CITY OF EPPING

MASTER PLAN

JUNE 9, 2016

PREPARED BY:

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CITY OF EPPING

MASTER PLAN

JUNE 9, 2016

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1. Executive Summary

A Master Plan is a tool to facilitate current planning to direct long-range planning in a community. It is primarily used as a standard to guide land uses and to evaluate proposed developments for conserving and promoting the public health, safety, and general welfare of the City. The planning process of the City of Epping (City) made comprehensive surveys and studies of present conditions and predictions for future growth. The Master Plan is intended to be a general guide for accomplishing the coordinated, attuned and harmonious development of a city and its surroundings. In accordance with NDCC Chapter 40-48, the City of Epping has exercised their authority to adopt this Master Plan.

The perimeter of the City has been relatively untouched until the recent oil boom, which has brought hundreds of trucks and people to the area. In recent years, the City has experienced noticeable change around its City limits with the development of several homes and a trans-loading facility to the east of the City. The development of mixed-used development to the south of the City and the inclusion of temporary housing camps for area hydrocarbon production has also exacerbated the changes to the community.

This Master Plan provides the opportunity to revisit the land use policies which will shape the future of this community as well as provide guidance to City officials as the City and surrounding areas change. This Plan specifically addresses the elements of culinary water, sanitary sewer, stormwater, and transportation in the City of Epping. Future additions to the Master Plans or even a General Plan may be created to address other land use components including but not limited to:

- Recreational Areas: Parks, Playgrounds, and Open Space
- Location of buildings, public properties, and historic properties
- Land Use and Density
- Improvement and control of architecture
- Economics

1.1 Summary of Projected Projects

The recommended improvements will support the City's objectives to better serve public's needs and provide adequate water pressure for fire protection as well as providing sufficient capacities to expand systems in areas of projected future growth. As new development occurs, the infrastructure systems will need to be expanded and improved to adequately serve growth. This may be done by partnering with developers and acquiring state and federal funding. Planning for potential growth and identifying funding sources that the City acquires may help to pay for the evaluation, repair and replacement of infrastructure.

It is recommended that the City implement a funding program for the proposed improvements consisting of a combination of increase user rates, altered rate structure, and government assistance. A summary of the proposed projects can be viewed in Table 1 on the following page. This table is split into two separate costs that describe the total possible costs that could be incurred to the City and the recommended projects list to meet existing demand.

Table 1 – Summary of Project Improvements

Culinary Water		Total Possible Cost	Current City Recommended Projects Costs for Existing Demand
1	New Fire Suppression System	-	$541,800
2	New Culinary Water System	$1,336,896	-
Sanitary Sewer			
1	Lagoon Rehabilitation	$333,519	-
2	Inspections of Existing Sewer	$99,422	$99,422
3	Upgrading Sewer Lines	$155,000	-
Summary of Improvements		$581,916	$99,422
Stormwater			
1	New Culverts	$253,872	$253,872
2	Regional Detention Basin	$392,197	-
Summary of Improvements		$646,069	$253,872
Roadway Improvements		**Option #1**	**Option #3**
1	School Ave.	$193,041	$68,769
2	Main St.	$367,267	$194,094
3	2nd St.	$504,666	$226,975
4	Front St.	$475,510	$202,699
5	3rd St.	$193,776	$74,709
6	1st. St	$219,848	$91,655
7	Uggen St	$209,110	$84,292
Summary of Improvements		$2,163,218	$943,194
New Public Safety/Fire Station		$322,500	$322,500
Grand Total		**$5,060,049**	**$2,160,788**

2. Introduction

The City of Epping's (City) infrastructure systems have reached their capacities and are beginning to experience deficiencies. The majority of the deficiencies are due to the systems reaching the end of their design life. In most of the City, pipes were installed as early as 1980. The lagoons were upgraded around 1981. Due generally to a lack of funds and planning efforts, little has been done in the last thirty years to upgrade and maintain the City's infrastructure (water, sewer, and transportation). The City is concerned that if these deficiencies are left unaddressed the conditions will worsen and that some of these deficiencies will eventually pose environmental and public safety issues and growth will continue to be hindered.

The City has been anticipating the growing needs and changes of the community and the surrounding areas. Therefore, the City of Epping contracted with Epic Engineering, P.C. (Epic) to help the City direct and manage current and future growth through the policies, guidelines, and standards of this Plan. Epic has performed a detailed analysis of the City's infrastructure systems and shall herein provide recommendations that will facilitate existing needs and future growth.

The evaluations modeled the existing system's capacities and demands in order to identify deficiencies and then prioritize those improvements that are most pivotal to the system. The systems analyzed are Culinary Water, Sanitary Sewer, Stormwater, and Transportation as detailed in this report. The evaluation also examined future anticipated demands and recommends upgrades to ensure that these systems will have sufficient capacity for build-out. ***However, it is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is achieved.***

2.1 History

The City of Epping is located off of County Highway 42, about twenty miles northeast of Williston, North Dakota. It is a community of approximately 200 people (75 households) that was founded in 1905 along the transcontinental railroad of the Great Northern Railway. Epping has proudly proclaimed itself "The Biggest Little Town" on the Great Northern Railroad. The City has a rich history with many prominent historic sites from when it was first developed, including the Buffalo Trail Museum. These sites are of great importance to the character of the City. Through the implementation of policies and regulations based on historical preservation, the personality of this community can be maintained and preserved in the years to come during the expansion of the City.

