.080	0.214	1.031	2.249	73.35	200	0.04%	0.182	5.896	3.6	61.9
520	519	0.103	0.103	3.800	0.393	0.238	0.000	0.080	0.318	0.318	0.711	76.15	200	0.40%	0.579	18.767	18.1	96.2

Table 4-3
Ultimate Sanitary Sewer System

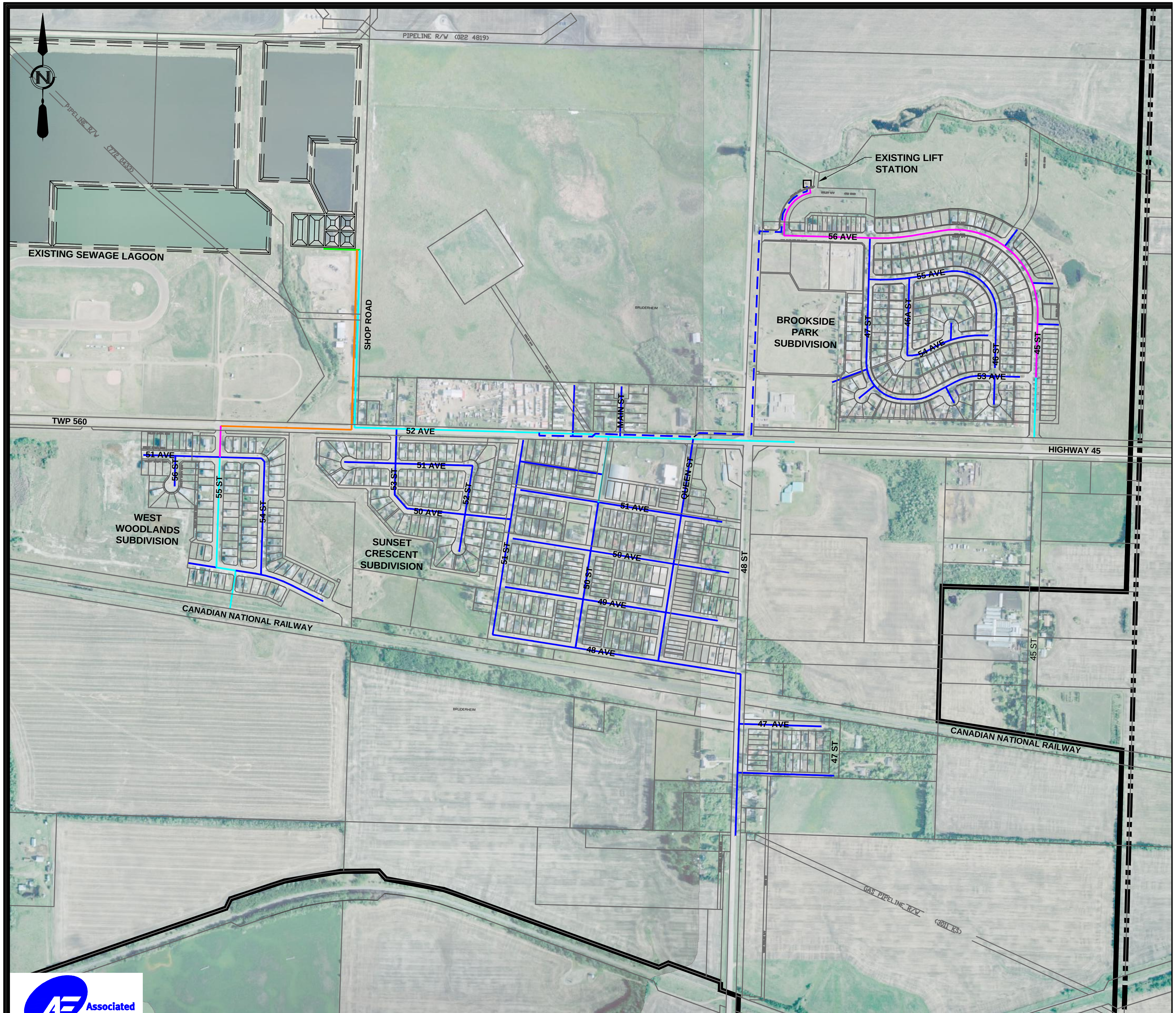
From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
519	518	0.038	0.141	3.800	0.536	0.087	0.000	0.080	0.167	0.485	1.020	88.12	200	0.40%	0.578	18.742	17.7	94.6
518	513	0.108	4.255	3.794	16.145	0.134	0.000	0.080	0.214	13.889	30.034	58.75	250	0.68%	0.872	44.198	14.2	32.0
521	511	0.049	0.049	3.800	0.185	0.112	0.000	0.080	0.192	0.192	0.377	91.81	200	0.37%	0.553	17.940	17.6	97.9
509	511	0.022	0.022	3.800	0.083	0.050	0.000	0.080	0.130	0.130	0.214	44.62	200	0.34%	0.535	17.365	17.2	98.8
511	510	0.000	0.070	3.800	0.268	0.000	0.000	0.080	0.080	0.402	0.670	10.18	200	0.21%	0.415	13.469	12.8	95.0
510	512	0.121	0.191	3.800	0.728	0.115	0.000	0.080	0.195	0.597	1.325	76.29	200	0.21%	0.420	13.623	12.3	90.3
512	513	0.059	0.251	3.800	0.952	0.056	0.000	0.080	0.136	0.733	1.685	88.13	200	0.21%	0.419	13.587	11.9	87.6
513	209	0.148	4.654	3.769	17.539	0.230	0.000	0.080	0.310	14.932	32.471	79.35	250	0.68%	0.872	44.190	11.7	26.5
209	208	0.000	8.175	3.592	29.368	0.000	0.000	0.080	0.080	24.508	53.876	26.79	375	0.39%	1.004	114.511	60.6	53.0
208	207	0.000	8.175	3.592	29.368	0.000	0.000	0.080	0.080	24.588	53.956	9.96	375	0.41%	1.029	117.355	63.4	54.0
207	206	0.000	8.175	3.592	29.368	0.000	0.000	0.080	0.080	24.668	54.036	39.12	375	0.41%	1.026	116.977	62.9	53.8
215	206	0.103	0.103	3.800	0.393	0.238	0.000	0.080	0.318	0.318	0.711	101.04	200	0.40%	0.580	18.798	18.1	96.2
206	205	0.000	8.279	3.588	29.704	0.000	0.000	0.080	0.080	25.066	54.770	69.84	375	0.41%	1.027	117.050	62.3	53.2
205	204	0.000	8.279	3.588	29.704	0.000	0.000	0.080	0.080	25.146	54.850	95.38	375	0.41%	1.027	117.111	62.3	53.2
204	203	0.248	8.527	3.578	30.509	0.801	0.000	0.080	0.881	26.027	56.536	100.97	375	0.35%	0.945	107.691	51.2	47.5
203	202	0.000	8.527	3.578	30.509	0.000	0.000	0.080	0.080	26.107	56.616	101.11	375	0.35%	0.945	107.770	51.2	47.5
F4	F3	11.285	11.285	3.480	39.268	36.400	0.000	0.000	36.400	36.400	75.668	400.00	375	0.80%	1.435	163.601	87.9	53.7
F3	F2	5.642	16.927	3.327	56.321	18.200	0.000	0.000	18.200	54.600	110.921	800.00	375	0.60%	1.243	141.682	30.8	21.7
F2	F0	13.021	29.948	3.096	92.704	42.000	0.000	0.000	42.000	96.600	189.304	720.00	375	2.10%	2.325	265.063	75.8	28.6
F1	F0	0.000	29.948	3.096	92.704	0.000	0.000	0.000	0.000	96.600	189.304	160.00	375	2.00%	2.269	258.675	69.4	26.8
F0	536	1.997	46.441	2.908	135.038	6.440	0.000	0.000	6.440	149.800	284.838	350.00	450	1.60%	2.292	376.227	91.4	24.3
537	536	0.074	0.074	3.800	0.282	0.190	0.000	0.080	0.270	0.270	0.553	86.53	200	0.87%	0.855	27.718	27.2	98.0
536	535	0.029	46.544	2.907	135.294	0.067	0.000	0.080	0.147	150.218	285.512	125.34	525	0.49%	1.406	314.273	28.8	9.2
535	522	0.069	46.614	2.906	135.465	0.160	0.000	0.080	0.240	150.457	285.923	117.87	525	0.88%	1.888	421.839	135.9	32.2
521	522	0.024	0.024	3.800	0.092	0.056	0.000	0.080	0.136	0.136	0.228	103.13	200	0.17%	0.382	12.389	12.2	98.2
522	507	0.000	0.000	3.800	0.000	0.000	0.000	0.080	0.080	0.080	0.080	95.82	200	0.80%	0.817	26.493	26.4	99.7
506	507	0.067	0.067	3.800	0.254	0.154	0.330	0.080	0.564	0.564	0.818	31.76	200	1.29%	1.038	33.652	32.8	97.6
508	507	0.132	0.132	3.800	0.503	0.305	0.654	0.080	1.039	1.039	1.543	78.19	200	0.60%	0.710	23.040	21.5	93.3
507	504	0.122	0.321	3.800	1.219	0.280	0.600	0.080	0.960	2.643	3.862	121.70	200	0.52%	0.658	21.351	17.5	81.9
504	503	0.063	0.384	3.800	1.459	0.146	0.312	0.080	0.538	3.181	4.640	38.78	200	0.50%	0.649	21.055	16.4	78.0
503	502	0.000	0.384	3.800	1.459	0.000	0.000	0.080	0.080	3.261	4.720	64.66	200	0.50%	0.646	20.956	16.2	77.5
506	505	0.096	0.096	3.800	0.365	0.221	0.474	0.080	0.775	0.775	1.140	74.04	200	0.74%	0.787	25.521	24.4	95.5
505	502	0.101	0.197	3.800	0.748	0.232	0.498	0.080	0.810	1.586	2.334	86.87	200	0.22%	0.432	14.014	11.7	83.3
501	502	0.168	0.168	3.800	0.637	0.386	0.828	0.080	1.294	1.294	1.932	106.70	200	0.52%	0.658	21.329	19.4	90.9

Table 4-3
Ultimate Sanitary Sewer System

From MH	To MH	Design Flows: Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Pipe Data: Length	Diameter	Slope	Velocity	Capacity	Pipe Capacity: Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
502	202	0.000	0.749	3.800	2.845	0.000	0.000	0.080	0.080	6.221	9.066	72.55	250	0.40%	0.770	38.993	29.9	76.8
202	201	0.105	9.381	3.545	33.256	0.339	0.000	0.080	0.419	32.746	66.003	88.46	375	0.35%	0.945	107.755	41.8	38.7
201	109	0.000	9.381	3.545	33.256	0.000	0.000	0.080	0.080	32.826	66.083	96.00	375	0.41%	1.030	117.477	51.4	43.7
109	107	0.000	9.381	3.545	33.256	0.000	0.000	0.080	0.080	32.906	66.163	96.00	375	0.41%	1.033	117.773	51.6	43.8
107	105	0.000	9.381	3.545	33.256	0.000	0.000	0.080	0.080	32.986	66.243	120.00	375	0.41%	1.032	117.714	51.5	43.7
105	103	0.000	9.381	3.545	33.256	0.000	0.000	0.080	0.080	33.066	66.323	57.77	375	0.42%	1.034	117.895	51.6	43.7
103	102	0.000	9.381	3.545	33.256	0.000	0.000	0.080	0.080	33.146	66.403	3.00	375	2.07%	2.306	262.951	196.5	74.7
412	408	0.029	0.029	3.800	0.111	0.067	0.000	0.080	0.147	0.147	0.258	53.52	200	0.40%	0.577	18.721	18.5	98.6
E1	415	4.688	4.688	3.766	17.655	15.120	0.000	0.000	15.120	15.120	32.775	570.00	250	3.00%	2.121	107.454	74.7	69.5
415	408	0.000	4.688	3.766	17.655	0.000	0.000	0.080	0.080	15.200	32.855	80.52	250	0.40%	0.669	33.899	1.0	3.1
408	407	0.022	4.739	3.763	17.833	0.050	0.000	0.080	0.130	15.478	33.310	40.49	250	0.50%	0.748	37.892	4.6	12.1
407	406	0.896	5.634	3.712	20.912	2.064	0.000	0.080	2.144	17.621	38.534	117.97	250	0.50%	0.749	37.969	-0.6	0.0
406	405	0.120	5.755	3.705	21.322	0.277	0.000	0.080	0.357	17.978	39.300	112.17	250	0.50%	0.750	38.025	-1.3	0.0
417	416	0.785	0.785	3.800	2.983	1.809	0.000	0.080	1.889	1.889	4.872	73.55	200	0.92%	1.012	32.828	28.0	85.2
416	405	0.123	0.908	3.800	3.450	0.283	0.000	0.080	0.363	2.252	5.701	65.47	200	0.54%	0.774	25.089	19.4	77.3
414	413	0.384	0.384	3.800	1.459	0.885	0.000	0.080	0.965	0.965	2.424	73.55	200	0.40%	0.577	18.704	16.3	87.0
413	412	0.060	0.444	3.800	1.686	0.137	0.000	0.080	0.217	1.182	2.868	65.47	200	0.40%	0.579	18.766	15.9	84.7
412	411	0.100	0.543	3.800	2.064	0.230	0.000	0.080	0.310	1.492	3.556	113.37	200	0.40%	0.579	18.769	15.2	81.1
411	410	0.156	0.699	3.800	2.655	0.358	0.000	0.080	0.438	1.930	4.585	121.92	200	0.40%	0.578	18.757	14.2	75.6
410	409	0.000	0.699	3.800	2.655	0.000	0.000	0.080	0.080	2.010	4.665	9.63	200	0.41%	0.587	19.042	14.4	75.5
409	405	0.083	0.781	3.800	2.969	0.190	0.000	0.080	0.270	2.280	5.250	86.46	200	0.40%	0.577	18.713	13.5	71.9
405	404	0.022	7.466	3.622	27.044	0.050	0.000	0.080	0.130	22.641	49.684	64.92	300	0.35%	0.706	51.512	1.8	3.5
404	403	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	22.721	49.764	91.44	375	0.24%	0.682	77.756	28.0	36.0
403	402	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	22.801	49.844	91.44	375	0.24%	0.684	77.933	28.1	36.0
402	401	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	22.881	49.924	91.66	375	0.24%	0.681	77.663	27.7	35.7
401	108	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	22.961	50.004	100.90	375	0.24%	0.681	77.634	27.6	35.6
108	106	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	23.041	50.084	96.00	375	0.24%	0.685	78.097	28.0	35.9
106	104	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	23.121	50.164	120.00	375	0.24%	0.686	78.197	28.0	35.8
104	102	0.000	7.466	3.622	27.044	0.000	0.000	0.080	0.080	23.201	50.244	57.77	375	0.25%	0.689	78.593	28.3	36.1
102	101 Lagoon	0.000	16.846	3.329	56.084	0.000	0.000	0.080	0.080	56.427	112.511	74.77	525	0.12%	0.685	153.042	40.5	26.5
									160.956									
D3	D2	1.458	1.458	3.800	5.542	3.360	0.000	0.000	3.360	3.360	8.902	800.000	200	0.40%	0.667	21.640	12.7	58.9
D2	D1	0.972	2.431	3.800	9.236	2.240	0.000	0.000	2.240	5.600	14.836	440.000	200	0.40%	0.667	21.640	6.8	31.4
D4	D1	5.226	5.226	3.734	19.515	12.040	0.000	0.000	12.040	12.040	31.555	600.000	250	1.00%	1.224	62.039	30.5	49.1
D1	LS2	0.851	32.083	3.066	98.382	1.960	0.000	0.000	1.960	73.920	172.302	50.000	525	0.22%	0.942	210.439	38.1	18.1
J4	J3	7.899	7.899	3.604	28.467	18.200	0.000	0.000	18.200	18.200	46.667	800	300	0.32%	0.782	57.067	10.4	18.2
J3	J1	2.917	10.816	3.495	37.802	6.720	0.000	0.000	6.720	24.920	62.722	260.000	375	0.18%	0.681	77.603	14.9	19.2
LS3	J2	3.524	3.524	3.800	13.392	8.120	0.000	0.000	8.120	8.120	21.512							

Table 4-3
Ultimate Sanitary Sewer System

From MH	To MH	Design Flows										Pipe Data					Pipe Capacity	
		Total DWF (L/s)	Accum DWF (L/s)	Harmon's Peaking Factor	Peak DWF (L/s)	General I/I (L/s)	Fnd Drain I/I (L/s)	Sag MH (L/s)	Total I/I (L/s)	Accum I/I (L/s)	Accum WWF (L/s)	Length	Diameter	Slope	Velocity	Capacity	Spare Capacity (L/s)	Spare Capacity (%)
												Estimated						
J2	J1A	4.375	7.899	3.604	28.467	10.080	0.000	0.000	10.080	18.200	46.667	500	375	0.15%	0.621	70.841	24.2	34.1
J1A	J1	4.861	12.760	3.435	43.829	11.200	0.000	0.000	11.200	29.400	73.229	300	375	0.30%	0.879	100.184	27.0	26.9
J1	D1	0.000	23.576	3.195	75.322	0.000	0.000	0.000	0.000	54.320	129.642	470	450	0.28%	0.959	157.387	27.7	17.6



the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING SANITARY SEWER SYSTEM

LEGEND:

STUDY AREA BOUNDARY
TOWN BOUNDARY
EXISTING LIFT STATION

PIPE SIZES:

EXISTING 200mm
EXISTING 250mm
EXISTING 300mm
EXISTING 375mm
EXISTING 450mm
EXISTING 200mm FORCEMAIN

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 4.1

Associated Engineering

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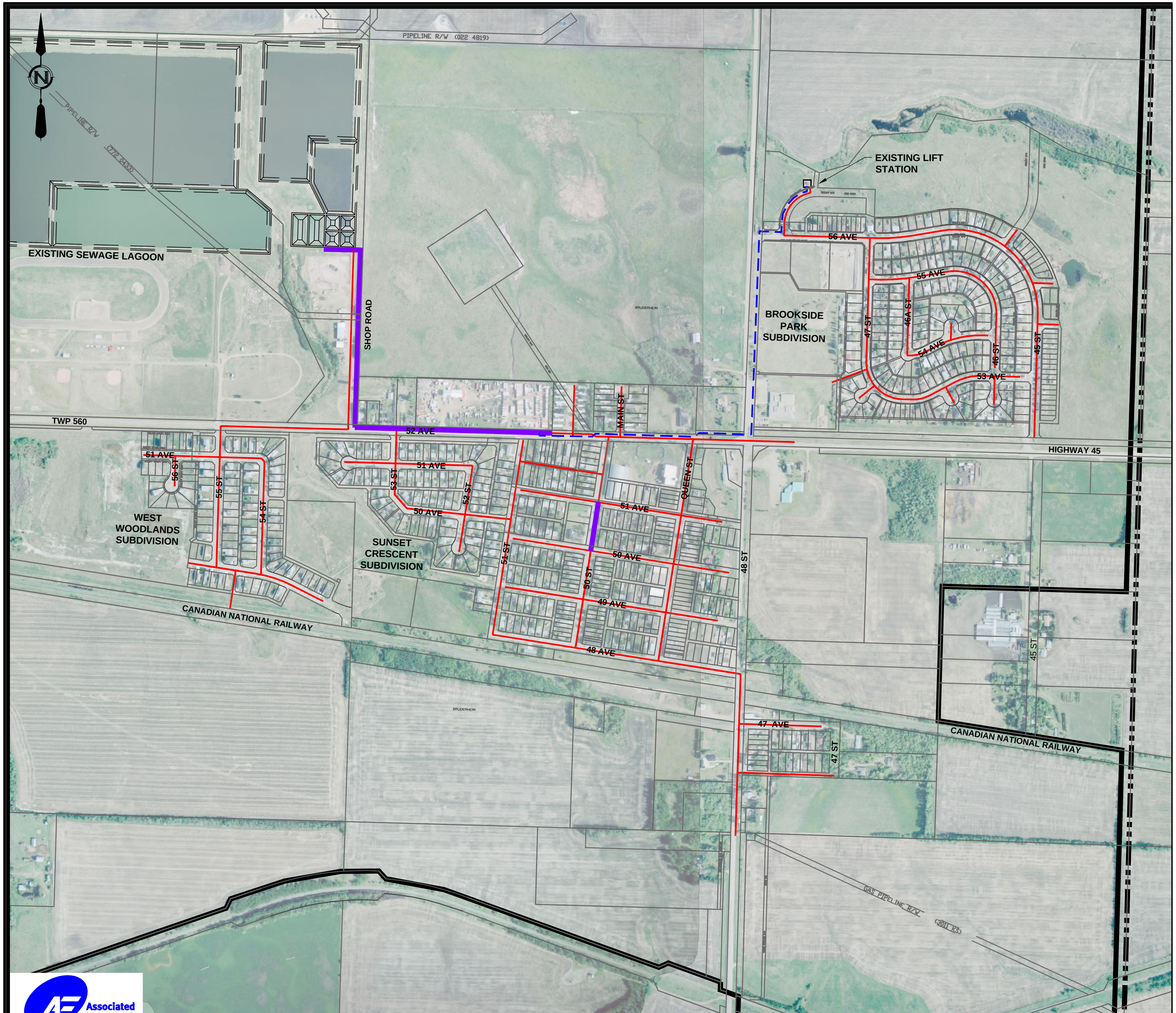
DATE: 12/1/2015, Kevin Grandish



the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING SANITARY SEWER SYSTEM HYDRAULIC ASSESMENT

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING SANITARY SEWER
- EXISTING 200mm FORCEMAIN
- PIPES WITH LESS THAN 20% REMAINING CAPACITY
- SURCHARGED PIPES (ZERO REMAINING CAPACITY)
- EXISTING LIFT STATION

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 4.2

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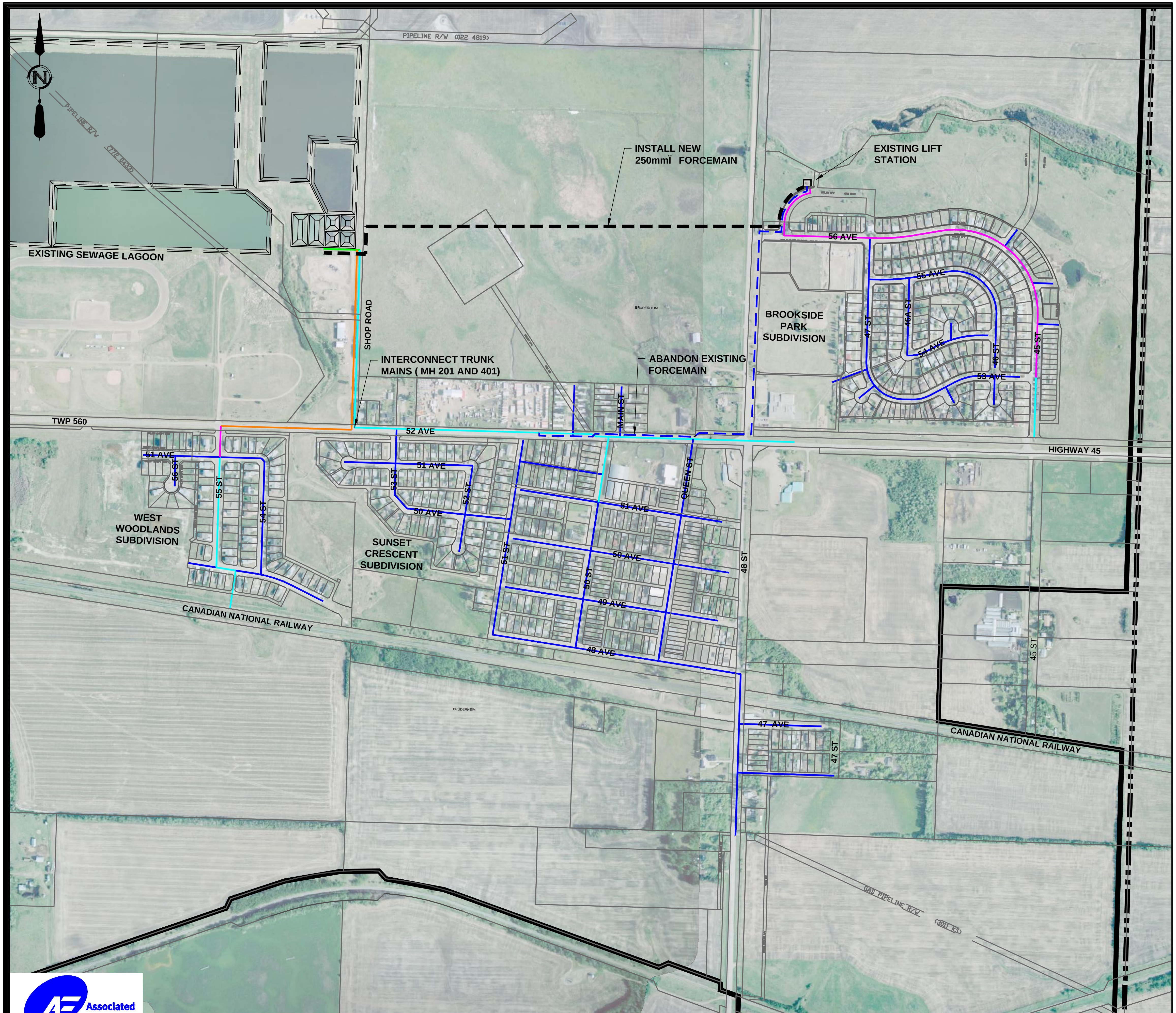
DATE: 12/1/2015, Kevin Grandish



P:\20133816\00_Master_Services_P\Working_Dwgs\100_Civil\Figure 4.3.dwg
DATE: 12/1/2015, Kevin Grandish

the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING SANITARY SEWER SYSTEM WITH UPGRADES

LEGEND:

STUDY AREA BOUNDARY
TOWN BOUNDARY
EXISTING LIFT STATION

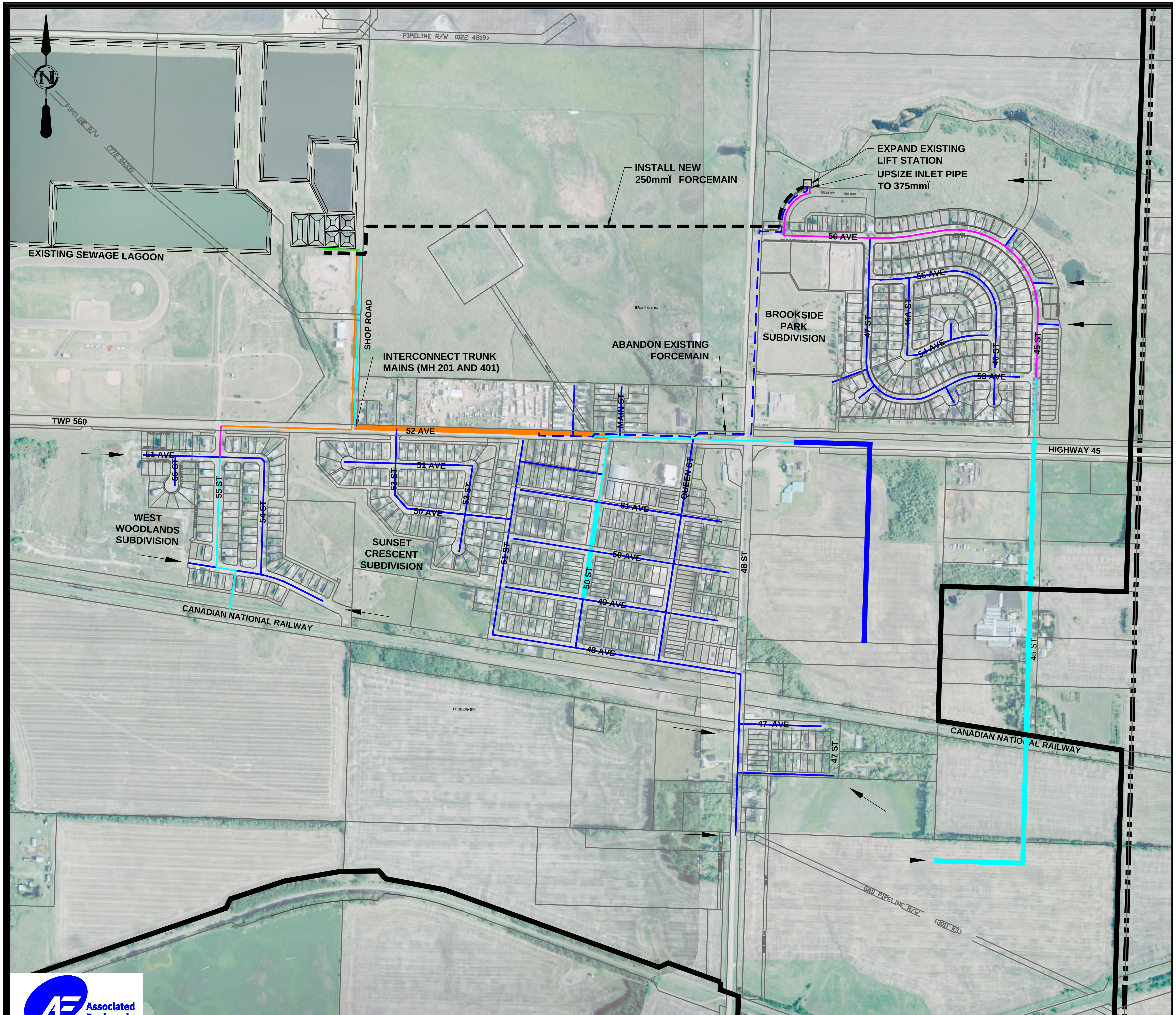
PIPE SIZES:

EXISTING 200mm
EXISTING 250mm
EXISTING 300mm
EXISTING 375mm
EXISTING 450mm
EXISTING 200mm FORCEMAIN
PROPOSED FORCEMAIN

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 4.3



the town of Bruderheim Alberta

MASTER SERVICES PLAN

PROPOSED SANITARY SEWER SYSTEM - PHASE 1

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING LIFT STATION

PIPE SIZES:

- EXISTING 200mm
- EXISTING 250mm
- EXISTING 300mm
- EXISTING 375mm
- EXISTING 450mm
- EXISTING 200mm FORCEMAIN
- PROPOSED 200mm
- PROPOSED 250mm
- PROPOSED 300mm
- PROPOSED 375mm
- PROPOSED 450mm
- PROPOSED FORCEMAIN

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 4.4

Associated Engineering

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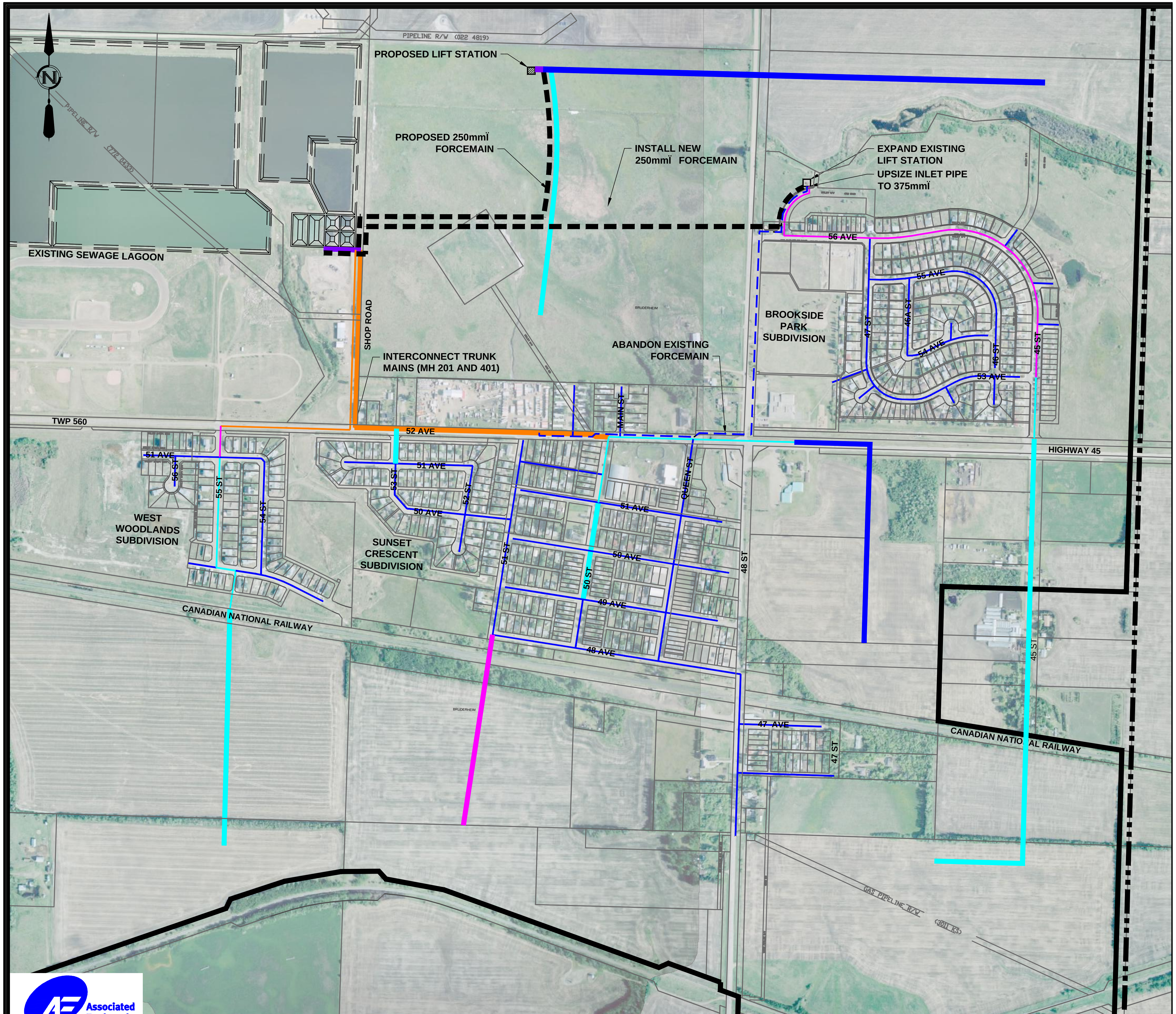
DATE: 12/1/2015, Kevin Grandish



the town of Bruderheim Alberta

MASTER SERVICES PLAN

PROPOSED SANITARY SEWER SYSTEM - PHASE 2

LEGEND:

STUDY AREA BOUNDARY
TOWN BOUNDARY
EXISTING LIFT STATION
PROPOSED LIFT STATION

PIPE SIZES:

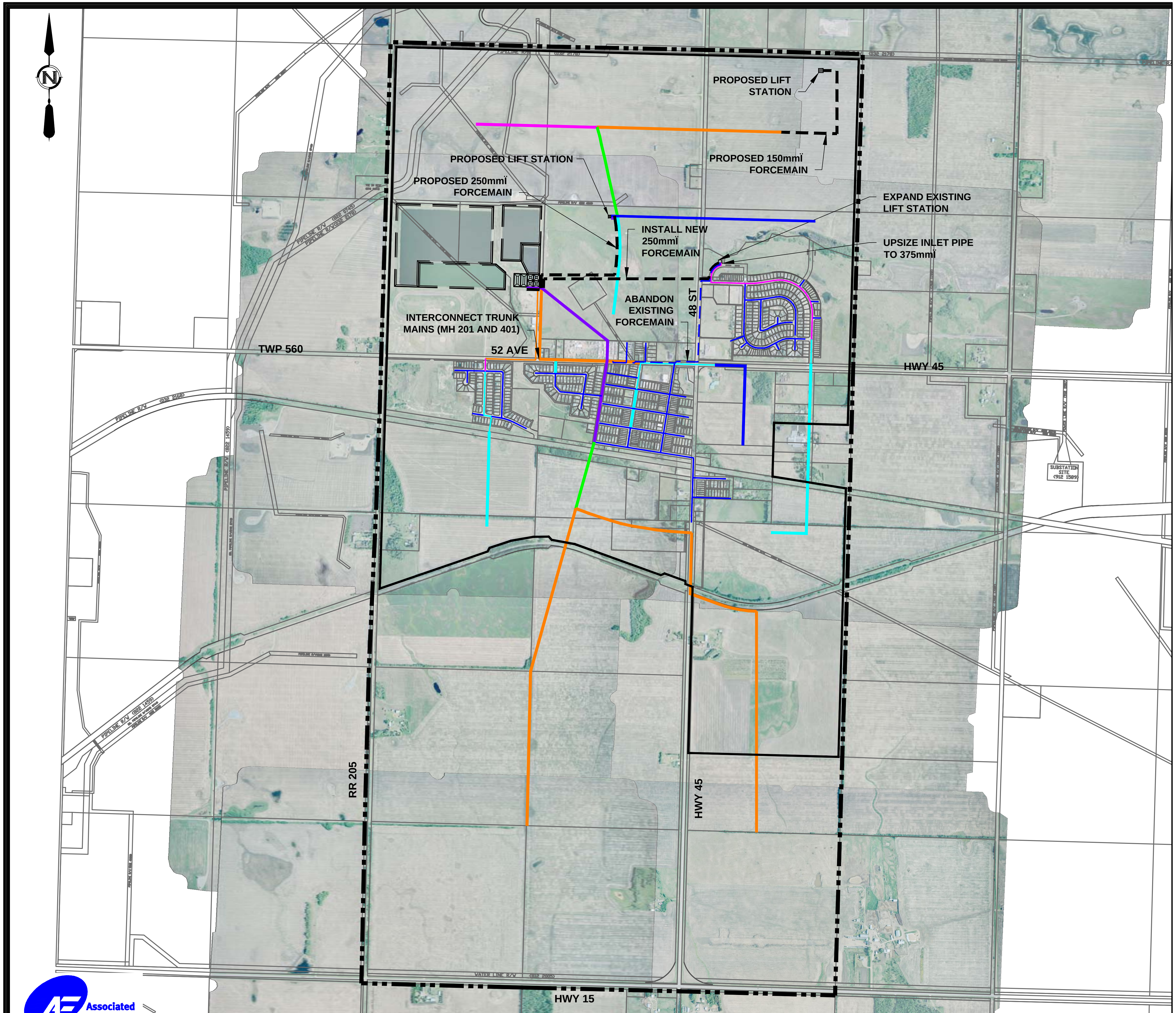
EXISTING 200mm
EXISTING 250mm
EXISTING 300mm
EXISTING 375mm
EXISTING 450mm
EXISTING 200mm FORCEMAIN
PROPOSED 200mm
PROPOSED 250mm
PROPOSED 300mm
PROPOSED 375mm
PROPOSED 450mm
PROPOSED 525mm
PROPOSED FORCEMAIN

SCALE : 1:8,000

DECEMBER, 2015

FIGURE 4.5

P:\20133816\00_Master_Services_P\Working_Dwgs\100_Civil\Figure 4.5.dwg
DATE: 12/1/2015, Kevin Grandish



Associated Engineering

P:\20133816\00_Master_Services_P\Working_Dwgs\100_Civil\Figure 4.6.dwg
DATE: 12/1/2015, Kevin Grandish

the town of Bruderheim Alberta

MASTER SERVICES PLAN

PROPOSED SANITARY SEWER SYSTEM - PHASE 3 (ULTIMATE)

LEGEND:

STUDY AREA BOUNDARY
TOWN BOUNDARY
EXISTING LIFT STATION
PROPOSED LIFT STATION

PIPE SIZES:

EXISTING 200mm
EXISTING 250mm
EXISTING 300mm
EXISTING 375mm
EXISTING 450mm
EXISTING 200mm FORCEMAIN
PROPOSED 200mm
PROPOSED 250mm
PROPOSED 300mm
PROPOSED 375mm
PROPOSED 450mm
PROPOSED 525mm
PROPOSED FORCEMAIN

SCALE : 1:20,000

DECEMBER, 2015

FIGURE 4.6

5 Storm Drainage System

5.1 EXISTING FACILITIES

The Town of Bruderheim is located just north of the intersection of Highway 15 and Highway 45, approximately 48 km northeast of Edmonton. The general direction of drainage in the area is to the north towards the Beaverhill Creek which eventually discharge to the Fort Saskatchewan River.

The Town of Bruderheim is servicing through a combination of surface drainage and underground pipes. Two Unnamed Creeks and Spring Creek, branches of a tributary of the Beaverhill Creek, are utilized in the storm drainage, along with a series of drainage culverts, culvert/bridge structures and connecting ditches. The Town has a formal stormwater management facility, a dry pond, located in the west side of the Town between the West Woodland Subdivision and Sunset Crescent Subdivision.

The Town´s drainage can be divided into five major drainage basins:
- Spring Creek.
- Central Unnamed Creek.
- East Unnamed Creek.
- West Boundary Creek.
- North Boundary Creek.

These basins are described further in the following sections.

Figure 5.1 shows the existing storm sewers and the primary basins in the Town of Bruderheim, and **Figure 5.2** provides a more detailed view of the existing major system.

Spring Creek Basin

Spring Creek drains through the west side of the Town between West Woodland and Sunset Subdivisions, and has a total drainage area of approximately 536 ha. The basin includes:

- Approximately 75 ha of developed area (mainly residential and utility land use) and approximately 48 ha of undeveloped area within the Town boundary.
- Approximately 413 ha of agricultural/undeveloped area outside of the Town boundary.
- A Stormwater management facility (dry pond) that provides water quality and quantity control to the West Woodland Subdivision and which discharges to Spring Creek. Flows from the dry pond are controlled by a 300 mm concrete pipe before discharging to Spring Creek. The pond has an approximately footprint area of 2.7 ha (based on survey data) and an average pond of depth of approximately 2.9 m. The estimated maximum storage capacity provided by the pond is approximately 49,500 m^3.
- Storm sewers that collect runoff from the West Woodland subdivision.
- Two catchbasins and catchbasin leads draining runoff from the Sunset Crescent subdivision.

- 2 -1000 mm diameter and 2 – 750 mm diameter corrugated steel pipe (CSP) culverts.
- A man-made channel of Spring Creek running along the east of the existing dry pond.
- A man-made channel section of Spring Creek running across the sewage treatment facility.
- An identified wetland, approximately 2.9 ha footprint area, located south of the railway (outside of the Town boundary).

Appendix B shows typical survey cross-section of the man-made channels of Spring Creek.

Central Unnamed Creek Basin

The Central Unnamed Creek drains through the main downtown area and has a total drainage area of approximately 622 ha. The Central Unnamed Creek basin includes the followings:

- Approximately 38 ha of developed area (mix of residential, institutional, commercial and industrial land uses), and approximately 171 ha of agricultural/undeveloped area within the Town boundary.
- Approximately 413 ha of agricultural/undeveloped area outside the Town boundary.
- Storm sewers collecting runoff from the main downtown area.
- Bridge File 00154 (Alberta Transportation numbering system) consist of a single span 4.9 m type “HC” girder bridge on a treated timber sub-structure located approximately 65 m west of the intersection of 52 Avenue and Highway 45.
- Creek culverts: 2 -1350 mm diameter CSP culverts.

Appendix B shows Creek culverts details of the Central Unnamed Creek.

East Unnamed Creek Basin

The East Unnamed Creek drains through the north side of the Town, specifically, north of the Brookside Park Subdivision and has a total drainage area of approximately 1358 ha. The East Unnamed Creek basis includes:

- Approximately 47 ha of developed area (mainly residential), and approximately 88 ha of agricultural/undeveloped area within the Town boundary.
- Approximately 1223 ha of agricultural/undeveloped area outside the Town boundary.
- Storm sewers collecting runoff from the Brookside Park Subdivision.
- 2 – 850 mm CSP culverts
- A man-made section of the Creek extending west from the downstream end of the 2 - 850 mm diameter CSP culverts to the confluence with Central Unnamed Creek. **Appendix B** shows a typical survey cross-section of the East Unnamed Creek section, located north of the Brookside Park subdivision, and the man-made channel west of the crossings.

West Boundary Creek Basin

The West Boundary Creek Basin is mainly undeveloped and has a total drainage area of approximately 4641 ha. This unnamed stream course drains through two culverts (1 - 900 mm diameter × 10 m length and 1 – 800 mm diameter × 10 m length CSP culverts), located under Range Road 205, and then east through a man-made channel located north of the sewage treatment facility.

The West Boundary Creek Basin connects to the Central and East Unnamed Creek Basins, as well as Spring Creek Basin, just north of the existing sewage treatment facility. From there, Spring and Unnamed Creek drain north through a man-made drainage channel which eventually discharges to the Beaverhill Creek.

A typical cross-section of the West Boundary Creek man-made channel (taken from the "Lagoon Discharge Channel Grading" record drawings completed by Associated Engineering in 2012) is shown in **Appendix B**.

North Boundary Creek Basin

The North Boundary Creek Basin is mainly undeveloped and has a total drainage area of approximately 101 ha. This basin includes:

- A man-made section north of the sewage treatment facility which eventually discharge to the Beaverhill Creek. **Appendix B** shows a typical cross-section of the man-made channel taken from the "Lagoon Discharge Channel Grading" record drawings completed by Associated Engineering in 2012.
- 2 – 1200 mm × 13 m length CSP culverts located under a field access.
- 2 – 900 mm × 8 m length CSP culverts located under an access road to an oil/gas pad.
- 1 – 1,000 mm x 14 m length CSP culvert:

5.1.1 Previous Stormwater Master Plans

The Town of Bruderheim Infrastructure Plan completed by Tritek Engineering Consultant Ltd. in 1988 was reviewed by Associated Engineering to gain an understanding of past flooding issues, concerns and developments within the Town, as well as any recommendations for future developments. The following is a brief summary of the report which is relevant to the existing drainage system.

- The report includes an assessment of the existing stormwater management to the year 2008.
- A number of ponding problems were noted in the Brookside Park Subdivision and the Main Town Area.
- No known problems within the West Woodland Subdivision.
- Future developments within Sec. 33-55-20-4 and other undeveloped areas require limiting the post-development runoff rate to pre-development rates by:
  - providing storm ponds with control structures,
  - maintaining existing drainage courses as much as possible,
  - maximizing the use of surface drainage.

5.2 EXISTING SYSTEM ASSESSMENT

The existing storm sewer (minor) drainage system was assessed using the 1:5 year event which is consistent with the Town of Bruderheim's Engineering Servicing Standards for minor drainage systems. The 1:100 year storm analysis performed to the minor system only provides a test of the system for a severe storm event.

The surface (major) system which consists of drainage culverts, ditches and overland flow paths was assessed using the 1:100 year storm event.

The PCSWMM model was simulated for the 1:5 year and 1:100 year, 4 hour storm event as described in Section 2.4.

Figure 5.3 and **Figure 5.4** show the modeled surcharge levels and flow loadings of the existing system for the 1:5 year and 1:100 year storm events respectively.

The surcharge levels, represented by dots, show the relative distance from ground surface to peak water level during the storm event simulation. Red dots indicate locations where the hydraulic grade line reaches ground surface. At these locations water would probably spill out of the manholes or ditches. The numbers adjacent to these dots show the depth of ponding or spill in meters. Note that model results for a major storm event are only approximate as the actual volume and locations of ponding depend on the inlet capacity and details of the major drainage system that are not explicitly modeled.

The flow loading is defined as the ratio of peak flow to pipe capacity (Qp/Qcap). A value of 1 means that the pipe is operating at its theoretical pipefull capacity, and higher value indicates that the pipe is carrying more flow than it was designed to carry. Generally, the potential impact increase with higher peak flow loadings.