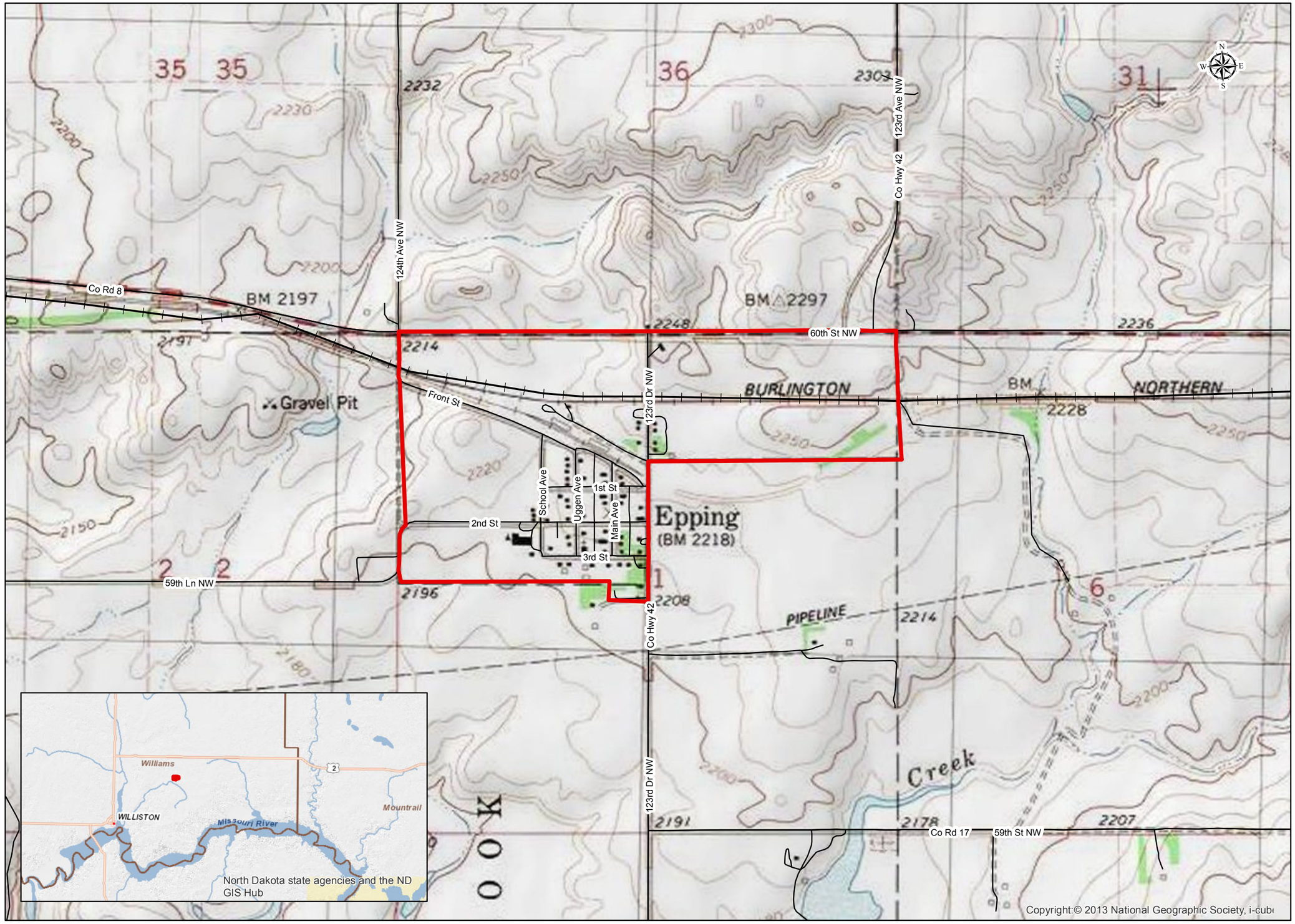
2.2 Topography

The City is located north of Stony Creek. The topography within the City limits is generally level and sloping in a southerly direction. Portions of the City extend north of the railroad to County Road 8 and it encompasses approximately 0.4 square miles of land in its current municipal boundary. However, the City has exercised its Extra Territorial Jurisdiction (ETJ) of an ½ mile and 1 mile from its existing borders thus having an area of influence of approximately 6.6 square miles. Ground elevation varies within the valley from approximately 2,198 feet above mean sea level (msl) to 2,266 feet msl (see Figure 1).

According to the U.S. Census Bureau, William's county has a total area of 2,148 square miles, of which 2,077 square miles is land and 70 square miles is water. It is the fourth largest county in North Dakota by area. Lake Sakakawea, a reservoir on the Missouri River, is situated on the southern boundary of the county. The Little Muddy Creek is entirely within Williams County. The confluence of the Yellowstone River with the Missouri is west of Williston. The Fort Union Trading Post National Historic Site is located in Williams County along the Missouri River on the Montana border. Williams County is one of several western North Dakota counties with significant exposure to the Bakken formation in the Williston Basin.

2.3 Climate

The average temperature of Epping is 44.1°F, which is similar to the North Dakota average temperature of 43.98°F and is much lower (19%) than the national average temperature of 54.50 °F. In the summer, temperatures rise to 66.6 °F on average with highest recorded temperature at 109.94 °F. The average winter temperature is 24.5°F with lowest record low at -50.08 °F. Annual precipitation is 14.34 inches with the record rainfall event being 4.93 inches in July of 1963. Average annual snowfall is 45.3 inches with the record snowfall event at 15 inches in 1986.



LEGEND

- ROADS
- RAIL ROAD
- CITY BOUNDARY

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 1,500'
(11"X17")

0 1/2"

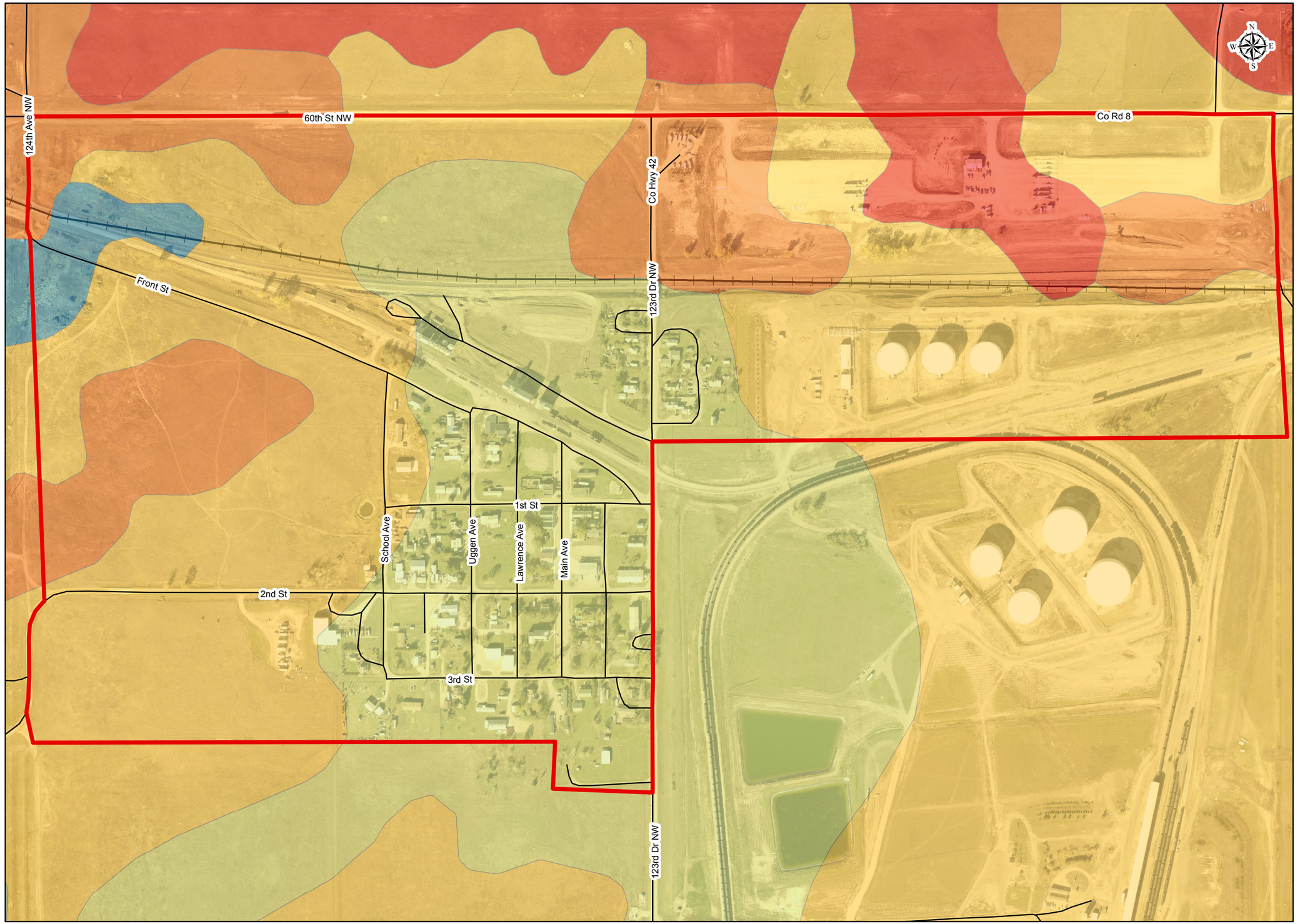
PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