The results show that the existing storm sewers generally have capacity for the 1:5 year storm event with the exception of three portions of pipe system in the main downtown area and Brookside Park subdivision. At these locations, the pipe systems are surcharged in the 1:5 years storm, and surcharge levels reach ground surface.

A more detailed assessment of the model results are described below.

5.2.1 Spring Creek Basin

The majority of the developed areas within Spring Creek basin are residential. Runoff from the West Woodlands Subdivision drains through a series of storm sewers before discharging to the existing dry pond. Two catchbasins leads collecting runoff from the Sunset Crescent subdivision drains directly to Spring Creek.

A residential area from the south section of the main downtown area is handled through overland flow resulting in long runs of street drainage, up to 350 m long.

The Creek crossings and storm systems considered in the analysis include:

- Railway culvert crossings.
- 52nd Avenue culvert crossings.
- Man-made creek channel between the West Woodland and Sunset Crescent Subdivisions.
- Man-made creek channel north of 52nd Avenue, specifically within the sewage treatment facility.
- Stormwater Management Facility (dry pond)

The model results show that the overall system in this area performs well in the 1:5 year storm. The railway and 52nd Avenue culverts listed above perform well in the major storm events. The man-made creek channel between the West Woodland and Sunset Crescent subdivision seems to have adequate capacity to carry the design flow during a 1:100 year storm event.

According to the model results, the man-made creek channel draining across the sewage treatment facility will be overtopped in the 1:100 year storm event.

The dry pond (DP) which services runoff from the West Woodland Subdivision outlets through a 300 mm diameter concrete pipe to Spring Creek. Based on the results, the pond has enough capacity to store runoff from the West Woodland Subdivision. **Table 5.1** summarizes the pond performance for the 1:100 year, 4 hour storm events based on model results.

Table 5.1
Dry Pond (DP) Performance during the Storm Simulations

	Dry Pond - West Woodland Subdivision					
Storm	**Qp (m^3/s)**	**Storage Available (m^3)**	**Storage Used (m^3)**	**Storage Surplus/Deficit (m^3)**	**Depth In Pond (m)**	**Depth of Pond (m)**
1:100 year 4 hour Storm	1.656	27,000	6486	20,514	0.34	2.9

As shown in **Table 5.1**, in the 4 hour storm event, the dry pond fills to a level of 0.34 m which is approximately 2.56 m below the pond top of bank elevation.

5.2.2 Central Unnamed Creek Basin

The Central Unnamed Creek basin consists of a storm sewer system collecting runoff from the north section of the downtown area which eventually discharges to the Central Unnamed Creek. This area is a mix of residential, institutional, and commercial land uses.

The major Creek crossing and system considered in the analysis include:

- Railway culvert crossings.
- Highway 45 culvert crossing.
- 52nd Avenue bridge structure.

The model results shows that a localized Manhole MH502 (Junction J20 in the model), located on 51 Avenue (between 50 Street and 51 Street) is surcharging during the 1:5 year storm, however, the rest of the system performs well during the model simulation. Upgrades to the storm sewer from Manhole MH502 (J20) to Manhole MH503 (J22) will require upgrading. A model profile through this section is shown in **Figure 5.5**.

The Creek crossings noted above perform well in the 1:100 year storm event.

5.2.3 East Unnamed Creek Basin

The East Unnamed Creek basin consists of a series of storm sewer systems collecting runoff from the Brookside Park Subdivision. The majority of the developed areas within the East Unnamed Creek basin are mainly residential. The storm sewer discharges to the East Unnamed Creek on the north side of the 45 Street.

The Bruderheim School is located on the west end of the basin. Currently runoff from this area drains north through road ditches to the existing culvert crossings under 48 Street.

The Creek crossings and drainage system considered in the analysis include:

- 48th Street culvert crossings.
- Man-made creek channel extending west from the 48 Street culverts.

Based on the model results, the overall existing storm sewer systems seem to be adequate for the 1:5 year storm event with the exception of two localized areas on 47 Street and 56 Avenue. Surcharge levels at Manhole MH301 (Junction J26 in the model) and Manhole MH306 (Junction J33 in the model) are above ground surface for the 1:5 year storm event. Model profiles through these sections are shown in **Figure 5.6** and **Figure 5.7**.

The 48th Street culvert crossings consist of 2- 850 mm diameter CSP culverts. The model results show that the culverts' headwater levels are above the crown elevations for the 1:100 year storm; however, the headwater likely will not overtop the road grade during the storm event.

The model results also show that the man-made creek channel which extends west of the existing 48 Street culvert crossings overtop during both design storms (1:5 and 1:100 year storm events). The existing channel cross-section, is significantly shallow to carry the East Unnamed Creek flows. The flow in this Creek will likely overtop the channel banks and extend to the floodplain during a storm event. The model results are consistent with ponding issues identified by the Town personnel along the approximately 46 ha of undeveloped area west of 48 Street and north of 52 Avenue.

5.2.4 West Boundary Creek Basin

The Unnamed Creek draining through the West Boundary Basin collects drainage from a large undeveloped area located west of the Town boundary. This outside basin drains through two culverts (1-900 mm diameter and 1-800 mm diameter CSP culverts), located under 61 Street, and through a man-made ditch along the north side of the sewage treatment facility.

The model results show that the headwater levels of the culverts are above the culverts' crown elevations for the 1:100 year storm; however, the water levels likely will not overtop the road grade during the storm event.

The man-made ditch located north of the sewage treatment facility seems to be adequate to carry the design flow during the 1:100 year storm event.

5.2.5 North Boundary Creek Basin

Model results show that the 2–900 mm and 1,000 mm diameter CSP culverts located at the north Town boundary are undersized and would flow with 0.26 m and 0.16 m of surcharge respectively during the 1:100 storm event.

According to the model results and flow depths, the headwater would not overtop the road grade.

Due to low traffic on the access road, upgrades will likely not be required.

5.3 UPGRADES TO EXISTING SYSTEM

The proposed upgrades focus on the storm sewer system where the upgrades will provide the greatest benefit in terms of an increased level of service and reduction of ponding/flooding issues. The storm sewer (minor system) upgrades have been developed for the 1:5 year storm while the surface (major) system upgrades have been developed for the 1:100 year storm event based on the Town of Bruderheim Engineering Design Standards. These upgrades are shown in **Figure 5.8** and described below for each subdivision.

Figure 5.9, **Figure 5.10** and **Figure 5.11** show the modeled surcharge levels for the 1:5, 1:25 and 1:100 year storm events respectively with the proposed upgrades. These figures show that the upgrades will significantly reduce the risk of ponding/flooding by lowering the surcharge levels below ground surface.

Overall, the existing storm system of the Town performs well in the 1:5 year storm event; however, there are few localized areas of the Town that will benefit from upgrading to enhance the performance of the storm drainage system.

5.3.1 Sunset Crescent and West Woodland Subdivisions

One storm sewer upgrade (Upgrade SC1) is proposed for Sunset Crescent Subdivision. The upgrade is located on 50 Avenue, between 52 Street and 53 Street, and includes the installation of a new drop manhole and storm pipe under Spring Creek.

The purpose of this upgrade is to provide stormwater management for the Sunset Crescent subdivision by directing runoff towards the existing dry pond facility.

An upgrade (Upgrade WW1) is proposed for the West Woodland subdivision. The existing drainage culvert under 52 Avenue, specifically at the intersection between 52 Avenue and RR 205, is undersized and required to be upgraded.

5.3.2 Downtown Area

Two upgrades are proposed for the Town's downtown area and include the replacement of the existing storm sewer on 51 Avenue (Upgrade DA1), between 50 Street and 51 Street, as well as the construction of a new storm sewer system along 51 Street (Upgrade DA2).

The new storm system will intersect runoff from the south downtown area, which currently is draining overland, and will divert flows towards to a proposed stormwater management facility located approximately on the southeast quarter section of Sec. 56-20-4 (this upgrade will be further discussed in Section 5.3.4).

5.3.3 Brookside Park Subdivision

Four upgrades are proposed in the Brookside Park Subdivision that involve the following:

- Replacement of four existing storm pipes located along 45 Street and 47 Street (Upgrade BP1).
- Construction of a stormwater management facility (P1) on the northwest part of the subdivision (Upgrade BP2).
- Installation of a new storm sewer pipe along the north side of the subdivision to intersect flows from 45 Street to the proposed stormwater management facility (Upgrade BP4).
- Installation of a new storm sewer pipe along 45 Street that will divert flows from the future south residential/commercial area of Highway 45 towards the proposed pond (Upgrade BP3).

The Brookside Park subdivision is planned for expansion along the east and north area of the subdivision. Proposed upgrades will not only reduce the existing surcharge levels below ground but it will also provide additional capacity for future development of the area without surcharging to ground surface.

Currently, uncontrolled flows are being discharged directly to the East Unnamed Creek. The proposed stormwater management facility will provide water quality and quantity control (to a release rate of 3.9 l/s/ha) in order to avoid erosion and environmental impact to downstream water bodies.

5.3.4 Sec. 5-56-20-4 (Southwest and Southeast Quarter Section)

Four upgrades are proposed for this section of the Town. Upgrades include the following:

- Construction of a new stormwater management facility (P2), including storm sewer systems to provide drainage towards the pond (Upgrade FUT1)
- Re-alignment and cross-section improvement to the man-made East Unnamed Creek channel (Upgrade FUT2).
- Channelization of the Central Unnamed Creek towards the proposed stormwater management facility and installation of a culvert structure under the future arterial road (Upgrade FUT3).
- Cross-section improvements of the man-made Spring Creek channel (Upgrade FUT4).

This quarter section is currently undeveloped, but planning for residential development is part of the future land use of the Town of Bruderheim. For new developments, the Alberta Environment stormwater management guidelines recommend implementing water quantity control in the form of storm ponds and controlled release rates, to minimize erosion impacts on receiving water bodies.

The proposed stormwater management facility will also provide water quality and quantity control for the downtown area which currently is discharging uncontrolled through a 900 mm diameter outlet pipe to the Central Unnamed Creek.

Note that the recommended design values noted in the following sections were estimated based on the DEM contours data and should be verified during the design stage once detailed survey of the area is completed.

5.3.5 NW ¼ Sec. 33-55-20-4 – North of Railway

Three upgrades are proposed for the Sec. 55-20-4 Northwest quarter section. The upgrades include the construction of two stormwater management facilities to serve the west and east side of the quarter section (Upgrade FUT5 and FUT6), and the installation of storm sewer pipes along 45 Street, specifically, south of Highway 45, to provide drainage to the future residential/commercial developments.

5.3.6 W ½ Sec. 33-55-20-4 – Between the two Railways

Two upgrades are proposed for this section of the Town which has a total area of approximately 53.5 ha. Upgrades include the following:

- Construction of a new stormwater management facility (P5), including storm sewer systems to intersect runoff towards the proposed pond (Upgrade FUT7).
- Channelization of an outside Unnamed Creek towards the existing 2 – 1350 mm diameter CSP culverts located under the railway (Upgrade FUT8).

5.3.7 N ½ Sec. 32-55-20-4 – Between the two Railways

Two proposed upgrades are recommended for the northwest and northeast quarter sections (between the two railways). The existing sections are currently undeveloped but the future land use map notes that these areas to be used for commercial/industrial development.

As described in Section 4.1, the Town of Bruderheim Engineering Design standards states that for commercial, industrial, or higher density residential (apartment or multi-family site) developments, onsite storm water management is required.

The proposed stormwater management facilities (Upgrade FUT9 and FUT10) will provide storage for the 1:25 year storm event as described in the Town´s Standards at a release rate of 3.9 l/s/ha.

5.4 ULTIMATE STORM DRAINAGE SYSTEM

To aid with future development in the Town of Bruderheim, this Master Plan will address, in concept, the future storm water management requirements. This section will also provide an overall drainage concept plan to assist with the planning of future development.

This study includes approximately twelve quarter sections with a mix of residential, commercial and industrial future land uses.

As described in Section 4.1, the Town´s drainage is divided into four major drainage basins: Spring Creek, Central Unnamed Creek, East Unnamed Creek and the West Boundary Basins. The Central and East Unnamed Creek basins and the Spring Creek basin drain from the south, through the Town, to the man-made channel located north of the sewage treatment facility. The West Boundary basin drains from the west, through the north side of the Town, to the man-made channel (similar to the other basins).

Based on the available DEM data, the basins seem to have a good natural drainage system which will likely facilitate the intersection of surface runoff through storm sewer systems towards the proposed stormwater management facilities. A more reliable source of data, such as LIDAR, will be required during the future design of the facilities to confirm elevations, quarter sections topography and the availability of storm sewers installation.

A maximum outflow rate of 3.9 l/s/ha is proposed for pond design in the Town of Bruderheim based on the Regional Analysis. The ponds will be designed to store runoff for the 1:100 year storm event (residential areas), and the 1:25 year storm event (commercial/industrial areas).

It is important to note that the storage volumes that will be recommended in the following pond sizing in future developments are conceptual only. The size of each pond should be confirmed during the design stage when details of the pond design and the development concept are finalized.

5.4.1 Proposed Stormwater Management Plan

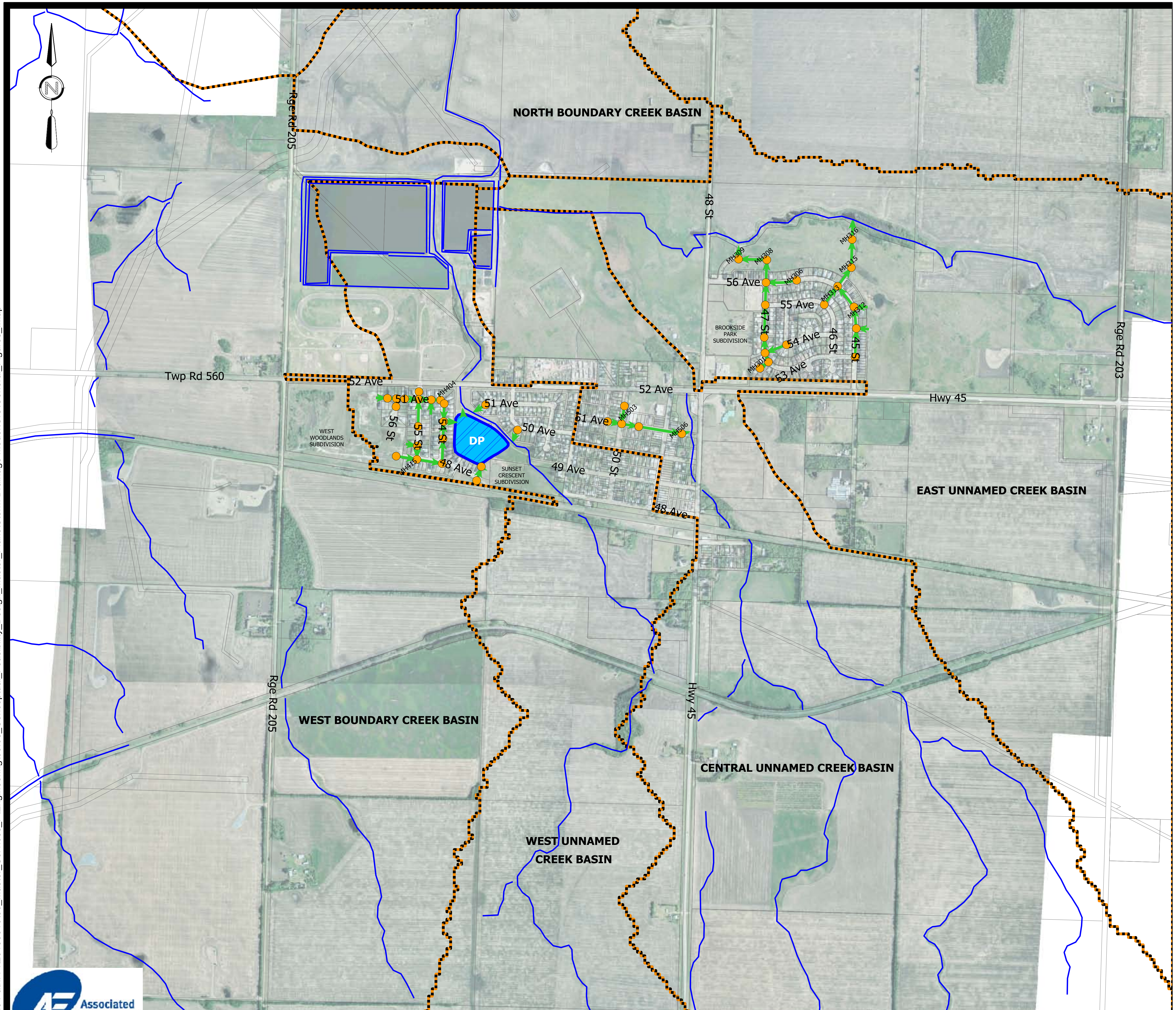
Figure 5.12 provides an overall view of the stormwater management concept plan for the future development area. The proposed concept plan was defined based on the followings:

- Stormwater Management guidelines described above to prevent flooding and erosion of downstream system and to protect the quality of water in the receiving streams.
- Existing topography and drainage systems.
- Preservation of existing wetlands and stream; whenever possible.

Appendix C summarizes the characteristics for the stormwater management facilities. **Appendix C** provides detailed calculations of the ponds sizes, storage volumes, and outfall rates. These are all subject to review in the design stage based on the design standards that apply at the time and based on the details of the servicing of those areas.

In general the stormwater management ponds will be discharging to the Spring and Unnamed Creeks in order to promote preservation of the existing drainage system.

The proposed stormwater management concept plan sets out the primary parameters that will guide future development. It is not mean to be prescriptive, and it is subject to further review in subsequent stages of the development process.



the town of Bruderheim Alberta

MASTER SERVICES PLAN

EXISTING STORM SEWERS
AND PRIMARY BASINS

LEGEND:

- EXISTING STORM MANHOLE
- EXISTING STORM PIPE
- DRY POND (DP)
- MAJOR DRAINAGE BASIN
- STREAM

SCALE: 1:15000

DECEMBER, 2016

FIGURE 5.1

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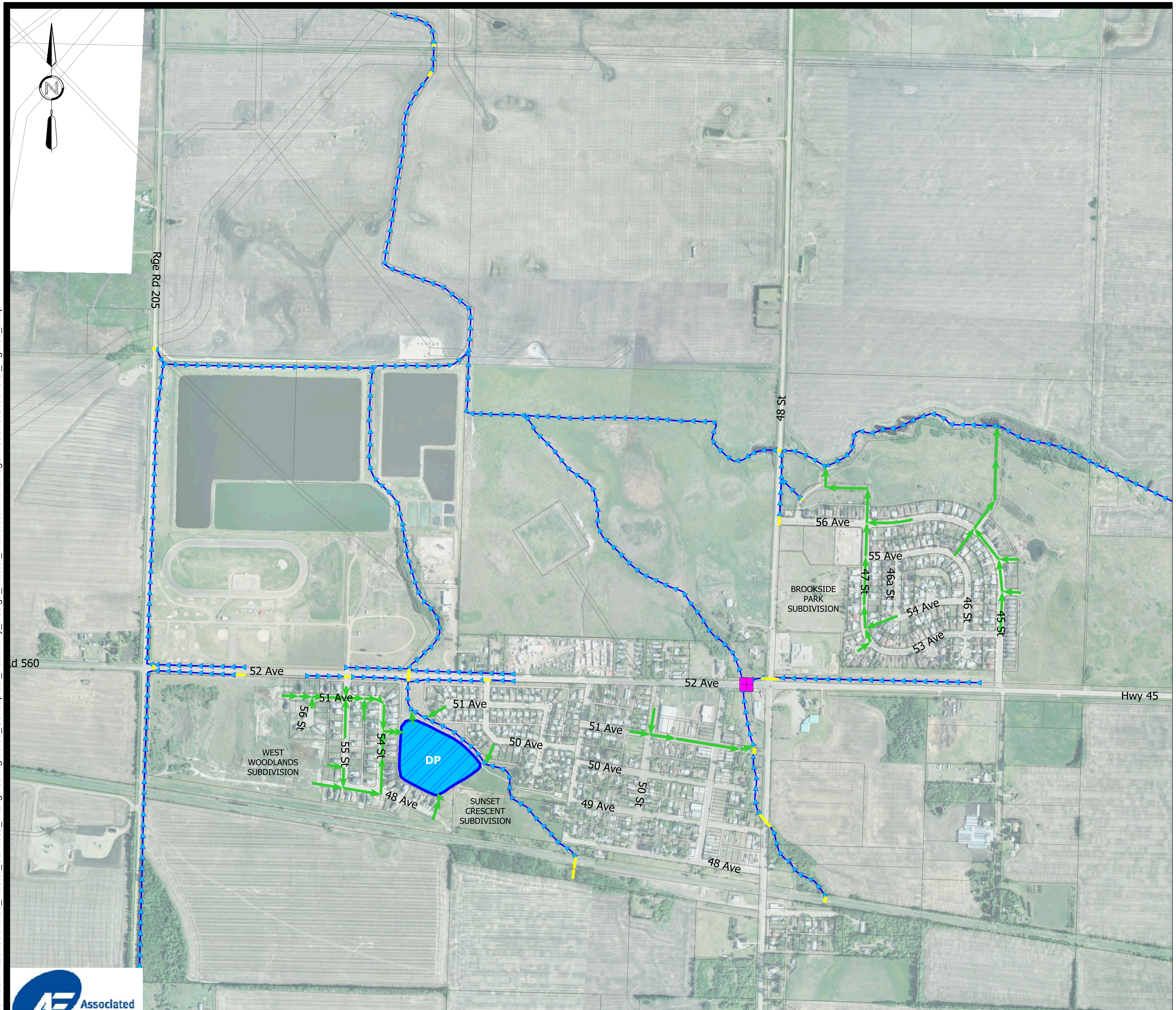
Associated Engineering



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the town of Bruderheim Alberta

MASTER SERVICES PLAN

DETAILED VIEW OF THE EXISTING MAJOR SYSTEM

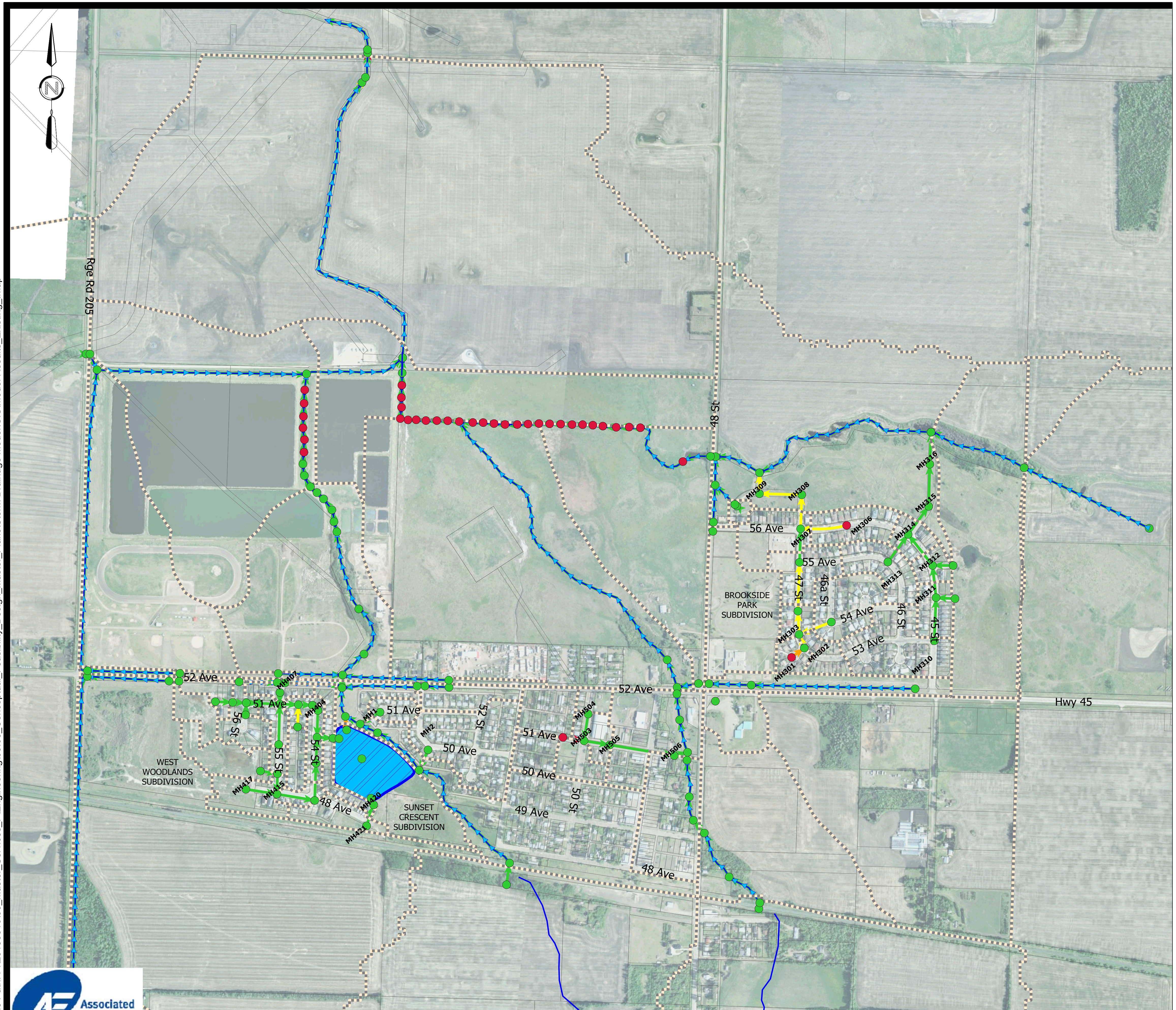
LEGEND:

- EXISTING STORM PIPE
- EXISTING CULVERT
- EXISTING BRIDGE
- DITCH/CREEK
- DRY POND (DP)

SCALE: 1:10000

DECEMBER, 2016

FIGURE 5.2



Associated Engineering

the town of Bruderheim Alberta

MASTER SERVICES PLAN

SIMULATED SURCHARGE LEVELS AND FLOW LOADING 1:5 YEAR STORM EVENT EXISTING CONDITIONS

LEGEND:

EXISTING DRY POND
CATCHMENT AREA
DITCH/NATURAL CHANNEL

SURCHARGE LEVEL:

ABOVE GROUND
BELOW GROUND

FLOW LOADING:

Qp/Qcap < 1
1 < Qp/Qcap < 1.5
1.5 < Qp/Qcap < 2
Qp/Qcap > 2

SCALE: 1:10000

DECEMBER, 2016

FIGURE 5.3

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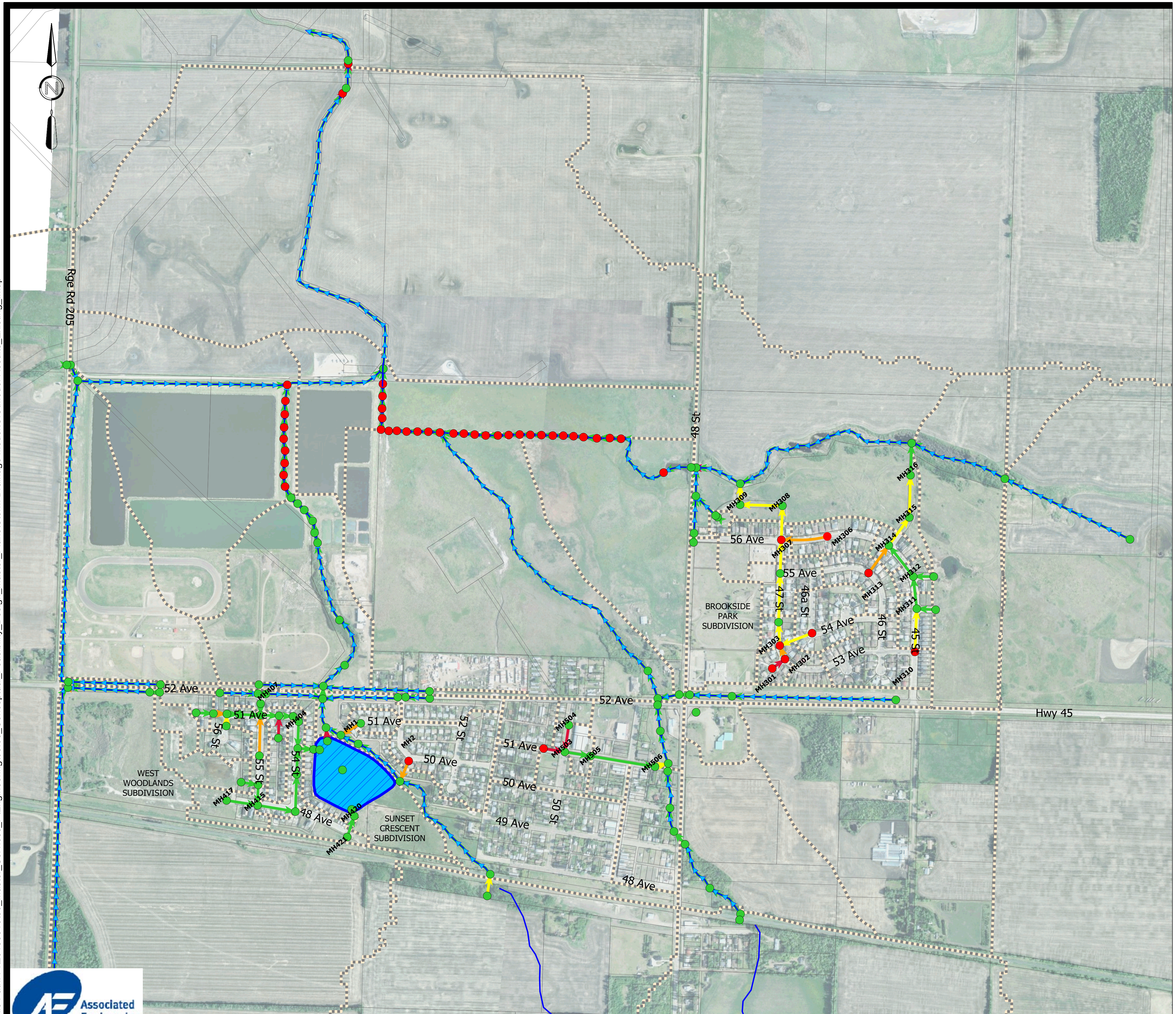

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the town of Bruderheim Alberta

MASTER SERVICES PLAN

SIMULATED SURCHARGE LEVELS AND FLOW LOADING 1:100 YEAR STORM EVENT EXISTING CONDITIONS

LEGEND:

EXISTING DRY POND
CATCHMENT AREA
DITCH/NATURAL CHANNEL

SURCHARGE LEVEL:
ABOVE GROUND
BELOW GROUND

FLOW LOADING:
Qp/Qcap < 1
1 < Qp/Qcap < 1.5
1.5 < Qp/Qcap < 2
Qp/Qcap > 2

SCALE: 1:10000

DECEMBER, 2016

FIGURE 5.4

Figure 5-5
Model Profile (1:5 year Storm) - Storm sewers on 51 Avenue

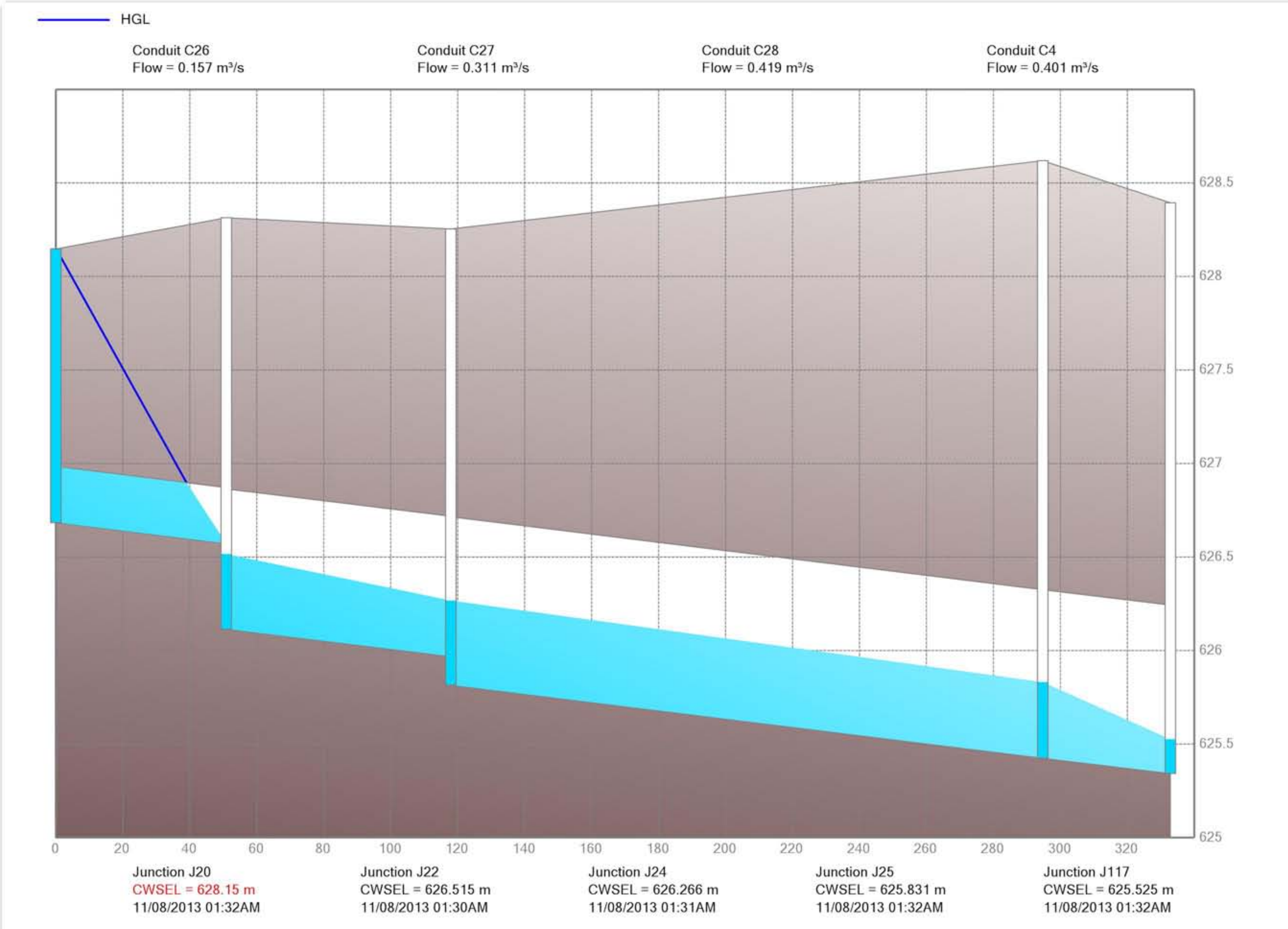


Figure 5-6

Model Profile (1:5 year Storm) - Storm sewers on 47 Street

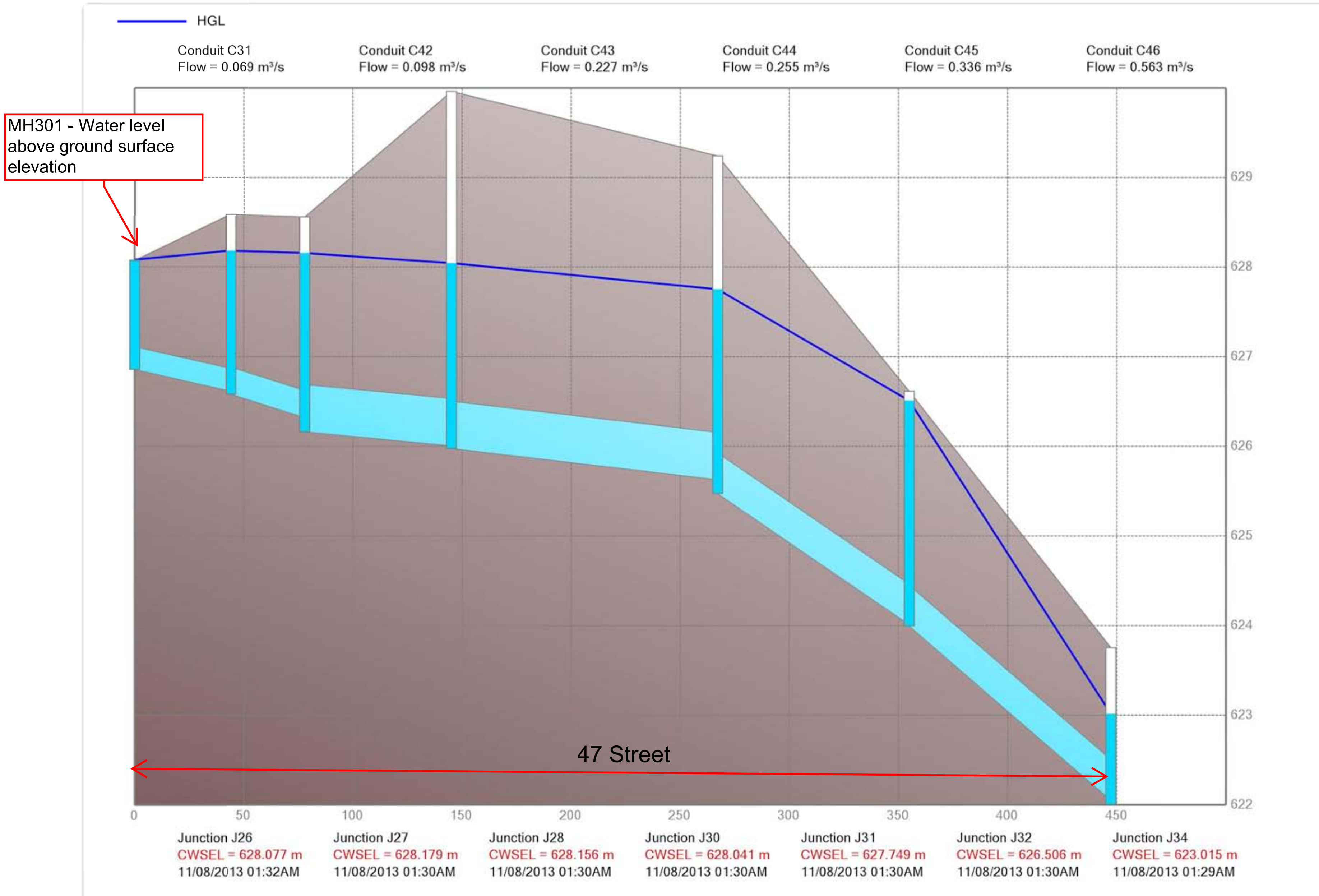
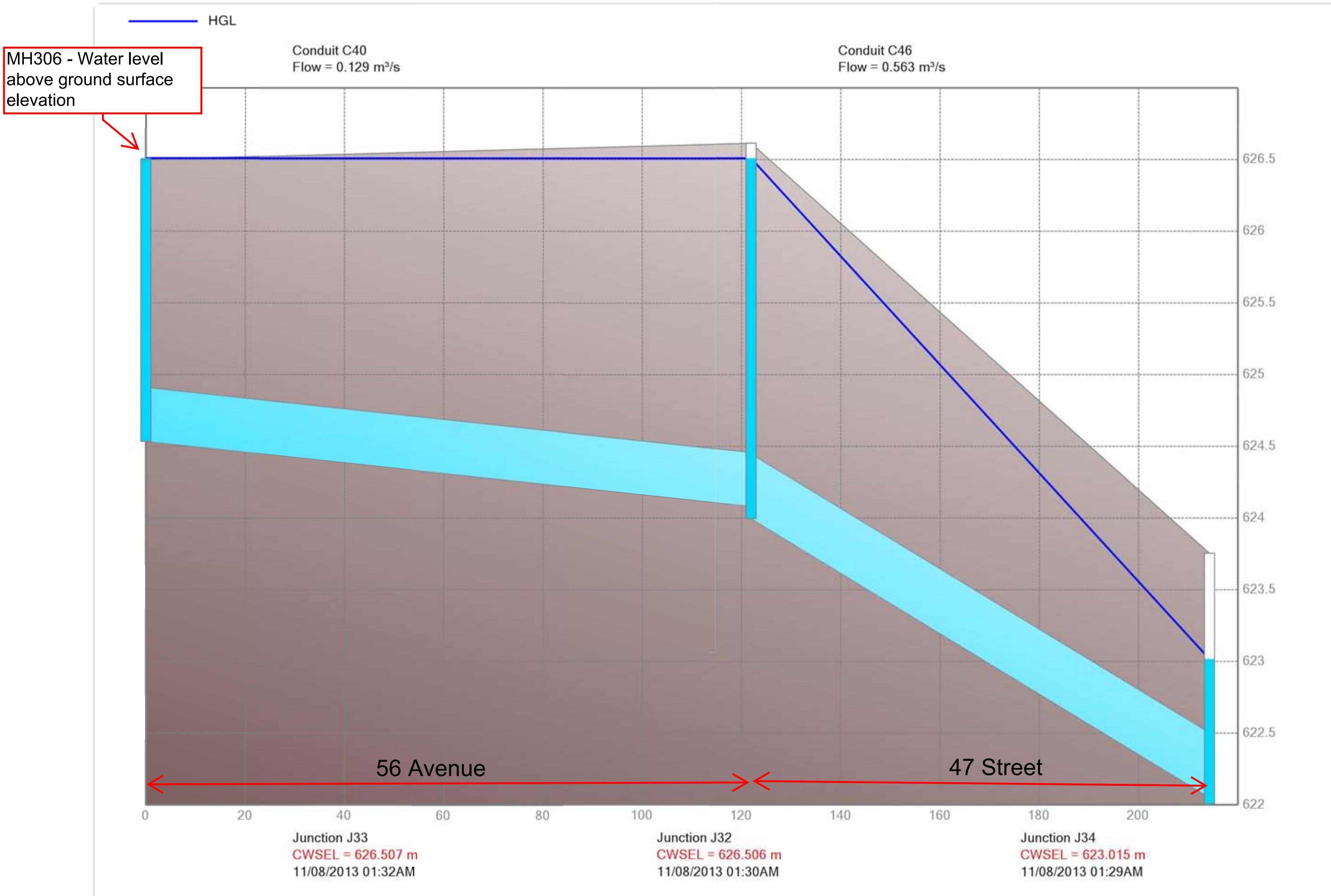
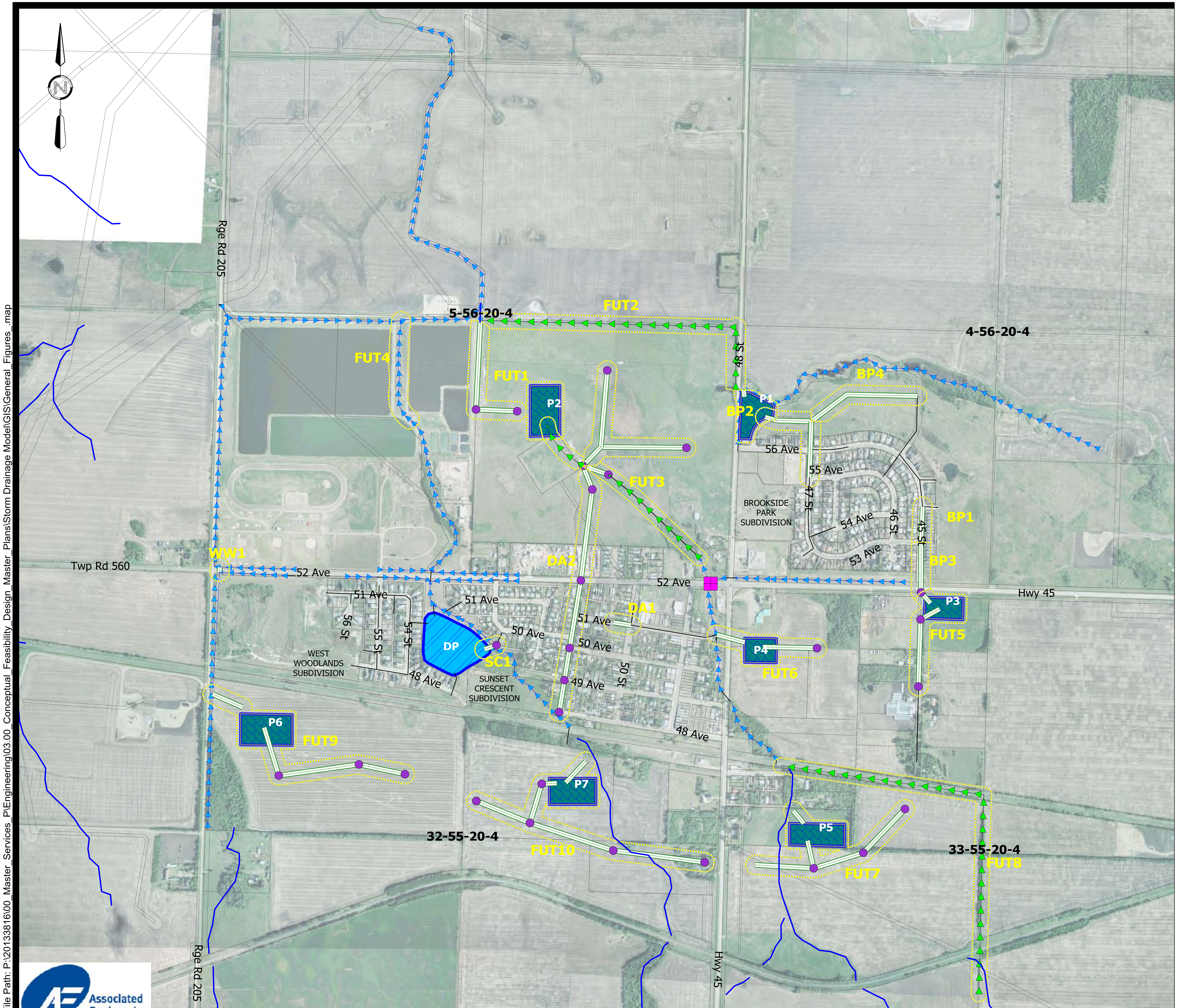


Figure 5-7

Model Profile (1:5 year Storm) - Storm sewers on 56 Avenue





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the town of Bruderheim Alberta