USGS 7.5 MIN QUADRANGLE

PLAN SET:	FIGURE:
FINAL	1



LEGEND

- ROADS
- RAIL ROAD
- CITY BOUNDARY
- VALLERS LOAM, MOD. SALINE, 0-1%
- WABEK-LEHR COMPLEX, 2 - 6 %
- WILLIAMS-BOWBELLS LOAMS, 0 - 3 %
- WILLIAMS-BOWBELLS LOAMS, 3 - 6 %
- WILLIAMS-BOWBELLS LOAMS, 6 - 9 %
- ZAHL-WILLIAMS LOAMS, 9 - 15 %

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 400'
(11"X17")

0 1/2"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

SOIL MAP

PLAN SET:	FIGURE:
FINAL	2

2.4 Soils

Williams County is located near the center of the Bakken and the Williston Basin. The pre-glacial sedimentary formations beneath the county are as much as 14,828 feet thick. Their beds dip generally to the south except along the flanks of the north-south striking Nesson anticline in the eastern part of the county. Late Wisconsinan glacial deposits cover all of Williams County except along the Missouri River and other small areas.

Figure 2 depicts the area soils according to the United States Department of Agriculture (USDA) National Resource Conservation Services (NRCS) 15th version of the Williams County, North Dakota soil survey published September 25th, 2015. The City is primarily composed of a Williams-Bowbells complex soil (clay-loam) with some Zahl-Williams and Vallers loams. These soils are typically classified as hydrologic soil C which is moderately drained. These soils are typically good farming material as shown by the City's historic agriculture utilization.

2.5 Planning Period

This report uses a planning period from 2016 to 2040 (24 years). Development is expected to continue in and around Epping because there is available land that can be developed to different densities based on the availability of infrastructure services. The extension of the ETJ and the City's plans to annexes additional properties will increase the demands for public services. The City will most likely not reach full build-out by the year 2040. ***It is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is achieved.***

2.6 Planning Area

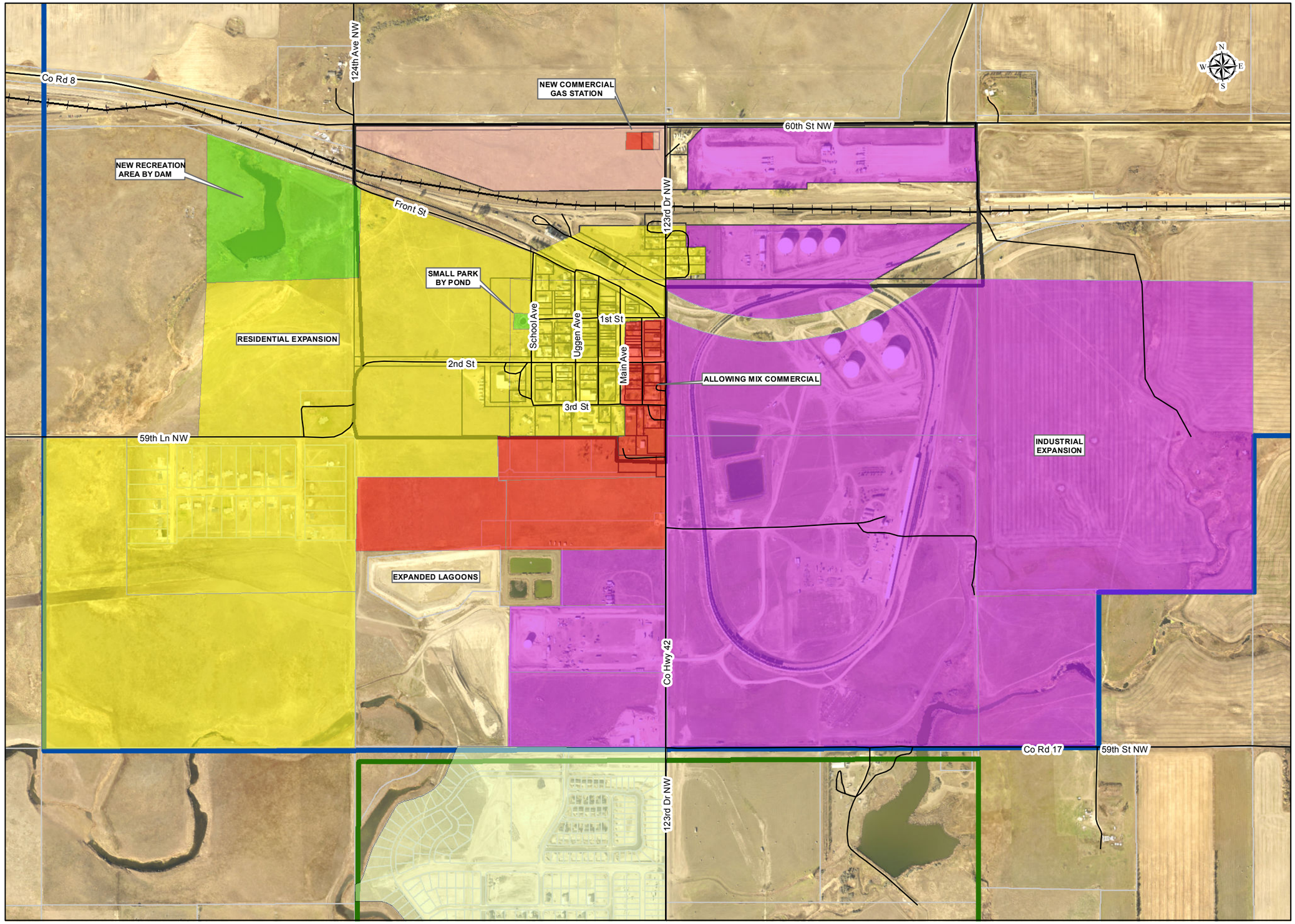
Epping has a significant amount of developable land to sustain substantial growth for many years to come. The City currently occupies approximately 242 acres. Over time, the surrounding area, from all sides of the City, are expected to annex into the City. Epping is the only entity in the area capable of annexing areas. At this time, the growth potential of the surrounding area far exceeds the current and projected demands. The majority of the residential future growth is currently anticipated to occur southwest of the City. Industrial activities have the ability to expand east of the rail spur and commercial can expand within the city and just south of the City. The areas of future anticipated growth are shown in Figure 3.