MASTER SERVICES PLAN

UPGRADES TO EXISTING SYSTEM

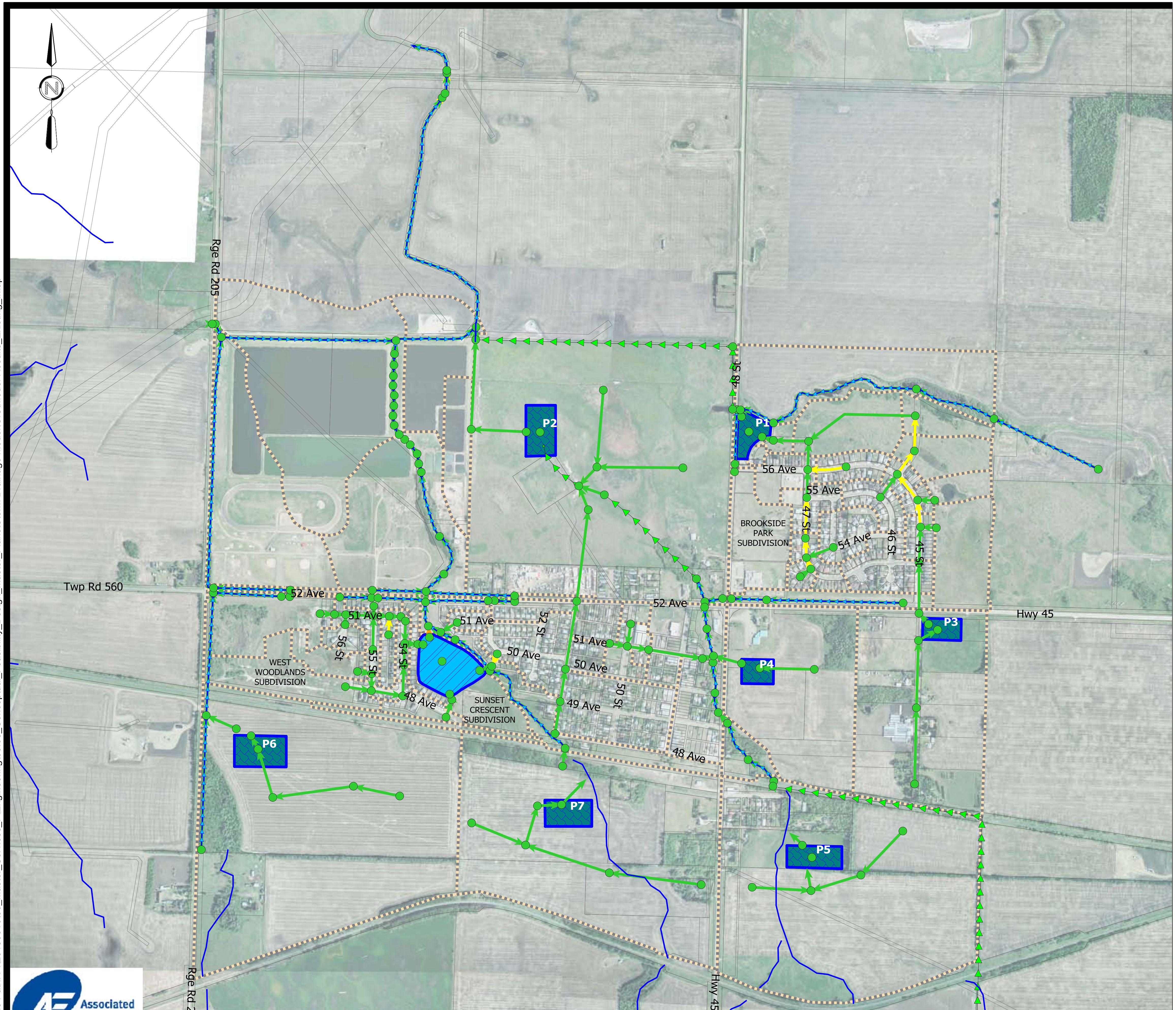
LEGEND:

- PROPOSED UPGRADE
- PROPOSED DITCH
- DITCH/CREEK
- PROPOSED PIPE
- PROPOSED MANHOLE
- EXISTING BRIDGE
- PROPOSED STORMWATER MANAGEMENT FACILITY
- DRY POND (DP)

SCALE: 1:12000

DECEMBER, 2016

FIGURE 5.8



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MASTER SERVICES PLAN

SIMULATED SURCHARGE LEVELS AND FLOW LOADING 1:5 YEAR STORM UPGRADES TO EXISTING CONDITIONS

LEGEND:

EXISTING DRY POND
PROPOSED STORMWATER MANAGEMENT FACILITY
PROPOSED DRAINAGE CHANNEL
DITCH/NATURAL CHANNEL
CATCHMENT AREA

SURCHARGE LEVEL:

ABOVE GROUND
BELOW GROUND

FLOW LOADING:

Qp/Qcap < 1
1 < Qp/Qcap < 1.5
1.5 < Qp/Qcap < 2
Qp/Qcap > 2

SCALE: 1:12000

DECEMBER, 2016

FIGURE 5.9

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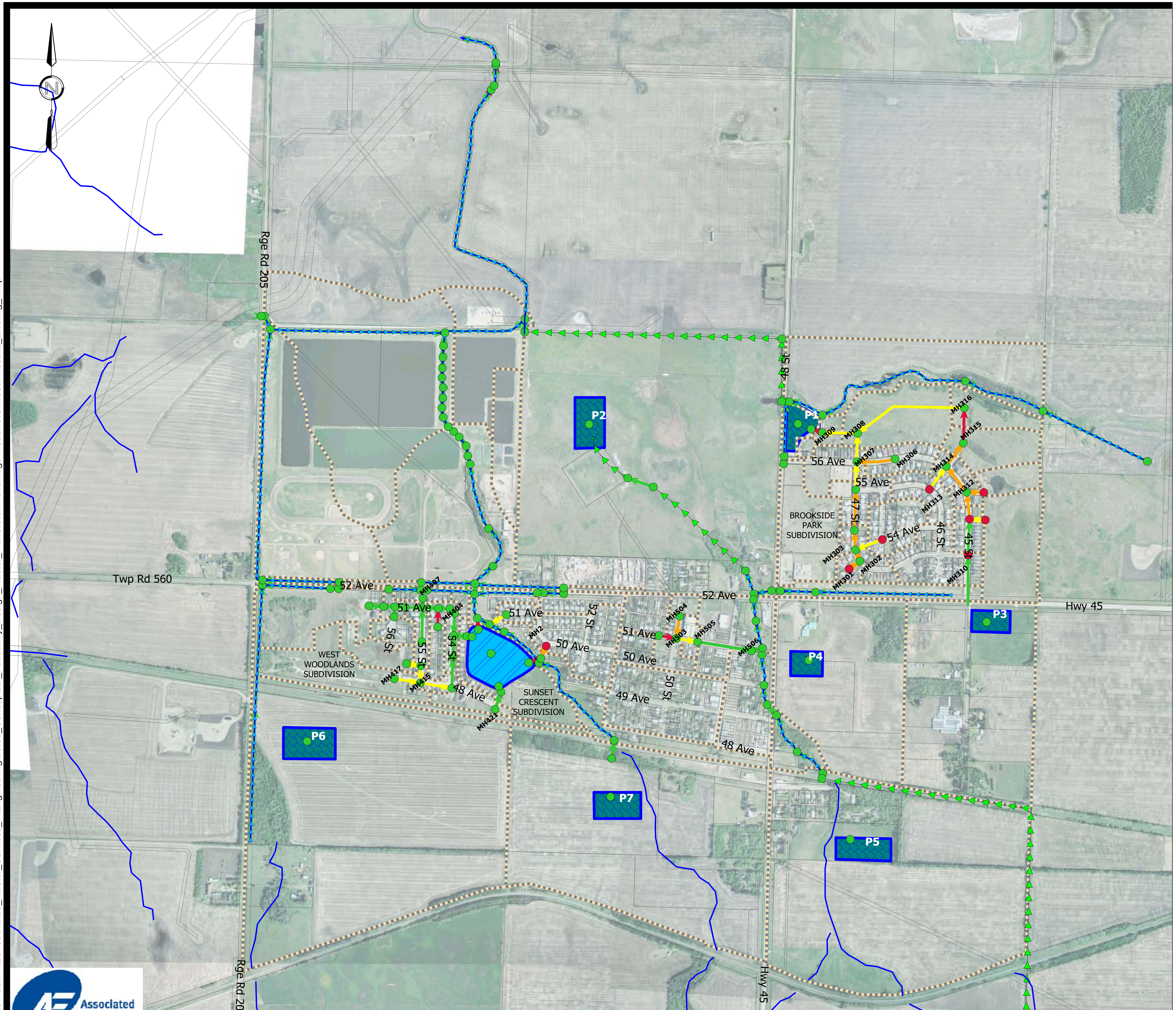

MASTER SERVICES PLAN

SIMULATED SURCHARGE LEVELS
AND FLOW LOADING
1:25 YEAR STORM
UPGRADES TO EXISTING CONDITIONS

LEGEND:

EXISTING DRY POND
PROPOSED STORMWATER MANAGEMENT FACILITY
PROPOSED DRAINAGE CHANNEL
DITCH/NATURAL CHANNEL
CATCHMENT AREA

SURGHARGE LEVEL:
ABOVE GROUND
BELOW GROUND

FLOW LOADING:
Qp/Qcap < 1
1 < Qp/Qcap < 1.5
1.5 < Qp/Qcap < 2
Qp/Qcap > 2

SCALE: 1:12000

DECEMBER, 2016

FIGURE 5.10

Date: 6/29/2016
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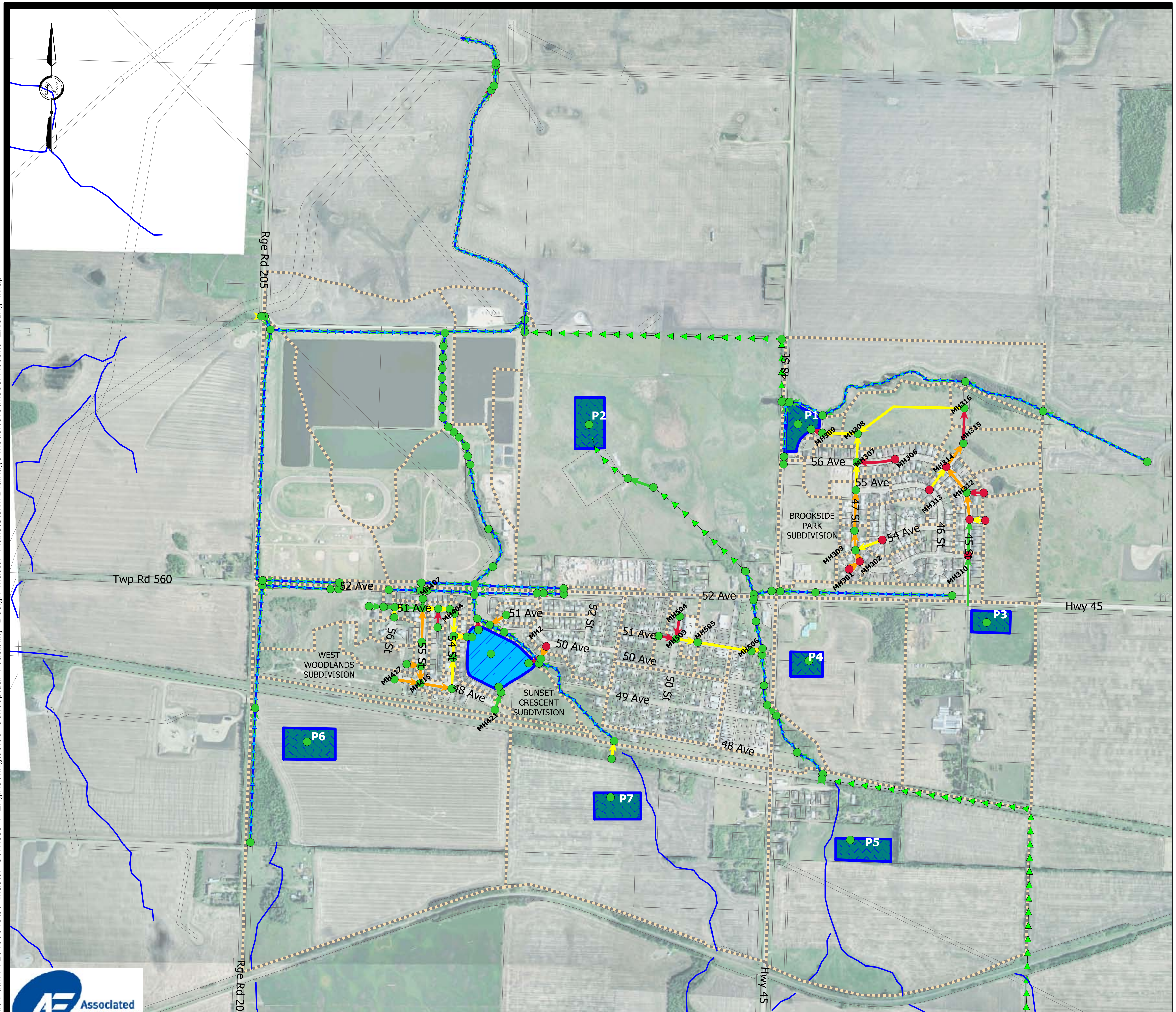
Associated Engineering



the town of Bruderheim Alberta

MASTER SERVICES PLAN

SIMULATED SURCHARGE LEVELS
AND FLOW LOADING
1:100 YEAR STORM
UPGRADES TO EXISTING CONDITIONS

LEGEND:

EXISTING DRY POND
PROPOSED STORMWATER MANAGEMENT FACILITY
PROPOSED DRAINAGE CHANNEL
DITCH/NATURAL CHANNEL
CATCHMENT AREA

SURCHARGE LEVEL:
ABOVE GROUND
BELOW GROUND

FLOW LOADING:
Qp/Qcap < 1
1 < Qp/Qcap < 1.5
1.5 < Qp/Qcap < 2
Qp/Qcap > 2

SCALE: 1:12000

DECEMBER, 2016

FIGURE 5.11

Date: 6/29/2016
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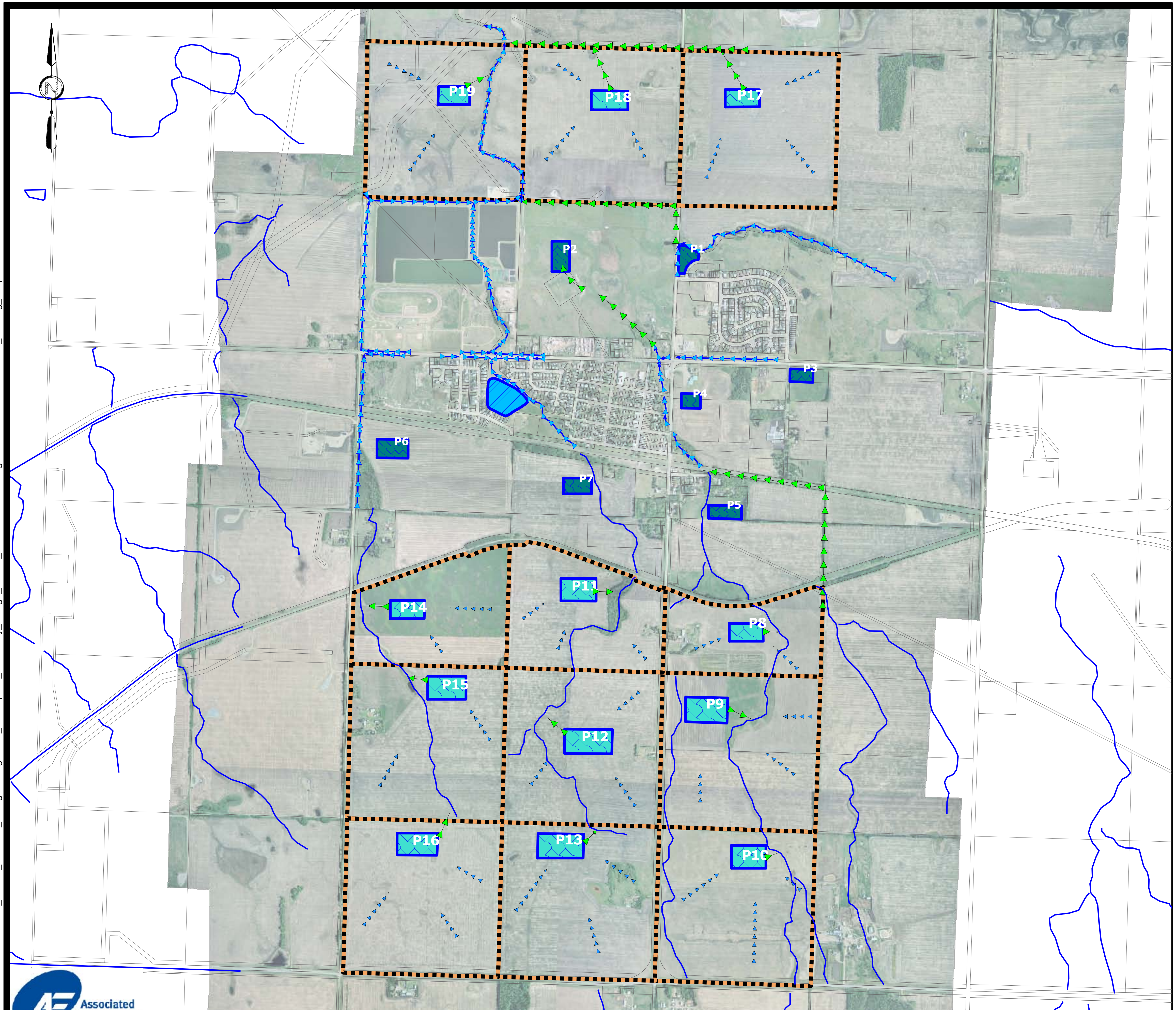

the town of Bruderheim Alberta

MASTER SERVICES PLAN

FUTURE DEVELOPMENTS

LEGEND:

- FUTURE STORMWATER MANAGEMNET FACILITY
- PROPOSED STORMWATER MANAGEMENT FACILITY
- EXISTING DRY POND
- PROPOSED DRAINAGE CHANNEL
- PROPOSED CATCHMENT AREA - ULTIMATE SYSTEM
- PROPOSED DRAINAGE DIRECTION
- STREAM

SCALE: 1:20000

DECEMBER, 2016

FIGURE 5.12

Associated Engineering

Date: 6/29/2016
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6 Transportation System

6.1 HISTORY

The last infrastructure plan developed for the Town of Bruderheim was completed by Tritek Engineering Consultants in 1988. The transportation component of that study found that the road network at that time was more than sufficient to meet the current needs of the community. The report recommended an expanded arterial and collector road network to meet the expected long-term growth of the community.

Since the completion of that report, growth has been slow in Bruderheim. The current road network, particularly the system of collectors and arterials, remains largely unchanged. The existing road network continues to adequately meet the needs of the community, and any short-term growth. AE considered the Tritek recommendations for future arterials and collectors. AE then updated those alignments to reflect the revised future growth plans for the community as outlined in the new MDP.

6.2 ROAD TYPES

Within a community, there are several types of roadways that function together to provide an effective transportation network. Typically, roadways are classified into several categories which define access and mobility on each type of roadway. A roadway with more access will have less mobility (lower speeds and lower capacity) than a roadway with less access points.

Municipalities in Alberta define several roadway classifications in order of mobility. These include:

- Freeways (most mobility, least access).
- Expressways.
- Arterials.
- Collectors
- Locals (least mobility, most access).

Mobility refers to a number of qualitative and quantitative elements related to riding comfort, speeds, amount of speed changes, and travel times. Access refers to the ability to access private or public property from the roadway network.

Freeways
Freeways provide the most mobility by not allowing direct access to adjacent lands. All access is via interchanges at major expressway or arterial roadways. In Alberta there are very few freeways and most are operated by Alberta Transportation or major municipalities. These roadways function to provide motorists with high travel speeds on high-capacity roadways between major junctions. Spacing between interchanges is usually three kilometres or greater. The Anthony Henday Drive and Whitemud Drive are examples of nearby freeways.

Expressways
Expressways provide significant mobility with limited access. Typically, expressways provide access to other expressways, freeways, or arterial roadways. Expressways typically function to provide high travel speeds on high-capacity roads, but with a tolerance for interruptions at intersections. Spacing between interchanges or intersection is usually greater than 800 metres. In Alberta, many major highways function as expressways, such as Highway 16 east of Edmonton, or Highway 21 and Highway 15 near Fort Saskatchewan.

Arterial Roadways
Arterial roadways provide significant mobility but with more consistent access points. Typically, arterial roadways provide access to higher-class facilities (freeways and expressways), other arterial roadways, and collector roadways. Arterial roadways function to balance significant travel volumes and travel distances while allowing connections to collector roadways. In some cases, arterial roadways will provide direct access to major public or private developments. Spacing between intersections is usually greater than 400 metres. In Bruderheim, Highway 45 and 52 Avenue function as arterial roads.

Collector Roadways
Collector roadways provide limited mobility with access points to arterial and local roads, and some public or private lands. Typically, collector roadways function to collect and distribute traffic from local roads or direct access to the arterial roadways. Spacing between intersections is often 100 to 200 metres and direct access to public or private lands is provided between intersections. In Bruderheim, 45 Street/56 Avenue and 55 Street are examples of collector roadways.

Local Roads
Local roadways provide minimal mobility with significant direct access to public and private lands. Typically, local roads function to move traffic from development to collector roads. Spacing between intersections is often less than 100 metres, and direct access is typically allowed almost anywhere on a local roadway. In Bruderheim, 54 Avenue and 54 Street are examples of local roads.

In Bruderheim, there needs to be a cohesive network of arterial, collector, and local roadways.

6.3 STUDY SCOPE

The scope of the transportation component of the Master Services Plan is as follows:

- Document and assess the existing transportation network from a functionality and connectivity perspective
- Identify improvements required to achieve future growth projected in stage one and two of the Municipal Development Plan
- Identify long-term improvements that will allow for all growth projected in the Municipal Development Plan
- Provide recommendations for cross-sections, geometric design, traffic control, and lighting

6.4 LAND USE

Section Two (Design Criteria) outlines the Town of Bruderheim's Municipal Development Plan. The current (2014) population is identified as 1,376 people. Within the identified 25-year horizon, the population in 2039 is projected to be 2,257 people based on the 2% annual growth rate. The MDP also identifies long-term projections of full build-out to within the study area and future Town boundary, which correspond to an ultimate population of 13,681 people.

6.4.1 Current Land Use

The residential population in Bruderheim is located primarily northeast and southwest of the intersection of 52 Avenue and 48 Street. There are some employment areas along 52 Avenue and along Queen Street. Many residents of Bruderheim commute southwest to the Alberta Industrial Heartland via Highway 45 and Highway 15. A school is located on the north east corner of 52 Avenue and 48 Street.

6.4.2 Future Land Use

The Municipal Development Plan provides three future phases for development. For the purposes of this Transportation Plan, two development horizons are identified. The first horizon includes Phase 1 and Phase 2 of the Municipal Development Plan and the corresponding transportation network improvements refer to this stage as the future network. The second horizon includes all identified development areas (Phases 1, 2 and 3), and is referred to as the long-term or ultimate network. More information on the phasing and land use is provided in Section Two.

6.5 TRAFFIC VOLUMES

Growth in the Town of Bruderheim has been fairly limited since the previous infrastructure plan, and there has been no need to update the existing network of arterials and collectors in the community. There is currently no identified issue with traffic volume and congestion within the existing network. The network is also equipped to deal with immediate growth in existing residential and commercial areas.

6.5.1 Existing Traffic

There are no available traffic counts directly in the Town of Bruderheim. Alberta Transportation has highway counts at the intersection of Highway 45 and Highway 15, south of Town, as well as a Highway Control Section Count on Highway 45 the east of Bruderheim.

In 2012, the average annual daily traffic (AADT) on Highway 45 north of Highway 15 was 1660 vehicles. East of Town, on Highway 45 the AADT is approximately half that value, according to the Highway Control Section counts from that same year. Based on these counts, AE assumes that approximately half of the 1660 vehicles on Highway 45 have an origin or destination in Bruderheim.

6.5.2 Future Traffic

As the existing residential areas are built out, there will be some volume increases on the existing collectors and arterials, but with general maintenance these roads will be able to accommodate that growth. Updates to the road network will be necessary as new areas are developed to service those developments and support connectivity within the community.

6.6 TRANSPORTATION NETWORK

6.6.1 Existing Transportation Network

The road network in Bruderheim is a mixture of Arterial Roadways, Collector Roads and Local Roads. The existing transportation network is shown in **Figure 6.1** – Ultimate Transportation System.

Highway 45 is also known as 48 Street within the Town limits south of 52 Avenue. 52 Avenue east of 48 Street is also Highway 45. Highway 45, 52 Avenue, and 48 Street are the main arterials in the community. 48 Street and 52 Avenue are currently arterials within the Town limits, with one lane in each direction, and a speed limit of 50 km/h. 48 Street has urban curb and gutter drainage roughly between Queen Street and 51 Street, and rural ditch drainage throughout the remainder of the roadway. These arterial roads provide access from the highway network to the Bruderheim's collector roadways. They also provide access to some commercial and industrial developments in the community.

The arterial roads are serviced by a network of collector roads. Key collector roads include 45 Street, 56 Avenue, 48 Avenue, 51 Street and 55th Street. The roads that connect to these collectors make up the local road network. These collector roads are all two lane roadways (one lane in each direction) with urban curb and gutter drainage. Most collector roads provide parking opportunities on both sides of the road and have posted speeds of 50 km/h.

With the exception of through traffic on Highway 45, the roads in Bruderheim mainly service local traffic. 52 Avenue provides access to Secondary Highway 830, but this connection will also mostly be made by local traffic. There is currently little concern over existing capacity or access on any of the roads in Bruderheim. The future development proposed within the new Town limits will require improvements to the arterial and collector road network to continue to service the community with adequate access and connectivity.

6.6.2 Future Transportation Network

The future transportation network will service the growth identified through Phase 1 and 2 of the Municipal Development Plan. Considerations for the future transportation network were to improve connections between existing developments and identify new arterial and collector roadways for future development areas. The future and ultimate road network can be seen in **Figure 6.1** – Ultimate Transportation System.

Arterial roads should be spaced at approximately 1.5-2.0 km, with intersections spacing at greater than 400 metres apart. Minimal direct property access should be allowed to and from the arterial road network.

Within Bruderheim, the arterial road network will likely be sufficient with one lane in each direction, but the Town should protect the right of way for a potential two lanes in each direction. Recommendations on cross-sections are outlined in Section 6.6. Exact configurations of the arterial roadways and intersections will need to be confirmed by further analysis such as through Traffic Impact Assessments when future developments are planned.

The future arterial road network extends the existing 48 Street arterial about 400 metres north of 56 Avenue (to the extents of Phase 1 and 2). 61 Street (Range Road 205) is identified as a future arterial between 52 Avenue and the Canadian Pacific Railway tracks. This new arterial will service the collector road coming out of proposed new industrial/commercial development between the two railway lines.

Collector roads should be spaced between 400 metres and 800 metres apart with intersection spacing on the roadways about 100 to 200 metres apart. Direct access is typically allowed on collector roads but should be reviewed for sightlines and proximity to intersections. Within Bruderheim, the collector road network will likely be sufficient with one lane in each direction. Recommendations on cross-sections are outlined in Section 6.6. Exact configurations of the collector roadways and intersections will need to be confirmed by further analysis such as through Traffic Impact Assessments completed for future development.

The expanded collector road network provides connections between the existing collector roads, as well as a network to service potential industrial development in the south and potential residential development north of 52 Avenue. The collector road network locations are based on ensuring adequate connection to the arterial roads. 51 Street is identified to be extended south of 48 Avenue to the Canadian Pacific Railway tracks. This will serve to allow residential traffic to access employment areas south of the train tracks. This future collector road will provide an additional crossing over the CN rail line, which will also serve to provide improved emergency access for fire and emergency medical services. Traffic calming and oversize restrictions can prevent heavy industrial traffic from using this route. As part of this collector expansion, AE recommends connecting the east and west portions of 48 Avenue to provide a cohesive collector network through the existing residential neighbourhoods between the CN railway and 52nd Avenue.

A future collector road is also identified east-west between the two railway tracks. This collector road will connect 61 Street (Range Road 205), the 51 Street extension, Highway 45, and east to tie into 45 Street. This new road will also require a crossing over the Canadian National rail line at 45 Street. 45 Street between the railway and Highway 45 will need to be upgraded as development occurs to bring this roadway up to the current Bruderheim standards.

51 Street is identified as a future collector road north of 52 Avenue through the future development area (about 800 metres north of 53 Avenue). This alignment runs through an existing industrial property north of 52 Avenue. This connection was preferable for continuity; 51 Street as the central arterial through the Town will provide the best connection between northern and southern expansion. 51 Street also has a preferable cross section over adjacent roadway alternatives. The Town should reserve the right of way for this expansion when presented with the opportunity. 56 Avenue is also identified to be extended west of 48 Street to provide connectivity to the future 51 Street extension.

56 Avenue (also identified as 45 Street in some plans) is identified as a future collector road to be extended approximately 400 metres north of 56 Avenue. This will support additional potential development north of Brookside Park.

6.6.3 Long-Term Transportation Network

The ultimate arterial road network will provide a complete north-south and east-west grid network to service the collector roads and provide access in and out of Bruderheim. Should the population ultimately grow to proposed levels, it is possible that the existing arterials may experience enough traffic volumes to warrant four lane configurations. The right-of-ways for future arterials should be protected to accommodate that possibility, but two lane cross sections should meet growing needs for the foreseeable future. Recommendations on cross-sections are outlined in Section 6.6. The Town should periodically evaluate traffic volumes and request new developments to complete Traffic Impact Assessments to identify required upgrades to the road network.

The ultimate arterial road network extends the future arterial roads within the study area. 61 Street (Range Road 205) is identified as an ultimate arterial roadway between Highway 15 and Township Road 562. 48 Street is also identified as an ultimate arterial north to Township Road 562.

The long-term collector road network will provide a complete collector system to service new growth areas. Recommendations on cross-sections are outlined in Section 6.6.

An extension of the future 51 Street is identified as an ultimate collector road south of the Canadian Pacific Railway tracks. This extension is about 1500 metres south of the rail line, and should be located about halfway between Range Road 205 and Highway 45. Between Range Road 205 and Highway 45, the ultimate collector road network is identified as a grid network spaced about 800 metres apart, roughly following the quarter section lines. The ultimate collector road network will also have a loop east of Highway 45, to service growth east of the Highway.

In the northern section of the study area, the ultimate configuration of 51 Street is identified to be extended an additional 400 metres north of the future 51 Street extension. A new east-west ultimate collector road is identified to connect 61 Street (Range Road 205), the ultimate 51 Street extension, 48 Street, and east to tie into the 56 Avenue/45 Street future collector extension.

6.6.4 Highway 45

Highway 45 is an Alberta Transportation roadway starting south of Bruderheim at Highway 15. Through Bruderheim, Highway 45 is not a High Load Corridor, and carries relatively low volumes. The main intersection in Bruderheim is a four-way stop controlled intersection of Highway 45 (which goes from a north south road to an east west road), with 52 Avenue and 48 Street.

There are no current access or traffic volume issues along Highway 45 east of the intersection of 48 Street and 52 Avenue. There are two intersections with Highway 45 east of that intersection; the first is a local access to a church approximately 70 m from the intersection. The other access is 45 Street, which is currently an offset t intersection. As development occurs south of Highway 45, it will be important to align the north and south leg of 45 Street.

There are, however, potential access concerns along Highway 45 south of the intersection of 48 Street and 52 Avenue. In the southwest corner of the intersection of Highway 45 and 52 Avenue there is a gas station and liquor store with multiple large accesses immediately to the south of the intersection. There is also an access point to the church in the southeast corner, less than 30 m from the intersection. Continuing south there are additional t-intersection accesses to the Town, and two railway crossings. There are no current traffic issues perceived along this corridor, but as growth progresses within the Town, this north-south leg of Highway 45 should be prioritized for an access management study.

6.7 CROSS-SECTION REQUIREMENTS

The Town of Bruderheim's Engineering Servicing Standards identifies cross-sectional requirements for various roadway classifications. Cross-sectional requirements for elements of the collector and arterial roadways are identified below.

6.7.1 Rural Arterial Undivided (Two or Four Lane)

- Two or four travel lanes at a width of 3.7 metres each.
- Two shoulders at a width of 3.0 metres each.
- Minimum right of way of 40.0 metres.
- Attempt to protect for ultimate 50.0 metres.

6.7.2 Urban Arterial (Two Lane Undivided or Four Lane Divided)

- Two or four travel lanes at a width of 3.7 metres.
- Straight faced curb and 0.5 metre gutter.
- 4.5 metre median (for divided).
- Separated walkway/trail on minimum one side of roadway.
- Minimum right of way of 40.0 metres.
- Attempt to protect for ultimate 50 metre right of way.

6.7.3 Urban Collector Undivided (2 Lanes)

- Two travel lanes at a width of 3.5 metres.
- Two parking lanes at 2.75 metres.
- Straight faced curb and 0.5 metre gutter.
- Minimum right of way of 24.0 metres.

6.8 ROADWAY GEOMETRICS

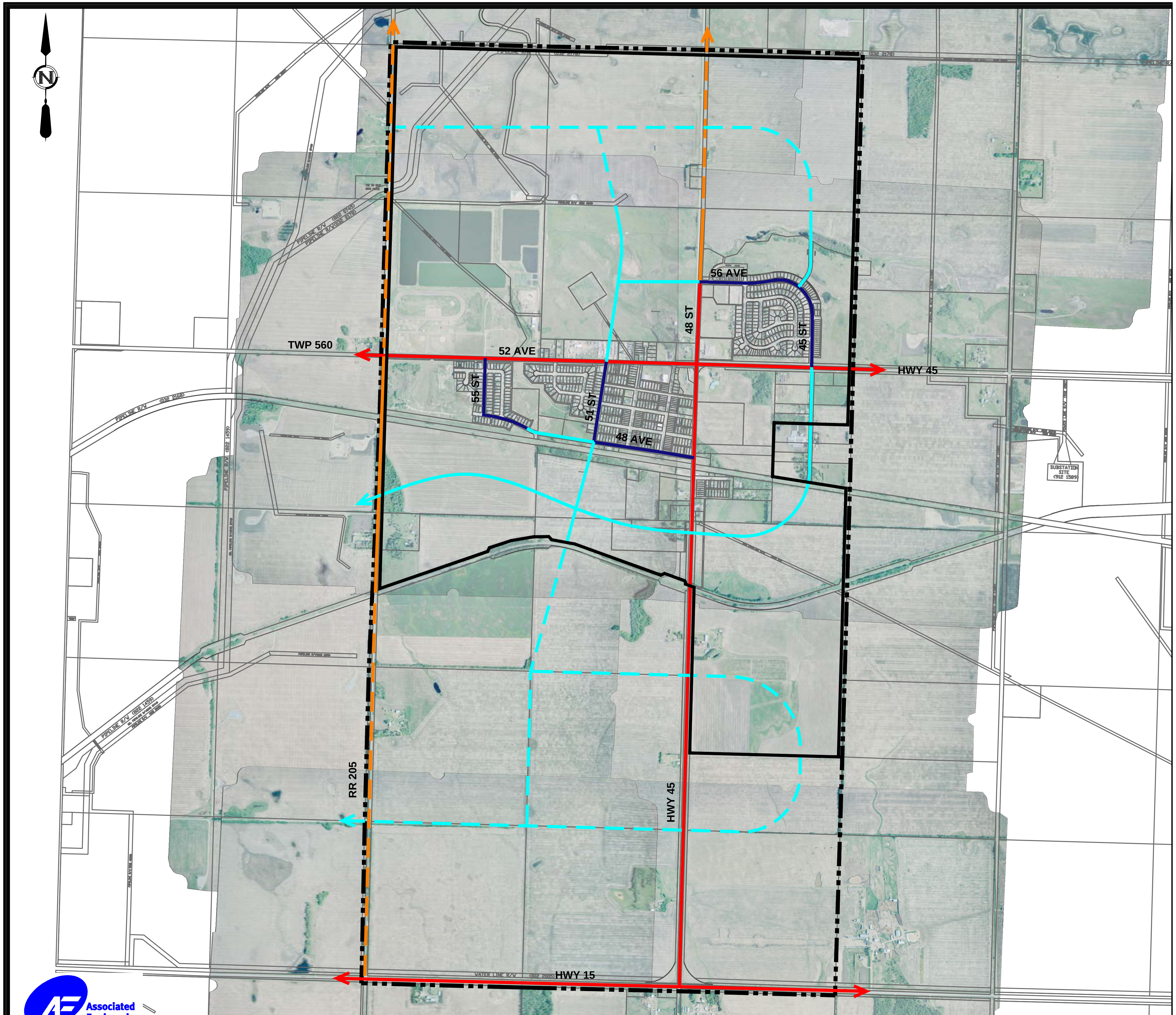
The Town of Bruderheim has defined basic roadway geometric information in the Engineering Servicing Standards (2008). In addition to these standards, Associated Engineering recommends that all roadway geometry be designed and constructed in accordance with the “Geometric Design Guide for Canadian Roads” published by the Transportation Association of Canada, and other industry best practices. Any connection to an Alberta Highway (such as Highway 45 through Bruderheim) must conform to the most recent update of the “Highway Geometric Design Guide” published by Alberta Transportation.

6.9 TRAFFIC CONTROL DEVICES (SIGNS AND SIGNALS)

Associated Engineering recommends that all traffic control devices (including signs, pavement markings, and signals) be designed and installed in accordance with the “Manual of Uniform Traffic Control Devices of Canada” published by the Transportation Association of Canada.

6.10 STREET LIGHTING

Associated Engineering recommends that any requirements for street lighting be designed and installed in accordance with the current “Guide for the Design of Roadway Lighting” published by the Transportation Association of Canada.



the town of Bruderheim Alberta

MASTER SERVICES PLAN

ULTIMATE TRANSPORTATION SYSTEM

LEGEND:

- STUDY AREA BOUNDARY
- TOWN BOUNDARY
- EXISTING ARTERIAL
- FUTURE ARTERIAL
- ULTIMATE ARTERIAL
- EXISTING COLLECTOR
- FUTURE COLLECTOR
- ULTIMATE COLLECTOR

SCALE : 1:20,000

DECEMBER, 2015

FIGURE 6.1

Associated Engineering

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DATE: 12/1/2015, Kevin Grandish

7 Cost Estimates

Cost estimates are provided for upgrades which are recommended for the existing system to satisfy present servicing standards and have been identified by Phase. All future upgrading will be the responsibility of the developer, therefore no costs have been identified. The estimates presented include an allowance for engineering (15%) and contingency (15%), but do not include G.S.T. The costs are based on 2014 construction dollars.

7.1 WATER SYSTEM UPGRADES

Unit costs and further estimate information for proposed Water System Upgrades are provided in Appendix D. Recommended upgrades for existing system:

		Town	Development
·	Reservoir Expansion (approximately 1,000 m^3)	$1,500,000 – Ph 1	
·	Upgrade Standby Pump	$ 200,000 – Ph 1	
·	Interconnect at Queen Street	$ 34,600 – Ph 1	
·	48th Street – 350 mm		$1,952,000 – Ph 1
·	48th Street – 300 mm Loop Connections		$ 344,000 – Ph 1
·	48th Street, South – 250 mm		$ 114,000 – Ph 1
·	48th Avenue – 250 mm		$ 291,000 – Ph 1
·	47th Street – 200		$ 126,000 – Ph 1
·	Additional Hydrants with Leads (27)	$ 324,000 – Ph 1	
·	Easement (10 m x 850)	$ 106,000 – Ph 1	
·	Reservoir to Brookside – 300 mm		$1,145,000 – Ph 2
	Total Water Distribution System Upgrades	**$2,164,000**	**$3,972,000**

7.2 SANITARY SYSTEM UPGRADES

Unit costs and further estimate information for proposed sanitary system upgrades are provided in Appendix D. Recommended upgrades for existing system:

		Town	Development
·	Interconnect trunk sewers (assume 2 new MH's)	$ 30,000 – Ph 1	
·	Easement (10 m x 850 m)	$106,000 – Ph 1	
·	Install 1200m - 250 mm sewage forcemain		$864,000 – Ph 2
	Total Sanitary Sewer System Upgrades	**$136,000**	**$864,000**

7.3 STORM DRAINAGE SYSTEM UPGRADES

Unit costs and further estimate information for proposed storm drainage system upgrades are provided in **Appendix D**. Recommended upgrades for existing system:

	Town	Development
· Upgrade SC1 – 450 mm and drop manhole	$ 91,000 – Ph 1	
· Upgrade WW1 – 750 mm CSP culvert	$ 111,000 – Ph 1	
· Upgrade DA1 – 450 mm	$ 100,000 – Ph 1	
· Upgrade BP1 – 450 mm – 1050 mm	$ 936,000 – Ph 1	
· Upgrade FT4 – Ditch Upgrades	$ 79,300 – Ph 1	
· Upgrade BP2 – Stormwater Management Facility		$865,000 – Ph 1
Total Storm Drainage System Upgrades	**$1,317,300**	**$865,000**

7.4 TRANSPORTATION SYSTEM UPGRADES

There are no upgrades proposed for the existing Transportation System; however, the following is recommended to facilitate system expansion:

- Acquire Right-of-Way north of 52 Avenue through existing Development.

$ 50,000 – Ph 1

7.5 TOTAL UPGRADES TO EXISTING SYSTEM

	Town	Development
· Total Water Distribution System Upgrades	$2,164,000	$ 3,972,000
· Total Sanitary Sewer System Upgrades	$ 136,000	$ 864,000
· Total Storm Drainage System Upgrades	$1,238,000	$ 865,000
· Total Transportation System Upgrades	$ 50,000	$ -
Total Upgrades to Existing System	**$3,588,000**	**$5,701,000**

8 Conclusions

8.1 WATER SYSTEM

- Pressures within the existing distribution system meet those recommended in the design criteria.
- Some locations in the distribution system do not satisfy the recommended fire flow demands.
- The distribution system does have 100% redundancy in the distribution pumping, in order to allow for pump maintenance and repair.
- The standby pump capacity does not meet the existing peak day plus fire flow demand.
- The existing reservoir does not have adequate storage capacity for the existing system based on the design criteria applied.
- Some areas of the Town do not have adequate hydrant coverage.

8.2 SANITARY SYSTEM

- Further information including a detailed site survey will be necessary prior to undertaking preliminary design of the recommended upgrades.
- Some existing sanitary sewers will surcharge during peak wet weather flow conditions.
- The existing sewage pumps in the sewage lift station appear to have ample capacity to deliver the peak wet weather flows based on one pump operating.
- The existing wet well capacity is unknown but is estimated to be adequate for the existing system.
- The lift station will require an expansion to service the entire future catchment area.
- The existing forcemain is estimated to be adequately sized for the current pumps.
- The existing forcemain has collapsed in the recent past and has been partially re-routed and abandoned. The Town has concerns over its current condition and longevity.
- The existing sewage lagoon has ample capacity to meet the treatment requirements to beyond the 25 year study period. The lagoon will require expansion to service the ultimate study area.

8.3 STORMWATER SYSTEM

8.3.1 General

- The Town of Bruderheim is servicing through a combination of surface drainage and underground pipes.
- The Town´s drainage can be divided into five major drainage basins: Spring Creek, Central Unnamed Creek, East Unnamed Creek, West Boundary Creek and North Boundary Creek Basins.

8.3.2 Existing Drainage Capacity

- The storm sewer system performs well during the 1:5 year storm, specifically in the area of West Woodland Subdivision.
- Minor portions of the pipes are surcharged in the 1:5 year storm event (and larger storms). Surcharge levels reach ground surface in localized places, specifically in the Sunset Crescent subdivision, downtown area and Brookside Park subdivision.
- The majority of the major system, including the dry pond, drainage culverts, major bridges/culverts structures, and road ditches perform reasonably well during the 1:100 years storm event.
- Both man-made Central and East Unnamed Creek channels are surcharging above ground during both storms events (1:5 and 1:100 year storms). The existing channel cross-sections are too shallow and do not have sufficient capacity to carry the design flow.
- Upgrades are required to provide benefits in terms of an increased level of service and reduction of ponding/flooding issues within the subdivisions.

8.3.3 Future development Needs

- Stormwater management will be required in all new developments to control peak runoff rates and to provide water quality control.
- Best management practice implies that wet facilities be used whenever possible. Existing wetlands and waterbodies should be preserved whenever possible.
- Based on the available DEM data, the basins have a good natural drainage system which will likely facilitate the intersection of surface runoff through storm sewer systems towards the proposed stormwater management facilities
- Proposed stormwater management pond will be discharging to the existing Unnamed Creeks in order to promote preservation of the existing drainage system.
- Recommended storage volumes used for the pond sizing are conceptual only. The size of each pond should be confirmed during the design stage when details of the pond design and the development concept are finalized.

8.4 TRANSPORTATION SYSTEM

- There are no current deficiencies in the Town’s transportation system/road network.
- The current transportation system adequately accommodates existing traffic volumes and patterns in the Town of Bruderheim.

9 Recommendations

9.1 WATER SYSTEM

- Construct the capacity related upgrades as indicated in **Figure 3.4**.
- All new watermains are recommended to be a minimum of 200 mm in diameter. It is recommended that as older pipes are repaired or replaced, that they be increased to at least this size for residential locations, and 250 mm or greater for other locations.
- Upgrade the standby pump to accommodate the 10 year peak day plus fire flow demand (212 L/s).
- Expand the storage capacity at the existing reservoir by 964 m^3 in order to accommodate the projected 25 year demand requirements. It may be possible to construct a new truckfill with dedicated storage at a location along Highway 45.
- Future expansion is recommended to occur in accordance with **Figure 3.5**.
- Recommend that an easement be secured for water extension from the Reservoir/Pumphouse to Brookside.

9.2 SANITARY SYSTEM

- Construct the proposed upgrades as indicated in **Figure 4.3**.
- Install a new 250 mm diameter sewage forcemain from the Lift Station west to the Lagoon. The increase in size will accommodate the proposed future catchment area.
- Construct Phase 1 Upgrades as presented in **Figure 4.4**.
- Construct Phase 2 Upgrades as presented in **Figure 4.5**.
- Construct Ultimate System Upgrades as presented in **Figure 4.6**.
- Continue to undertake CCTV investigations to identify structural shortcomings in the existing sanitary sewer system.
- Recommend that an easement be secured for sewer forcemain realignment from the Sewage Lagoon to Brookside.

9.3 STORM SYSTEM

9.3.1 Existing System

- It is recommended that the Spring Creek man-made channel be upgraded to provide additional flow capacity during the 1:100 year storm event. (Upgrade FT4)
- Selective upgrades (SC1,4 WW1, DA1, BP1, BP2) should be considered at 4 locations to improve drainage, reduce the risk of ponding, and provide additional capacity for future developments.
- A more reliable source of data such as LIDAR, should be used during the future design of the stormwater management facilities to confirm pond characteristics and elevations of outlets pipes.

9.3.2 Future Development

- Provide stormwater management facilities in all future development areas to control flows and runoff water quality.
- Adopt the stormwater management plan shown in **Figure 5.12** as the basis for future developments, subject to review during the development planning and subdivision design process.
- Adopt a maximum outfall rate of 3.9 l/s/ha for pond design in the Town of Bruderheim.
- Preserve existing wetlands, waterbodies, and overland drainage courses.
- Address water quality improvements in all drainage design.
- It is recommended that the East Unnamed Creek man-made be upgraded and realigned to provide capacity for the 1:100 year storm event without surcharging above ground surface, and to allow further use of the existing land for future development.
- Seven stormwater management facilities are recommended to be constructed in the Town drainage system to provide water quality and quantity control to a pre-development release rate of 3.9 l/s/ha.

9.4 TRANSPORTATION SYSTEM

The following recommendations will allow the network to adapt to the growing community.

- An expanded arterial and collector road network has been laid out to accommodate growth in phases and is presented in **Figure 6.1** – Ultimate Transportation System.
- Future and ultimate arterial and collector roadways should be constructed when adjacent development occurs.
- Cross-sections and roadway geometry for new construction should conform to the Town of Bruderheim’s Engineering Servicing Standards and all applicable industry standards including those from the Transportation Association of Canada.
- Intersection treatment and configuration will need to be determined by traffic impact assessments completed during the new development approval stage.
- Acquire Right-of-Ways for proposed new collector and arterial roads.

REPORT

Closure

This report was prepared for the Town of Bruderheim for the purpose of providing a Master Services Plan for the water distribution, sewage collection, storm drainage and transportation systems.

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.