Growth within the current City limits current developed area is limited. There are several buildable residential lots available throughout town but these lots are primarily used as their owner's "overflow" of their primary lots. Approximately, 75 new homes have been proposed in the west of the City (Epping Meadows) along with several hundred homes to the south (Epping Ranch Subdivision). No part of the Epping Ranch Subdivision has been incorporated into the City's ETJ or City limits at this time. In order for the City to grow, the City is going to have to utilize the existing undeveloped area to the west and plan for annexation to the west past their boundary. A number of the commercially zoned areas to the south may choose to connect to the system or increase their density over time, which could add future connections and increased water utilization.

2.7 Population and Growth Projections

Population projections are necessary to make realistic planning decisions on such items as the amount of land needed for residential, commercial, and industrial purposes; the need for additional community facilities such as schools and parks; the need for construction or expansion of the public water and sewer systems; and the future level of tax revenues that will be available to pay for the necessary or desirable improvements.

The City of Epping has grown from a population of 116 people in 1920 to over 200 people in 2015. The growth patterns indicate a stop-and-go growth rate, with a few periods of population decline. The population growth is highly dependent upon job availability in the area, which is known to be tied to oil production, transportation of oil and gas, and continuous farming activities.



LEGEND

- ROADS
- RAIL ROAD
- CITY BOUNDARY
- CITY PARCELS
- COUNTY PARCELS
- EJT 1 MI BOUNDARY
- EJT 1/2 MI BOUNDARY
- AGRICULTURE=AG
- RURAL RESIDENTIAL=RR
- RURAL COMMERCIAL=RC
- URBAN RESIDENTIAL=UR
- URBAN COMMERCIAL=UC
- INDUSTRIAL
- RECREATIONAL=R
- PLANNED UNIT DEVELOPMENT=PUD

DATE

3/15/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT # 15SM2260.03

SCALES

HORIZ: 1"= 800'
(11"X17")

0 1/2"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

FUTURE GROWTH

PLAN SET: FINAL

FIGURE: 3

Table 2 shows the historic population and growth rates while Table 3 shows the population growth projections from the Williams County report for the City of Epping. Figure 4 graphically presents the historic and projected population for the City of Epping.

Table 2 – Historic Population

	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2014	2015
Growth Rate		5.78%	-1.58%	0.26%	-0.44%	-0.73%	-2.57%	-3.85%	2.34	2.66%	-3.00%	127%
Population	116	183	154	158	151	140	104	64	79	100	88	200
Pop Increase		67	-29	4	-7	-11	-36	-40	15	21	-12	112

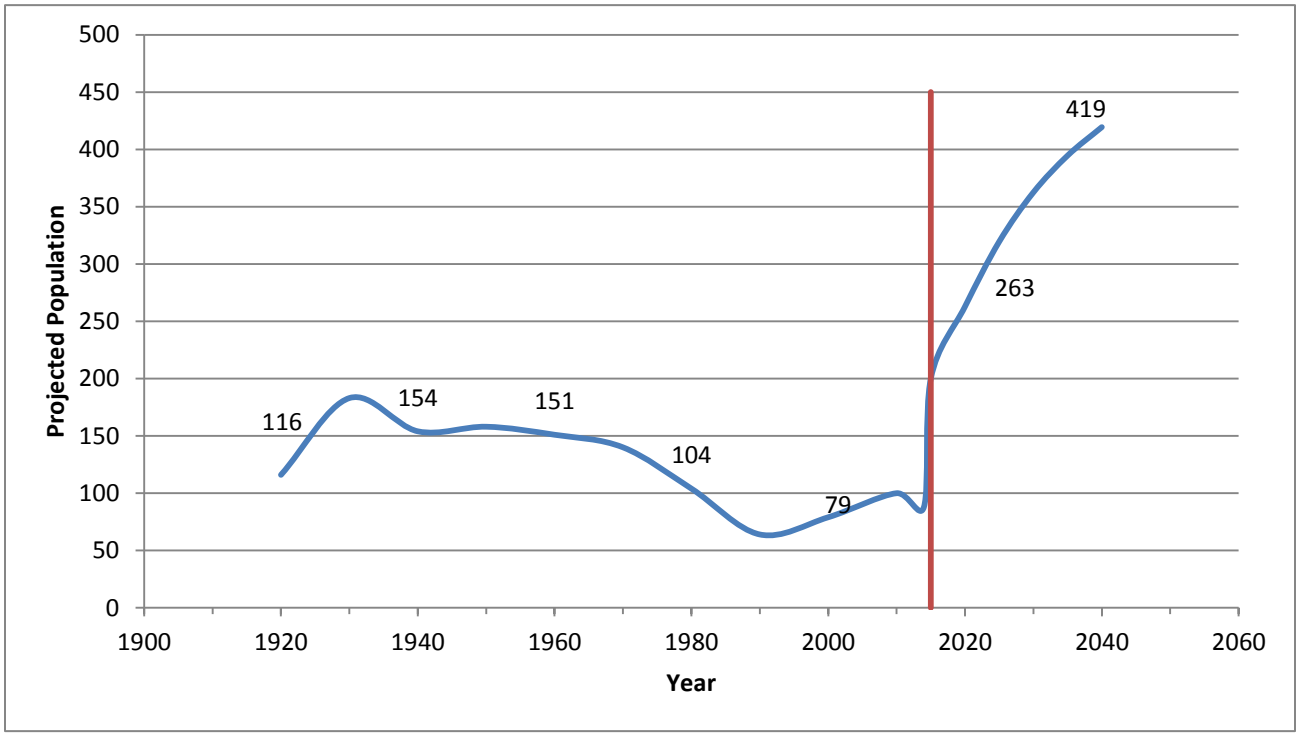
Table 3 – Future Population Projections

	2015	2020	2025	2030	2035	2040
Growth Rate	127%	5.47%	3.90%	2.53%	1.70%	1.22%
Population	200	263	320	363	395	419
Pop Increase	112	63	57	43	32	25

* Projected growth rate up to 2040 based on Williams County population growth rates

The population is expected to grow at an average rate of approximately 4.7% through the year 2025 and then slow to 1.22% by the year 2040. Based on these projections, the number of connections can be expected to almost double in the next 25 years. The actual growth will likely continue in a stop-and-go fashion remaining dependent on the growth of area's industries and job availability. This plan should be evaluated and updated periodically as population updates become available. This plan should also be evaluated if a new industry is established in or around the City, which could radically change the infrastructure projects proposed by this plan (i.e. a large residential subdivision in the City's boundaries or a large industrial development).

Figure 4 – Historic Population and Population Projections of Epping, ND



3. Culinary Water

This culinary water evaluation included both the analysis of the existing system and a detailed presentation of improvements that will assist the City to meet current and projected demands.

The recommendations for improvements will aid the implementation of the City's goals to improve service to the public, to provide adequate pressure, and fire protection. The proposed recommendations will provide sufficient capacity to expand the system in areas projected for future growth. As new development occurs, the culinary water system will need to be expanded to adequately serve new residents and aging components will need to be replaced to sustain current and serve projected needs for the entire community.

Since the future growth of the City cannot be accurately predicted ***it is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is achieved.***

3.1 Existing Water System

The existing water system is supplied by water purchased from William's County Rural Water District, which comes from Williston to the south at an average of 70-80 psi. The water is conveyed through a 6-inch transmission pipeline from several miles away. Water storage for the City is also several miles away. The water is primarily serviced through 3-inch dead-end lines with 1-inch laterals. Due to the size of the pipe, it is impossible to provide fire flows.

Additionally, there is no looping or redundancy in the existing system. Looping provides system redundancy that allows for decrease vulnerability by being able to isolate segments and available system bypasses. Furthermore, it increases system pressures stability, increase fire flow capacities, and decrease the size of pipe needed. It also decreases water residence time/age by increased flushing of the pipes.

The existing culinary water system is shown in Figure 5 with estimated water usage in Table 4. The system was modeled by using data provided by William's County Rural Water District, topographical data obtained from United State Geological Survey (USGS) 10M digital surface models (DEMs), and Bentley WaterGEMS V8 water modeling software. The model determined that the City does not have adequate capacity in order to meet projected needs or fire flow needs.

After identifying these deficiencies, a series of alternatives were simulated to determine the most effective means to correct the noted problems. These recommendations are discussed in the following sections. The system was then modeled to reflect future conditions and determine if any deficiencies are likely to result from the anticipated growth.

Table 4 – Water Usage

Type	Water Usage (gpcd)	People	Total Water Demand (gpd)
Church	10	100	1000
Factories	70	10	700
House	150	3	450
Travel Trailer Park	200	8	1600
Bar	10	20	200
School	30	40	1200
Restaurant	20	20	400
Assembly Hall	4	30	120

LEGEND

- RAIL ROAD
- CITY BOUNDARY
- 1"
- 2"
- 3"
- 4"
- 5"
- 6"
- 12"

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 600'
(11"X17")

0 12"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

EXISTING WATER SYSTEM NETWORK

PLAN SET: FINAL

FIGURE: 5

3.2 Recommended Water System Improvements and Upgrades

The City of Epping does not operate its own water system and is currently reliant upon the William's County Rural Water District for their water needs. It is possible for the City to manage their own culinary water system and obtain the benefits of controlling that system not just for future growth, but for maintenance of the system with increased revenue for the City. However, due to the excessive costs of developing their own culinary water system, it is recommended to only install a fire suppression system.

3.2.1 NEW FIRE SUPPRESSION SYSTEM (RECOMMENDED)

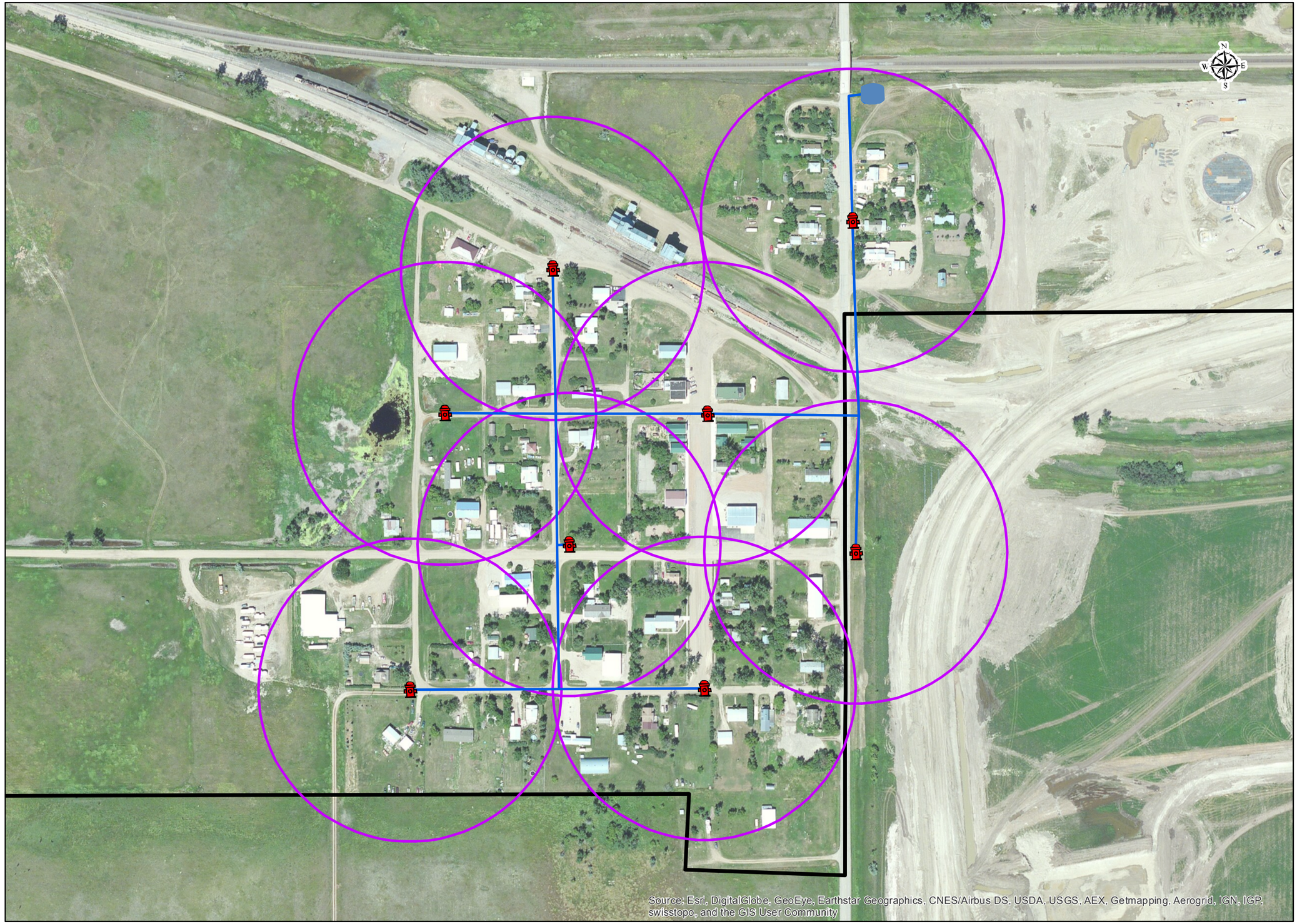
In order to have water available for fire flows, it is recommended that the City install a new tank. This tank will also serve to be a reservoir in the event of a fire (120,000 gallons allowing 1,000 GPM for 2 hours) to allow more efficient protection to the public. This tank should not need to be elevated in a tower and will be able to supply the system in the event of a fire through a small booster pump and a small amount of elevation head. The land would have to be acquired for the tank near the north of the City. Due to the tank's proximity to existing industry, the tank may be able to have cost sharing benefits with existing businesses that should be thoroughly investigated.