PROFESSIONAL ENGINEER ALBERTA — P. D. MASTROMATTEO

June 29, 2016
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Project Manager

PROFESSIONAL ENGINEER ALBERTA — CANDICE E. GOTTSTEIN

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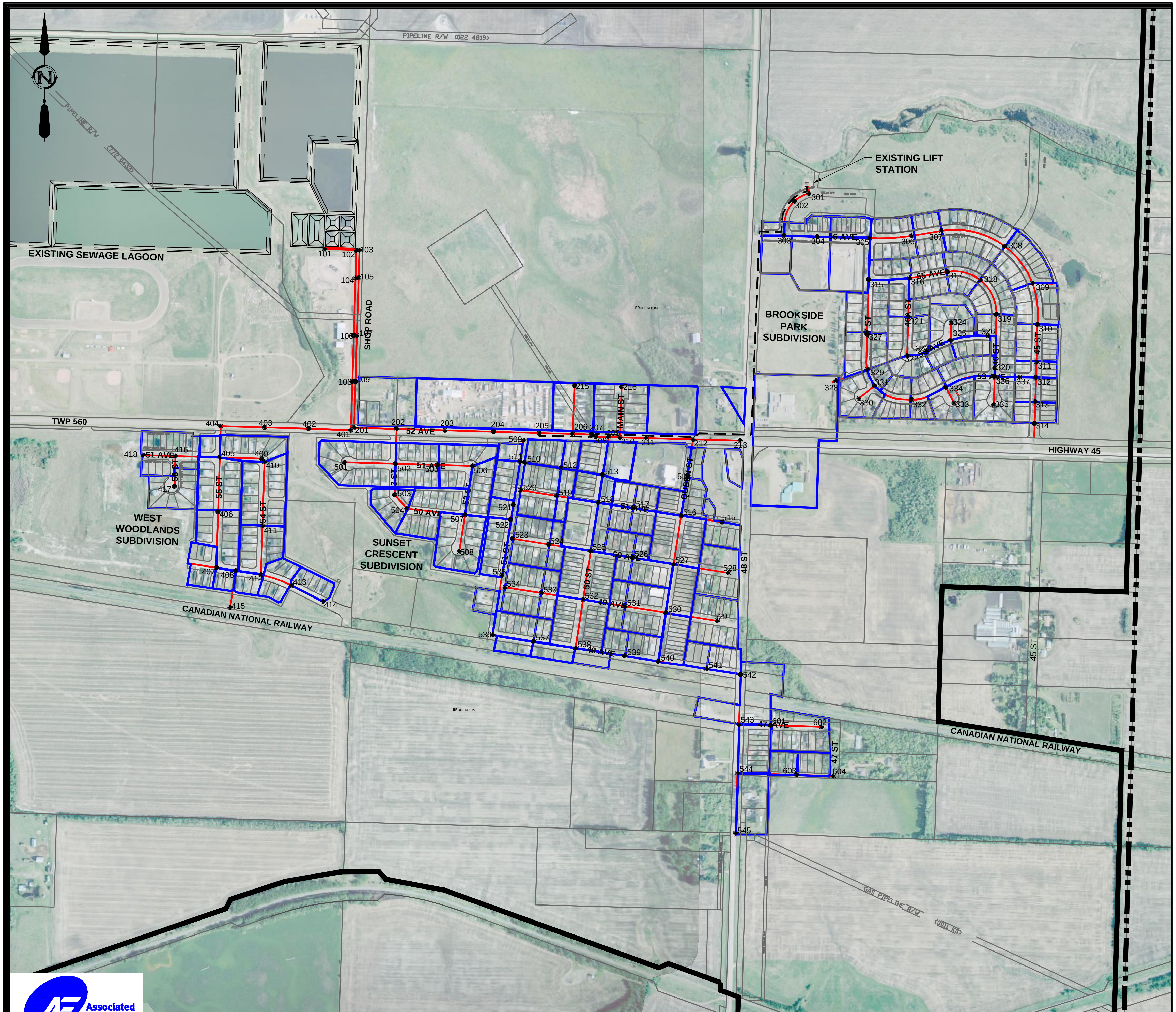
2016. 06. 29
Carolyn Sherstone, P. Eng.
Transportation Engineer

ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF
Signature:
Date: June 29, 2016

APEGA Permit to Practice P 3979

Appendix A - Sanitary Manhole and Catchment Figures



the town of Bruderheim Alberta

MASTER SERVICES PLAN

ULTIMATE SANITARY SEWER SYSTEM MANHOLE NUMBERING AND CATCHMENT PLAN

LEGEND:

	STUDY AREA BOUNDARY
	TOWN BOUNDARY
	EXISTING LIFT STATION
	PROPOSED LIFT STATION
	EXISTING SANITARY SEWER
	EXISTING FORCEMAIN
	CATCHMENT BOUNDARY
528	MANHOLE NUMBER

SCALE : 1:8,000

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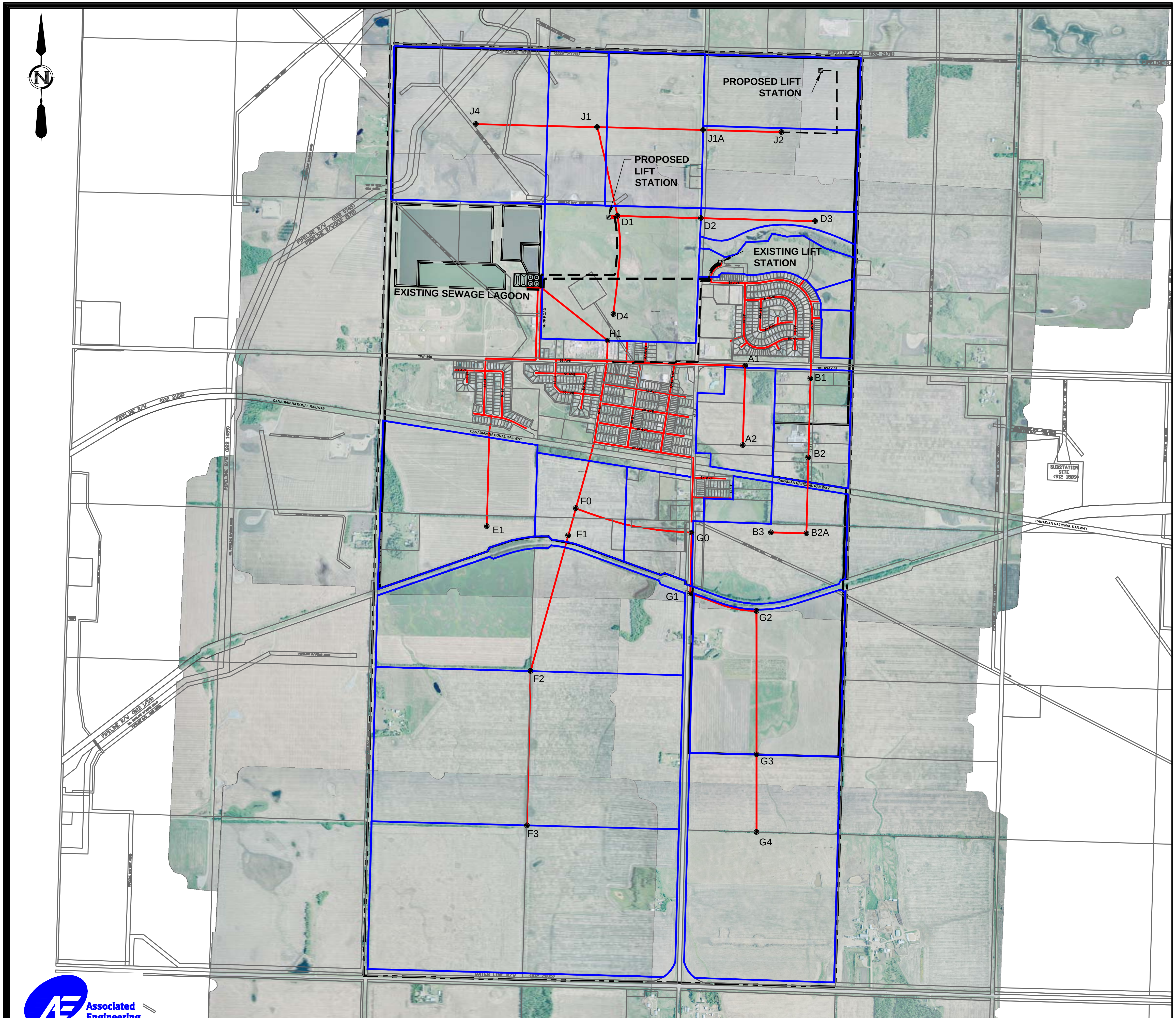

the town of Bruderheim Alberta

MASTER SERVICES PLAN

FUTURE SANITARY SEWER SYSTEM MANHOLE NUMBERING AND CATCHMENT PLAN

LEGEND:

▬ · ▬ · ▬	STUDY AREA BOUNDARY
▬▬▬	TOWN BOUNDARY
□	EXISTING LIFT STATION
▨	PROPOSED LIFT STATION
red line	EXISTING SANITARY SEWER
– – –	EXISTING FORCEMAIN
blue line	CATCHMENT BOUNDARY
G2	MANHOLE NUMBER

SCALE : 1:20,000

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SANITARY INDEX A2

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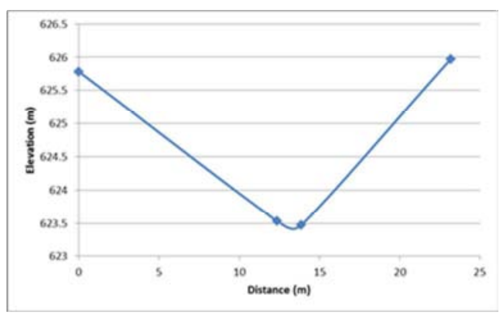
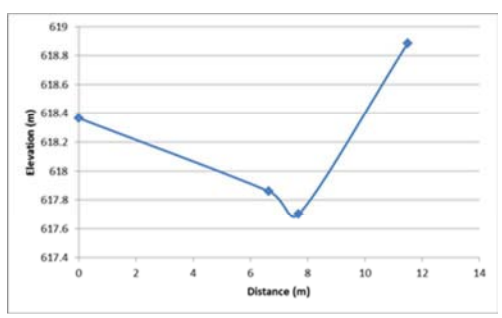
Appendix B - Basin Structures and Creek Channel Cross Sections

West Unnamed Creek Basin

Culverts Structures

Structure	Photo
2- 1000 mm diameter × 33.3 m length corrugated steel pipe (CSP) culverts located under 52 Avenue, specifically between 53 Street and 55 Street.	
2- 750 mm diameter × 54.8 m corrugated steel pipe (CSP) culverts located under the railway, south of 48 Avenue	

Typical Survey Cross-sections of West Unnamed Creek Man-made Channels

Description	Surveyed Channel Cross-Sections
West Unnamed Creek between West Woodland and Sunset Crescent Subdivisions	
West Unnamed Creek across Sewage Treatment Facility	

Central Unnamed Creek Basin

Culverts Structures

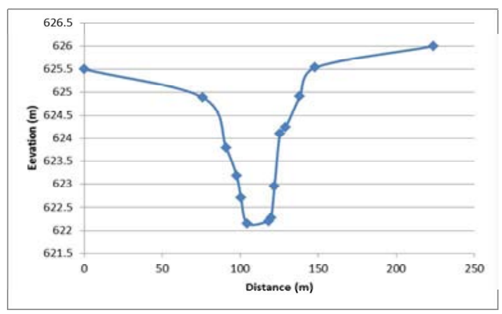
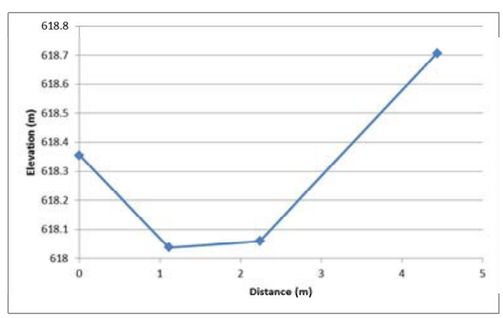
Structure	Photo
2 – 1350 mm diameter × 15.5 m CSP culverts under the railway, north of 47 Avenue.	
Bridge File 73652 (Alberta Transportation numbering system) consist of a 2000 mm diameter × 42 m length concrete culvert under Highway 45, approximately 36 m north of the intersection of 49 Avenue and Highway 45.	
1500 mm diameter × 15 m length and 600 mm diameter × 16 m length CSP culverts under park trail located at the east end of 51 Avenue	

East Unnamed Creek Basin

Creek Culverts

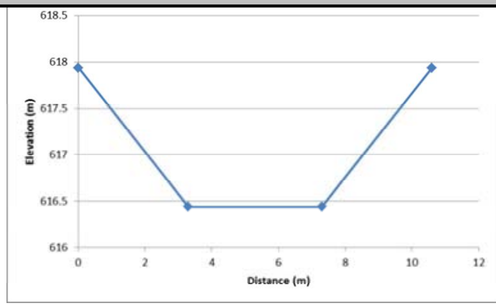
Structure	Photo
2 – 850 mm × 13 m length CSP culverts under 48 Street, approximately 180 m north of the intersection of 48 Street and 56 Avenue.	

Typical Survey Cross-sections of East Unnamed Creek

Description	Surveyed Channel Cross-Sections
East Unnamed Creek north of the Brookside Park Subdivision	
East Unnamed Creek west of the Culvert Crossings	

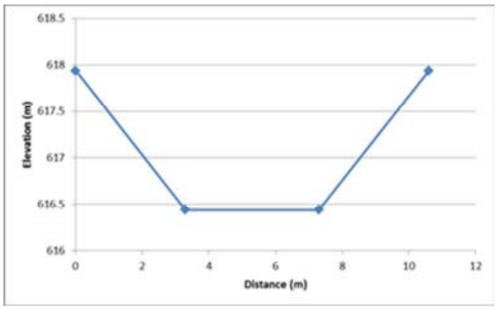
West Boundary Creek Basin

Typical Cross-sections of West Boundary Creek

Description	Channel Cross-Section
West Boundary Creek man-made channel located north of the Sewage Treatment Facility	

North Boundary Creek Basin

Typical Cross-sections of North Boundary Creek Man-made Channel

Description	Channel Cross-Section
North Boundary Creek man-made channel	

Detailed Upgrades Information

Upgrade SC1

SC1 consists of the replacement of Manhole MH2 (J170) with a new drop manhole structure (approximately 1 m drop).

A new 450 mm diameter storm pipe, approximately 42 m long, is proposed to be installed from the new drop manhole to the existing dry pond facility. The new storm sewer pipe will cross under the existing man-made Creek channel with an approximately clearance of 0.6 m. Details for this upgrade should be confirmed during the design stage once survey of the area is available.

Upgrade WW1

WW1 consists in the replacement of the existing 450 mm diameter CSP culvert with new 750 mm diameter CSP culvert to prevent overtopping of the road grade during the 1:100 year storm event.

Upgrade DA1

DA1 includes the replacement of the existing 300 mm storm sewer, running from Manhole MH502 (J20) to Manhole MH503 (J22), with a new 450 mm storm sewer pipe with a total length of approximately 51m. This upgrade will reduce the surcharge levels for the 1:5 year storm event and reduce ponding risk along 51 Avenue.

Upgrade DA2

DA2 includes the installation of five storm sewer pipes along 51 Street. The proposed storm sewer sizes are summarized in Table 5.6. Conceptual pipe sizes were designed for the 1:5 year storm event.

The total length for the proposed pipes will be approximately 800 m and will start from a new Manhole J172 to a new outfall structure discharging to the proposed Central Unnamed Creek channel.

Upgrade DA2 – Proposed Storm sewer Pipe Sizes

Pipe ID	From MH	To MH	Proposed Pipe (mm)	Approx. Pipe Length (m)
C104	J172	J175	750	102
C177	J175	J179	750	102
C178	J179	J173	750	216
C105	J173	J77	900	290
C100	J77	New Outfall	1050	88

The purpose of this upgrade is to prevent long runs of overland flow along the south part of the downtown area, and to provide water quality and quantity control through the diversion of flows to a new stormwater management facility.

Upgrade BP1

BP1 consists of the replacement of four storm sewer pipes located along 45 Street and 47 Street. The proposed storm sewer sizes are summarized below.

Upgrade BP1 – Proposed Storm sewer Pipe Sizes

Pipe ID	Location	From MH	To MH	Existing Pipe Size (mm)	Proposed Pipe Size (mm)	Length (m)
C45	47 Street	MH305	MH307	450	525	87.8
C46	47 Street	MH307	MH308	450	600	92.3
C47	47A Street	MH308	MH309	525	1050	112.8
C33	45 Street	MH310	MH311	375	450	112.8

As noted above, the purpose of these upgrades is to reduce surcharge levels about ground in the 1:5 year storm event, and provide additional capacity for future subdivision expansion.

Upgrade BP2

BP2 consists of the construction of a stormwater management facility (P1) on the northwest part of the Brookside Park Subdivision. The proposed ponds will be provided to temporarily store stormwater runoff in order to promote the settlement of runoff pollutants and to restrict discharge to predetermined levels to reduce downstream flooding and erosion potentials.

The conceptual design for the proposed stormwater management facility will have the following characteristics:

- Normal Water Level (NWL) of 619.5 m.
- High Water Level (HWL) of 621.5 m.
- Minimum top of berm elevation of 622 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 617.5 m (2 m depth of permanent pool).
- Required flood storage of 16640 m^3 (calculated based on a release rate of 3.9 L/s/ha).
- Total contributing area of approximately 42.6 ha. This area does not include the future residential/commercial area south of Highway 45.
- Pond footprint area of 1ha.
- Pond Outlet: 1050 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 312 mm diameter orifice to control the peak discharge of 0.263 m^3/s. The orifice was sized to accommodate the contributing area form the residential/commercial area, south of Highway 45.

- An emergency overflow.

The elevations noted above are based on the DEM information and survey of existing twin 850 mm diameter culvert inverts under the 48 Street. These elevations should be confirmed during the design stage.

In order to provide stormwater management for the Brookside Park subdivision, the two existing outfalls to the East Unnamed Creek should be abandoned. A new storm sewer is proposed to be constructed to intersect existing system at Manhole MH316 towards the proposed pond (Upgrade BP3).

Upgrade BP3

Upgrade BP3 consists of the installation of a new storm sewer pipe along the north side of the division to intersect flows from 45 Street to the proposed stormwater management facility (P2).

The new 900 mm diameter storm pipe is recommended to be installed from the existing Manhole MH316 (located on 45 Street) to another existing Manhole MH308 (located on 47 Street). This pipe will intersect flows from the existing system and divert them to Pond P1.

Upgrade BP4

BP4 upgrade includes the installation of approximately 158 m of new 450 mm diameter storm sewer, starting from a new Manhole J140 (located on 45 Street, just south of Highway 45) to existing Manhole MH310 located at the intersection between 45 Street and 53 Avenue.

As previously mentioned, this upgrade will divert flows from the future south residential/commercial area of Highway 45 towards to the proposed pond P1. Flows from this area will be controlled before discharging to the proposed 450 mm diameter storm sewer.

Upgrade FU1

As mentioned above, a new stormwater management facility (P2) is proposed to be constructed in this quarter section to provide water quality and quantity control for a total contributing area of approximately 88.6 ha.

The Pond P2 will provide stormwater management to the future residential development within the Sec. 56-20-4 (Southeast Quarter Section) and existing downtown area. The north part of the downtown area will continue discharging to the Central Unnamed Creek which will eventually be draining towards the proposed stormwater management facility. Runoff from the south part of downtown area will be intersected through a new 750 mm diameter storm sewer (as described in the Upgrade DA2), and directed to the proposed pond P2.

In order to provide positive overland drainage and installation of storm sewer pipes towards the proposed pond, grading and filling of the quarter section will be required.

The conceptual design for the proposed stormwater management facility will have the following characteristics:

- Normal Water Level (NWL) of 618.5 m.
- High Water Level (HWL) of 620.5 m.
- Minimum top of berm elevation of 621 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 616.5 m (2 m depth of permanent pool).
- Required flood storage of 41630 (calculated based on a release rate of 3.9 L/s/ha).
- Pond footprint area of 1.9 ha.
- Pond Outlet: 1500 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 950 mm diameter orifice to control the peak discharge of 2.2 m^3/s. The orifice was sized to accommodate the offsite contributing areas draining towards the Central Unnamed Creek.
- Emergency overflow.

The elevations noted above are based on the DEM contours. Detailed survey will be required during the design stage to confirm elevations and general topography of the quarter section.

Storm pipes in the range of 900 mm – 1050 mm diameter will be required along the future arterial road to intersect surface runoff and direct it towards to the new stormwater management facility as shown in Figure 5.8.

A 1500 mm diameter storm sewer is also proposed along the west side of the quarter section. This proposed pipe will carry the controlled flow from Pond P2 and discharge it to the main man-made channel located north of the sewage treatment facility.

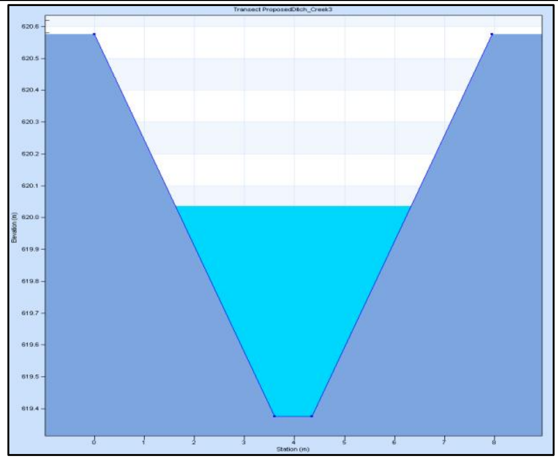
Upgrade FU2

The East Unnamed Creek man-made channel is currently undersized for both design storms (1:5 and 1:100 year) based on the model results. Upgrades and re-alignment of the channel are recommended to provide capacity for the 1:100 year storm event without surcharging above ground surface, and to allow further use of the quarter section for future development.

The proposed channel alignment will run north, parallel to 48 Street, and then west along the north quarter section boundary, as shown in Figure 5.8. The proposed channel will connect to the existing main man-made channel located just north of the sewage treatment facility.

The conceptual East Unnamed Creek channel characteristics and cross-section are summarized below.

Conceptual Channel Characteristics and Cross-Section – East Unnamed Creek

Channel Characteristics	Values	Proposed Channel Cross-Section
Slope (%)	0.3	
Approx. Total Length (m)	1000	
Top Width (m)	7.95	
Bottom Width (m)	0.75	
Channel Depth (m)	1.2	
Channel Sideslope (H:V)	3:1	
Max. Water Depth (m) (1:100 year storm)	0.9	
Freeboard (m) (1:100 year storm)	0.3	

Upgrade FU3

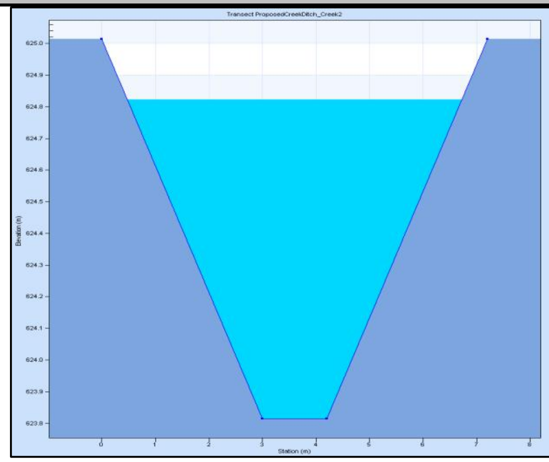
The Central Unnamed Creek currently does not have a well define drainage channel after it passes through the existing bridge structure (Bridge File 00154) located on 52 Avenue, just west of Highway 45 intersection. Creek flow seems to be trapped within the quarter section until it finds its way to the existing East Unnamed Creek man-made ditch. The available DEM contours does not reflect low areas within this section, however, based on conversations with Town personnel, this area has present ponding issues and drainage concerns in the past.