Supplementary parts of this project not likely to have cost sharing are new fire suppression lines and hydrants for the main area of town. In order to provide fire flow service to the City, it is recommended that a minimum 6-inch waterlines be installed. This was designed to have the minimum amount of length and hydrants (400-ft radius) required as shown in the following Figure 6. The probable costs of the new fire suppression system are listed in Table 5.

The proposed improvements will be able to support existing and proposed land use along with fire flow. Additional funds may also be generated through the expansion of the fire suppression system by the proposed development to the west.

Table 5 – Probable Costs of Fire Suppression System

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	120,000 Gallon Tank	$1.50	120,000	GAL	$180,000
2	Pump Installation	$25,000	1	EA	$25,000
3	Land Acquisition (1/2 acre)	$5,000	1	EA	$5,000
4	Fire Suppression Lines (6" min.)	$40	4250	FT	$170,000
5	New Hydrants	$5,000	8	EA	$40,000
				Subtotal Construction Cost	**$420,000**
	Engineering & Survey	8%			$33,600
	Construction Management	7%			$29,400
	Admin & Legal & Warranty	4%			$16,800
	Contingency	10%			$42,000
				Total Opinion of Probable Improvement Cost	**$541,800**



LEGEND

- HYDRANT
- TANK
- FIRE LINE
- HYDRANT RADIUS (400 FT)
- CITY BOUNDARY

DATE

4/28/16

epic ENGINEERING

REVISIONS
1.

DRAWN: JRC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 250'
(11"X17")

0 1/2"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

PROPOSED FIRE SUPPRESSION SYSTEM

PLAN SET:	FIGURE:
FINAL	6

3.2.2 NEW CULINARY SERVICE SYSTEM (NOT RECOMMENDED)

It is possible for the City to manage their own culinary water system and obtain the benefits of controlling that system. However, due to the unreliable water source development and increased maintenance costs, this option is not recommended. The proposed improvements include source development, storage, new waterlines, and improved water meters. The proposed improvements would also be able to support existing and proposed land use along with fire flow.

Due to the continuous costs of conventional surface water treatment, it is recommended that the City develop a culinary drinking water well to provide a stable source of water for the City. The shallow Sentinel Butte-Tongue River Formation in the Lake Sakakawea basin is commonly used for domestic water supply in the area. A domestic well drilled in 1963 to a depth of 61 feet for the Epping School, water was hit at 34 feet. However, this aquifer may not be suitable quality to meet standards of the North Dakota Department of Health.

It is recommended that the City install a new tank (200,000 gallons to supply fire flow and average day demand) to capture water from the new well and provide greater stability to the City's water supplies during peak conditions. However, to easily obtain water pressure for the City, it is recommended to be elevated and will be more expensive to construct.

In order to provide fire flow service to the City, it is recommended that a minimum 6-inch waterlines be installed. These waterlines are more expensive in unit price than the previously suggested fire suppression system due to the increased laterals and meters necessary. The waterlines will also be looped in order to increase system stability and redundancy but adding more length overall to the project.

To more accurately track the water usage and significantly improve data gathering speed and efficiency, it is proposed to replace the existing registers with new devices capable of more powerful radio transmissions and the addition of a transceiver at the Assembly Hall or at the proposed new Fire Station/Public Safety Building. The probable costs of proposed culinary water system are presented Table 6.

Table 6 – Probable Costs of New Water System

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	200,000 Gallon Tank (Elevated)	$2	200,000	GAL	$400,376
2	Pump Installation	$40,000	1	EA	$40,000
3	Land Acquisition (1/2 acre)	$5,000	1	EA	$5,000
4	New Water Lines (6" loop)	$50	8500	FT	$425,000
5	New Hydrants	$5,000	8	EA	$40,000
6	New Water Meters	$300	76	EA	$22,800
7	Source Development-Well	$400	200	LF	$80,000
				Subtotal Construction Cost	**$1,012,800**
	Engineering & Survey	10%			$101,280
	Construction Management	8%			$81,024
	Admin & Legal	4%			$40,512
	Contingency	10%			$101,280
				Total Opinion of Probable Improvement Cost	**$1,336,896**

4. Sanitary Sewer

Observations from Epic Engineering staff have indicated that the Epping sewer system is experiencing a number of deficiencies. The majority of the deficiencies are due to the system reaching the end of its design life. In most of the City, pipes were installed in the early 1980s. Computer modeling of the existing sanitary sewer conveyance system indicates that the majority of the existing system is providing an acceptable level of service in its present condition, although improvements will be required to prevent further degradation. The modeling process also identified a number of potential problems, the most pervasive of which is scour velocity from insufficient slopes in pipes throughout the system. The existing effluent treatment system was also evaluated and found to be in generally acceptable condition, although many repairs were noted. Improvements to correct insufficient capacity and upgrade failing components are a high priority and should be completed within the next five years or as soon as funding is available. Correcting these deficiencies will protect the public health and safety as well as minimize the environmental damage that could result from future system failures.

Additional modeling of the existing system considered the cumulative stress of future demands, which highlighted a number of pipe segments that will become overwhelmed in the coming years. The existing treatment capacity was also evaluated. It was determined that the existing lagoons will not be sufficient to treat the effluent through the year 2040; therefore, additional treatment capacity will be required. Completion of these projects will provide for adequate system capacity and allow the City to grow and maintain the current level of service. These projects may need to be completed in conjunction with growth and are generally a lower priority than the improvements.

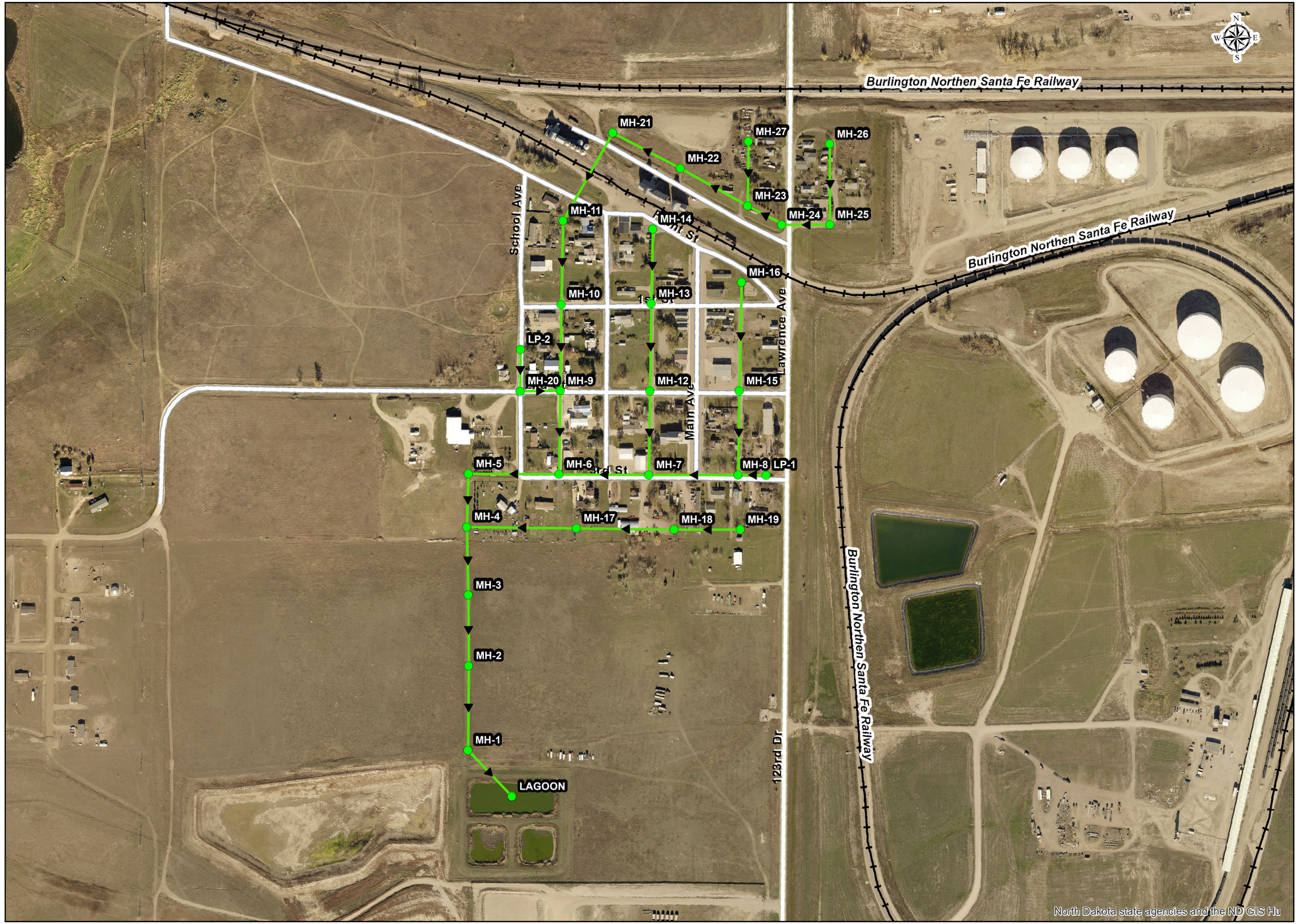
Since the future growth of the City cannot be accurately predicted ***it is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is achieved.***

4.1 Existing Sanitary Sewer System

The existing system includes approximately 9,070 feet of 8-inch transmission lines connected with approximately 29 manholes and 69 service laterals as viewed in Figure 7. The wastewater is conveyed via gravity flow to the sewer lagoon south of the City with slopes shown in Figure 8. The Sanitary Sewer system is separate from the storm water conveyance system. The sewer system is designed to transport wastewater only. Sewage flow rates are not directly measured. However, culinary water use is typically metered at every connection. To model the sewer system in Epping, the North Dakota 2009 Uniform Plumbing Code for daily water use on each lateral was used. The sewer usage table for the City can be seen in Table 7. The system was modeled by using a combination of SewerGEMS V8 and EPA SWMM 5. The model consists of a series of nodes which are connected by pipes. Each node is assigned spatial information, as well as effluent loading parameters. The model uses the pipe and node data to route flows through the system and determine the capacity as well as the maximum flow for every component as shown in Appendix B.

Table 7 – Sewer Usage

Type	Water Usage (gpcd)	Capita Used	Total Water Demand (gpd)
Church	5	100	500
Factories	35	10	350
House	75	3	225
Travel Trailer Park	100	8	800
Bar	5	20	100
School	15	40	600
Restaurant	10	20	200
Assembly Hall	2	30	60



LEGEND

- MH
- 8" SEWER

SOURCE CITY OF EPPING, NDGIS AND WILLIAMS COUNTY GIS

DATE
1/26/16

epic ENGINEERING

REVISIONS

DRAWN: KMC
DESIGNED: RDK
REVIEWED: KSW

16SM2260.03

SCALES
HORIZ: 1"= 400'
(11"X17")
0 1/2"

PROJECT NAME:
CITY OF EPPING, ND

SHEET TITLE:
EXISTING SANITARY SEWER LAYOUT

PLAN SET: PRELIM.