The proposed channel will provide capacity for the 1:100 year storm event without surcharging above ground surface and will drain directly towards the proposed stormwater management facility (P2).

The conceptual Central Unnamed Creek channel characteristics and cross-section are summarized in the below Table.

A 1500 mm diameter CSP culvert with an approximately length of 80 m is proposed to be installed to carry the Central Unnamed Creek under the future arterial road. The culvert will provide capacity for the 1:100 year storm event without overtopping the future road grade (conceptual road grade elevation estimated from DEM contours).

Conceptual Channel Characteristics and Cross-Section – Central Unnamed Creek

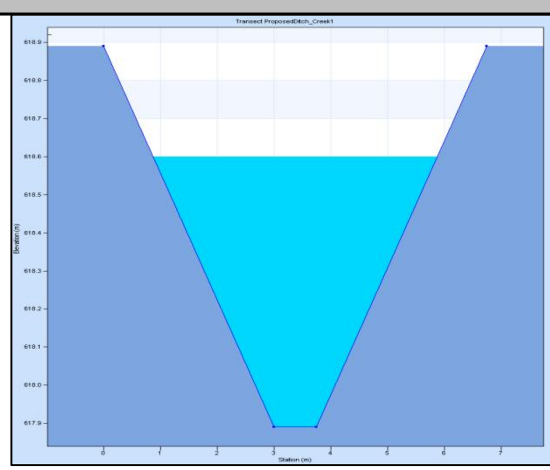
Channel Characteristics	Values	Proposed Channel Cross-Section
Slope (%)	0.5	
Approx. Total Length (m)	611	
Top Width (m)	7.2	
Bottom Width (m)	1.2	
Channel Depth (m)	1	
Channel Sideslope (H:V)	3:1	
Max. Water Depth (m) (1:100 year storm)	0.6	
Freeboard (m) (1:100 year storm)	0.4	

Upgrade FU4

The West Unnamed Creek man-made channel, specifically, the channel section located within the sewage treatment facility, is currently undersized for both design storms (1:5 and 1:100 year) based on the model results.

Upgrades of the channel cross-section are recommended to provide capacity for the 1:100 year storm event without surcharging above the channel top of banks. The conceptual East Unnamed Creek channel characteristics and cross-section is shown below.

Table 5.10
Conceptual Channel Characteristics and Cross-Section – West Unnamed Creek

Channel Characteristics	Values	Proposed Channel Cross-Section
Slope (%)	0.7	
Approx. Total Length (m)	301	
Top Width (m)	6.75	
Bottom Width (m)	0.75	
Channel Depth (m)	1	
Channel Sideslope (H:V)	3:1	
Max. Water Depth (m) (1:100 year storm)	0.7	
Freeboard (m) (1:100 year storm)	0.3	

Upgrade FU5

FU5 includes the construction of a new stormwater management facility (P3), as shown in Figure 5.6, to serve the east side of the quarter section (due to the existing topography of the area) and provide storm quantity control at a pre-development release rate of 3.9 l/s/ha.

The proposed upgrade will provide stormwater management for the future development area and will direct controlled flows north, towards the Brookside Park existing storm sewer system (as described in Upgrade BP4).

The conceptual design for the proposed Pond P3 will have the following characteristics:

- Normal Water Level (NWL) of 627.5 m.
- High Water Level (HWL) of 628.8 m.
- Minimum top of berm elevation of 629.3 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 625.5 m (2 m depth of permanent pool).
- Required flood storage of 12810 m^3 (calculated based on a release rate of 3.9 L/s/ha).
- Pond footprint area of 0.8 ha.
- Pond Outlet: 450 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 200 mm diameter orifice to control the peak discharge of 0.097 m^3/s.
- Emergency overflow.

This upgrade also includes the installation of approximately total length of 450 m of 900 mm diameter storm pipes along the 45 Street to intersect runoff from the future developments and direct it towards to the stormwater management facility (P3). The proposed pipe was sized for the 1:5 year storm event as per the Town of Bruderheim Engineering Design Standards.

Upgrade FU6

Similar to FU5, upgrade FU6 includes the construction of a new stormwater management facility (P4) to serve the west side of the quarter section, and to provide water quality and quantity control at a pre-development release rate of 3.9 l/s/ha.

The proposed upgrade will provide stormwater management for the future development area (mix of commercial, residential and institutional land uses). A 1000 mm outlet pipe is proposed to drain the controlled flows from the Pond P4 across Highway 45 and towards the Central Unnamed Creek, as shown in Figure 5.8.

The conceptual design for the proposed stormwater management facility will have the following characteristics:

- Normal Water Level (NWL) of 626.5 m.
- High Water Level (HWL) of 628 m.
- Minimum top of berm elevation of 628.5 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 624.5 m (2 m depth of permanent pool).

- Required flood storage of 12130 m^3 calculated based on a release rate of 3.9 L/s/ha).
- Pond footprint area of 7.5 ha.
- Pond Outlet: 1000 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 175 mm diameter orifice to control the peak discharge of 0.080 m^3/s.
- Emergency overflow.

Upgrade FU7

This section is mainly undeveloped with small residential and commercial areas. Planning for future land uses includes mainly residential developments. In order to minimize erosion and impact to downstream waterbodies, the stormwater management guidelines recommends implementing water quantity control in the form of storm ponds and controlled release rates.

The conceptual design for the proposed stormwater management facility (P5) will have the following characteristics:

- Normal Water Level (NWL) of 631.1 m.
- High Water Level (HWL) of 633.1 m.
- Minimum top of berm elevation of 633.6 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 629.1 m (2 m depth of permanent pool).
- Required flood storage of 31620 m^3 (calculated based on a release rate of 3.9 L/s/ha).
- Pond footprint area of 1.3 ha.
- Pond Outlet: 1200 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 270 mm diameter orifice to control the peak discharge of 0.208 m^3/s.
- Emergency overflow.

Controlled flows from Pond P5 will be discharging to the Central Unnamed Creek, as shown in Figure 5.8.

1200 mm diameter CSP pipes are the preliminary pipe sizes recommended to intersect runoff from the section and drain it towards to Pond P5. The conceptual alignment of the storm sewer pipes are recommended to be installed along the future arterial road, however, alignment and location will likely change based on future residential development plans.

The pipes were sized for the 1:5 year storm event and based on the available DEM contours information.

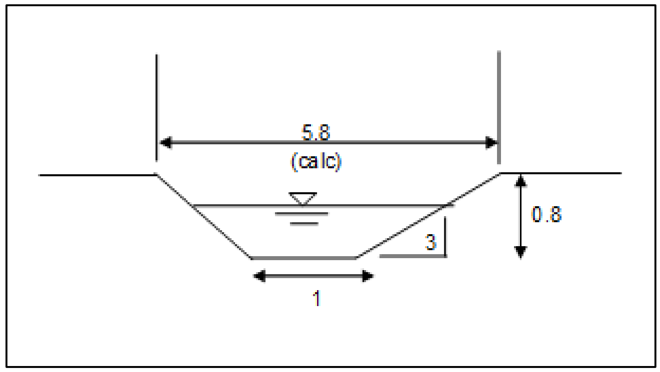
Upgrade FU8

A small tributary of the Central Unnamed Creek is currently draining through the southeast corner of the section under the railway. FU8 consists in the channelization of the small tributary along the east side boundary of the Town, as show in Figure 5.8.

The proposed creek channel is proposed to run north along the east Town boundary and then, west towards the existing 2-1350 mm diameter CSP culverts. The channel will provide capacity for the 1:100 year storm event without surcharging above ground surface.

Peak flow used for the conceptual design of the channel was estimated by assuming that the contributing area (area outside of the Town boundary) will continue be undeveloped. If the area is developed in the future, stormwater management shall be provided to control flows to a pre-development rate of 3.9 l/s/ha.

Conceptual Channel Characteristics and Cross-Section – Small Tributary

Channel Characteristics	**Values**	**Proposed Channel Cross-Section**
Slope (%)	1	
Approx. Total Length (m)	1300	
Top Width (m)	5.8	
Bottom Width (m)	1	
Channel Depth (m)	0.8	
Channel Sideslope (H:V)	3:1	
Max. Water Depth (m) (1:100 year storm)	0.5	
Freeboard (m) (1:100 year storm)	0.3	

Upgrade FU9

The proposed stormwater management facility (P6) will be located on the northwest quarter section (between the two railways). A 1500 mm diameter outlet pipe will be required to drain flows from the pond towards to the existing road ditch along 61 Street.

The conceptual design for the proposed stormwater management facility will have the following characteristics:

- Normal Water Level (NWL) of 632 m.
- High Water Level (HWL) of 634 m
- Minimum top of berm elevation of 634.5 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 630 (2 m depth of permanent pool).
- Required flood storage of 44460 m^3 (calculated based on a release rate of 3.9 L/s/ha).
- Pond footprint area of 1.65 ha.
- Pond Outlet: 1500 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 270 mm diameter orifice to control the peak discharge of 0.23 m^3/s.
- Emergency overflow.

1500 mm diameter CSP pipes are the recommended pipe sizes to intersect runoff from the section and drain it towards to the proposed stormwater management facility (P6). Pipes were sized for the 1:5 years storm event without surcharging (RIM elevations were assumed based on the existing topography and DEM contours).

Upgrade FU10

FU10 includes the construction of a stormwater management facility (P7) located on the northeast quarter section (between the two railways). A 1500 mm diameter outlet pipe will be required to drain flows from the pond towards to the West Unnamed Creek at a pre-development release rate of 3.9 l/s/ha.

The conceptual design for the proposed stormwater management facility will have the following characteristics:

- Normal Water Level (NWL) of 629.8 m.
- High Water Level (HWL) of 631.8 m.
- Minimum top of berm elevation of 632.3 m, providing 0.5 m freeboard.
- Bottom of pond elevation of 627.8 m (2 m depth of permanent pool).
- Required flood storage of 27190 m^3 (calculated based on a release rate of 3.9 L/s/ha).
- Pond footprint area of 1.25 ha.
- Pond Outlet: 1500 mm diameter PVC pipe with inlet depressed under water.
- A control structure will be required with a 220 mm diameter orifice to control the peak discharge of 0.14 m^3/s.
- Emergency overflow.

This upgrade also includes the installation of 1500 mm diameter storm sewers along the future arterial roads to intersect runoff from the future developments and direct it towards to the stormwater management facility.

The proposed pipes were sized for the 1:5 year storm event as per the Town of Bruderheim Engineering Design Standards.

Upgrade FU11

FU11 consists in the replacement of the existing 2 – 900 mm diameter CSP culverts with 2 new 1200 mm diameter CSP culverts to prevent overtopping of the road grade during the 1:100 year storm event.

Appendix C - Future Development - Detailed Storm Pond Calculations

Characteristics of Future Stormwater Management Facilities

Pond ID	Contributing Area (ha)	Future Land Use	Design Storm	Required Storage (m3)**	Peak Outfall (m3/s)	Pond Footprint Area (ha)	Pond Bottom EL. (m)	NWL EL. (m)*	HWL EL. (m)*	Top of Berm EL. (m)*	Pond Depth (m)	Orifice Size (mm)
P8	35.2	Commercial	1:25 year	27280	0.14	1.7	638.5	640.5	642.5	643.0	2.0	222
P9	65.9	Commercial/Industrial	1:25 year	43050	0.26	2.6	650.5	652.5	654.5	655.0	2.0	301
P10	67.0	Industrial	1:25 year	37540	0.26	2.3	663.0	665.0	667.0	667.5	2.0	305
P11	46.8	Commercial/Industrial	1:25 year	36070	0.18	2.2	643.5	645.5	647.5	648.0	2.0	255
P12	65.9	Commercial/Industrial	1:25 year	49730	0.26	3.0	650.5	652.5	654.5	655.0	2.0	301
P13	65.9	Commercial/Industrial	1:25 year	49730	0.26	3.0	662.5	664.5	666.5	667.0	2.0	301
P14	45.2	Industrial	1:25 year	25620	0.18	1.6	644.5	646.5	648.5	649.0	2.0	251
P15	65.5	Industrial	1:25 year	36710	0.26	2.3	653.0	655.0	657.0	657.5	2.0	302
P16	65.5	Industrial	1:25 year	36710	0.26	2.3	662.5	664.5	666.5	667.0	2.0	302
P17	65.5	Residential	1:100 year	23870	0.26	1.5	615.5	617.5	619.5	620.0	2.0	302
P18	65.5	Residential	1:100 year	23870	0.26	1.5	615.0	617.0	619.0	619.5	2.0	302
P19	65.5	Residential	1:100 year	23870	0.26	1.5	615.0	617.0	619.0	619.5	2.0	302

*** Estimated Elevations based DEM contours.**

**** Storage calculated based on the Modified Rational Method and Future Land Use**

Appendix D - Unit Cost and Detailed Cost Estimates

Table D-1
Town of Bruderheim Master Services Plan
Water Distribution System Unit Costs

Watermains

Undeveloped Lands

Item	200mm	250mm	300mm	350mm	400 mm
Topsoil Stripping and Stockpile (assume depth of 0.4m)	$20	$20	$20	$20	$22
Trenching and backfilling	$290	$290	$290	$290	$340
Pipe Zone Material	$30	$30	$30	$30	$55
Supply and Install DR18 Pipe	$90	$120	$170	$230	$300
Place Topsoil, compact and seed	$40	$40	$40	$40	$45
Fire Hydrant (1 every 90 m)	$110	$110	$110	$110	$110
Gate Valve (1 per 100m, 300 mm down)	$35	$55	$75	$100	$65
Fittings (Tees, Bends, Reducers, Plugs)	$12	$14	$16	$18	$22
Miscellaneous (Mob/De-Mob, Survey, Signage) (10%)	$63	$68	$75	$84	$96
Total Construction	$690	$747	$826	$921	$1,055
Contingency (15%)	$103	$112	$124	$138	$158
Engineering (15%)	$103	$112	$124	$138	$158
Project Total (rounded)	**$900**	**$970**	**$1,070**	**$1,200**	**$1,370**

Developed Lands

Item	200mm	250mm	300mm	350mm	400mm
Asphalt Pavement Removal	$50	$50	$50	$50	$75
Granular Base Removal and Disposal	$35	$35	$35	$35	$50
Curb,Gutter, Sidewalk Removal	$55	$55	$55	$55	$55
Trenching and Backfilling	$400	$400	$400	$400	$450
Pipe Zone Material	$30	$30	$30	$30	$55
Supply and Install DR 18 Pipe	$90	$120	$170	$230	$300
Monolitic Sidewalk Curb and Gutter	$210	$210	$210	$210	$210
Existing Pavement Repair	$220	$220	$220	$220	$330
Fire Hydrant (1 every 90 m)	$110	$110	$110	$110	$110
Gate valve (1 per 100m 300mm down, 1 per 200m 400mm and up)	$35	$55	$75	$100	$100
Fittings (Tees, Bends, Reducers, Plugs)	$12	$14	$16	$18	$22
Reconnect Services	$220	$220	$220	$220	$220
Manhole/Valve/Catch Basin Adjustments	$10	$10	$10	$10	$0
Miscellaneous (Mob/De-Mob, Survey, Signage) (10%)	$148	$153	$160	$169	$198
Total Construction	$1,624	$1,681	$1,761	$1,856	$2,174
Contingency (15%)	$244	$252	$264	$278	$326
Engineering (15%)	$244	$252	$264	$278	$326
Project Total (rounded)	**$2,110**	**$2,190**	**$2,290**	**$2,410**	**$2,830**

Table D-2
Town of Bruderheim Master Services Plan
Water Distribution System Upgrades

Location (Roadway or Township Plan)	From		To		Length	Ex. Pipe Diameter	Prop. Pipe Diameter	Unit Price	Cost
	Roadway	*Node #	Roadway	*Node #	(m)	(mm)	(mm)	($/m)	($)
Interconnect at Queen Street	52 Ave	J-89	52 Ave	J-47	15	-	300	$2,290	$34,000
48th Street looped mains					150	-	300	$2,290	$344,000
48th Street	52 Ave	J-50	46 Ave S.	J-93	810	-	350	$2,410	$1,952,000
48th Street south		J-93		J-79	52	-	250	$2,190	$114,000
48th Avenue	53 St	J-72	51 St	J-42	300	-	250	$970	$291,000
Reservoir to Brookside		J-54		J-26	1070	-	300	$1,070	$1,145,000
47th Street	47 Ave	J-26	46 Ave	J-26	140	-	200	$900	$126,000
								Subtotal	**$4,006,000**
Additional Items									
Reservoir Expansion								$1,500/$m^3$	$1,500,000
New Standby Pump								$200,000	$200,000
Install New Hydrants					27	each		$12,000	$324,000
Easement								$125,000/ha	$106,000
								Subtotal	**$2,130,000**
								Total	**$6,136,000**

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Table D-3
Town of Bruderheim Master Services Plan
Sanitary Collection System Unit Costs

Sanitary Forcemain

Undeveloped Lands

Item	200mm	250mm
Topsoil Stripping and Stockpile (assume depth of 0.4m)	$20	$20
Trenching and backfilling	$290	$290
Pipe Zone Material	$30	$30
Supply and Install DR25 Pipe	$65	$100
Place Topsoil, compact and seed	$40	$40
Plug Valve (1 per 500 m)	$10	$12
Fittings (Tees, Bends, Reducers, Plugs)	$12	$14
Miscellaneous (Mob/De-Mob, Survey, Signage) (10%)	$47	$51
Total Construction	$514	$557
Contingency (15%)	$77	$83
Engineering (15%)	$77	$83
Total	$668	$724
Project Total (rounded)	**$670**	**$720**

Manholes (1,200 mm dia; depth to invert 3-4 m) $12,000/each

Easement (850m x 10m) $125,000/ha

Storm Drainage System
Detailed Cost Estimate

Cost estimates have been developed for each of the upgrades described in Section 5.3. The cost estimates include:

- Excavation & Removal of existing storm pipes.
- Storm Sewer (including supply and install of pipes, manholes and drop structures).
- Excavation for stormwater management facilities.
- Landscaping.
- Control Structure (for storm pond options only).
- Culvert replacement.
- Channel re-alignment and upgrades.
- 50% for Engineering, Administration, Overheads, and Contingency.

Upgrade SC1 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
450 mm Diameter Storm Pipe	l.m.	42	1500	63000
Drop MH	v.m.	1	7000	7000
Total				70000
30% Overhead, Administration, Engineering and Contingency				21000
Total Cost				**91000**

Upgrade WW1 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
750 mm Diameter CSP Culverts	l.s.	1	85000	85000
Total				85000
30% Overhead, Administration, Engineering and Contingency				25500
Total Cost				**110500**

Upgrade DA1 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
450 mm Diameter Storm Pipe	l.m.	51	1500	76500
Total				77000
30% Overhead, Administration, Engineering and Contingency				23100
Total Cost				**100100**

Upgrade BP2 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	25000	15	375000
Landscaping	lump sum	1	50000	50000
Inlet/outlet pipes 1050 mm	l.m.	50	2280	114000
Connect to Existing MH	each	1	3500	3500
Control Structure	l.s	1	100000	100000
Outfalls (flared end)	each	3	7500	22500
Total				665000
30% Overhead, Administration, Engineering and Contingency				199500
Total Cost				**864500**

Upgrade DA2 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
750 mm Diameter Storm Pipe	l.m.	420	1890	793800
900 mm Diameter Storm Pipe	l.m.	290	2160	626400
1050 mm Diameter Storm Pipe	l.m.	88	2280	200640
New MH	each	5	17500	87500
Total				1708340
30% Overhead, Administration, Engineering and Contingency				512502
Total Cost				**2220842**

Upgrade BP1 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
450 mm Diameter Storm Pipe	l.m.	113	1500	169500
525 mm Diameter Storm Pipe	l.m.	88	1550	136400
600 mm Diameter Storm Pipe	l.m.	93	1680	156240
1050 mm Diameter Storm Pipe	l.m.	113	2280	257640
Total				719780
30% Overhead, Administration, Engineering and Contingency				215934
Total Cost				**935714**

Upgrade BP3 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
900 mm Diameter Storm Pipe	l.m.	364	2160	786240
Connect to Existing MH	each	2	5000	10000
Total				796240
30% Overhead, Administration, Engineering and Contingency				238872
Total Cost				**1035112**

Upgrade FUT1 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	45000	15	675000
Landscaping	lump sum	1	50000	50000
Outlet Pipe 1500 mm	l.m.	130	3600	468000
Control Structure	l.s	1	100000	100000
Outfalls (flared end)	each	2	7500	15000
Total				1308000
30% Overhead, Administration, Engineering and Contingency				392400
Total Cost				**1700400**

Upgrade BP4 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
450 mm Diameter Storm Pipe	l.m.	158	1500	237000
Connect to Existing MH	each	1	5000	5000
New MH	each	1	17500	17500
Total				260000
30% Overhead, Administration, Engineering and Contingency				78000
Total Cost				**338000**

Upgrade FUT2 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	9540	15	143100
Supply and Place 150mm depth Topsoil and Seed	m2	7950	15	119250
Total				262350
30% Overhead, Administration, Engineering and Contingency				78705
Total Cost				**341055**

Upgrade FUT3 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	4400	15	66000
Supply and Place 150 mm depth Topsoil and Seed	m2	4400	15	66000
Total				132000
30% Overhead, Administration, Engineering and Contingency				39600
Total Cost				**172000**

Upgrade FUT4 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	2032	15	30480
Supply and Place 150 mm depth Topsoil and Seed	m2	2032	15	30480
Total				60960
30% Overhead, Administration, Engineering and Contingency				18300
Total Cost				**79260**

Upgrade FUT5 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	14400	15	216000
Landscaping	lump sum	1	50000	50000
Inlet/Outlet Pipe 900 mm	l.m.	40	2160	86400
Outfalls (flared end)	each	2	7500	15000
Control Structure	l.s	1	100000	100000
Total				467400
30% Overhead, Administration, Engineering and Contingency				140220
Total Cost				**607620**

Upgrade FUT6 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	15000	15	225000
Landscaping	lump sum	1	50000	50000
Inlet/Outlet Pipe 1050 mm	l.m.	100	2280	228000
Outfalls (flared end)	each	3	7500	22500
Control Structure	l.s	1	100000	100000
Total				625500
30% Overhead, Administration, Engineering and Contingency				187650
Total Cost				**813150**

Upgrade FUT7 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	30000	15	450000
Landscaping	lump sum	1	50000	50000
Inlet/Outlet Pipe 1200 mm	l.m.	120	3000	360000
Outfalls (flared end)	each	2	7500	15000
Control Structure	l.s	1	100000	100000
Total				975000
30% Overhead, Administration, Engineering and Contingency				292500
Total Cost				**1267500**

Upgrade FUT8 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	7540	15	113100
Supply and Place 150 mm depth Topsoil and Seed	m2	7540	15	113100
Total				226200
30% Overhead, Administration, Engineering and Contingency				67900
Total Cost				**294100**

Upgrade FUT9 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	42000	15	630000
Landscaping	lump sum	1	50000	50000
Inlet/Outlet Pipe 1500 mm	l.m.	260	3600	936000
Outfalls (flared end)	each	3	7500	22500
Control Structure	l.s	1	100000	100000
Total				1738500
30% Overhead, Administration, Engineering and Contingency				521550
Total Cost				**2260050**

Upgrade FUT10 Cost Estimate

Description	Unit	Quantity	Unit Cost	Cost
Excavation and Grading	m3	30000	15	450000
Landscaping	lump sum	1	50000	50000
Inlet/Outlet Pipe 1500 mm	l.m.	130	3600	468000
Outfalls (flared end)	each	3	7500	22500
Control Structure	l.s	1	100000	100000
Total				1090500
30% Overhead, Administration, Engineering and Contingency				327150
Total Cost				**1417650**