FIGURE: 7

LEGEND

- ROADS
- RAIL ROAD
- CITY BOUNDARY
- SEWER MH

PIPE SLOPES %

- 0.00
- 0.50
- 0.75
- 1.00
- 1.00+

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 400'
(11"X17")

0 1/2"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

EXISTING SLOPE

PLAN SET:	FIGURE:
FINAL	8

4.2 Lagoon Analysis

The lagoons were designed by Webster, Foster, & Weston in 1981. Construction of the lagoon system was completed in 1983. The lagoons consist of an inlet structure which contains screens to remove large solid matter as well as a Parshall Flume. Three lagoons (ponds) are used to achieve the primary treatment through a series of aerobic and anaerobic steps. The lagoons are designed to have a retention time of 120 to 150 days when operating at a peak capacity of 0.402 million gallons per day (mgd) (summer flow). The lagoon configuration is shown in Figure 9and Appendix C Lagoon Analysis Results. The discharge structure contains a chlorination unit to ensure the effluent meets the discharge standards of the NPDES Permit (NDG322233).

4.3 Recommended Improvements and Upgrades

This section presents the recommended improvements to the existing system. The recommended improvements have been identified as the best value or least cost alternative that would provide sufficient capacity to convey or treat both existing and future effluent. In addition to identifying the improvements, this section prioritizes the recommended improvements. The prioritization is determined using engineering judgment while considering the following:

1. Public Health and Safety
2. Improvements that will have the largest effect on the existing deficiencies
3. The anticipated need for future improvements
4. Available funding sources
5. Environmental considerations
6. Constructability

A series of construction and maintenance projects will be required to correct the problems with the existing system noted in the previous sections. The construction projects are generally divided into six categories described in Table 8.

Table 8 – Types of Capital Improvements

Recommended Action	Description
New Pipe	The construction of a new sewer line and manholes that follows a different alignment or will be of a different diameter than the existing line.
Pipe Replacement	The construction of a new sewer line and manholes that follows the same alignment and is of the same diameter as the existing pipe.
Pipe Sealing	The process of cleaning, inspecting, coating the pipes, and manholes with a protective material to minimize the infiltration of groundwater.
Pipe Cleaning	The process of cleaning and inspecting the pipes and manholes.
Abandoning Pipe	The process of decommissioning existing sewer lines, and eliminating unnecessary sources of inflow and infiltration flow.
Other	Necessary improvements that do not fit into the above categories (e.g. New Lift Station)

LEGEND

- MH
- SEWER

SOURCE CITY OF EPPING, NDGIS AND WILLIAMS COUNTY GIS

DATE
2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KSW

PROJECT #
16SM2260.03

SCALES
HORIZ: 1"= 200'
(11"X17")
0 1/2"

PROJECT NAME:
CITY OF EPPING, ND

SHEET TITLE:
EXISTING SEWER LAGOON CONFIG.

PLAN SET:	FIGURE:
PRELIM.	9

The improvements are divided into two categories for discussion and funding consideration. The two categories are: 1) Capital Improvements, which are required today to bring the system up to a minimal acceptable level of service, and 2) Capital Facilities, which will become necessary to maintain the level of service as the system grows. A summary of the proposed improvements is shown in Table 9.

Table 9 – Summary of Sanitary Sewer Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	Lagoon Rehabilitation	$249,587	1	EA	$249,587
2	Inspections and Cleaning of Existing Sewer	$75,320	1	EA	$75,320
3	Upgrading Sewer Lines	$125,000.00	1	EA	$125,000
				Subtotal Construction Cost	**$469,287**
	Engineering & Survey	8-10%			$40,984
	Construction Management	7-10%			$30,003
	Admin & Legal	2-4%			$25,480
	Contingency	10%			$44,991
				Total Opinion of Probable Improvement Cost	**$591,365**

4.3.1 LAGOON UPGRADES

Modeling the existing sewer lagoon, Epic has found that the existing ponds will not have the capacity needed for proper treatment by the year 2020. The current system capacity will need to be effectively doubled within the next 25 years if the population projections in this report accurately reflect the growth of the City. Table 10 shows the necessary increase in lagoon capacity to properly treat a doubling of the City population. Additionally, studying imagery of the ponds along with site visits, have indicated that the ponds are not healthy and may not be discharging properly due to recent area construction activities. Upgrades to the existing facilities also need to be done to treat the sewage more efficiency and improve the stability of the existing system. ***It is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is approached.***

Table 10 – 25 Year Lagoon Capacity Projections

Population	419
Wastewater Per Capita (gpd/person)	75
Population Wastewater Inflow (gpd)	31,425
Commercial Wastewater Inflow (gpd)	3,915
Total Inflow (gpd)	35,340
180-day Pond Flow Volume (gallons)	6,361,200
Existing 180-day Pond Flow Volume (gallons)	3,524,297
25 year 180-day Pond Volume Needed (gallons)	6,361,200
Additional Capacity Needed (gallons)	**2,836,903**

Appendix C shows the full Lagoon Analysis Results with the estimated costs for the additional capacity needed for full build-out shown in Table 11, below. These costs may be significantly augmented if agreements for the further utilization of other area ponds are reached. Combining treatment ponds may allow increased stability of all systems and lower maintenance costs due to the shared responsibility. Furthermore, by combining the ponds, it will reduce the overall footprint needed for full build-out allowing more area to be allocated to the continued growth of all communities involved.

Table 11 – Lagoon Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	Excavation Costs	$14.00	14565	CY	$203,907
2	Liner	$0.30	115600	SF	$34,680
3	Outlet Structures	$11,000	1	EA	$11,000
				Subtotal Construction Cost	**$249,587**
	Engineering & Survey	8%			$24,959
	Construction Management	7%			$17,471
	Admin & Legal	8%			$19,967
	Contingency	10%			$24,959
				Total Opinion of Probable Improvement Cost	**$336,943**

4.3.2 EXISTING SEWER INSPECTIONS

The existing sanitary sewer system is currently maintained by the City. It is several decades old and reaching the end of its usable service life. While there are no known existing problems in the system, it is recommended that a full system inspection including cleaning and video documentation be completed. When pipes are laid too flat, debris can accumulate which will decrease capacity. Where inspections find infiltration sources, the pipes and manholes should be lined or replaced to eliminate the infiltration source as required. Where major structural failures are located, repairs via lining or replacement should be performed to restore the capacity of the lines. Estimated costs of the inspections are shown in Table 12; however, the costs of rehabilitation of the system are not included due to its unknown condition.

Table 12 – Existing Sewer Inspections

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	Mobilization	$2,000.00	1	LF	$2,000
2	8-inch Sewer lines inspections and cleaning	$8.00	9165	LF	$73,320
				Subtotal Construction Cost	**$75,320**
	Engineering & Survey	8%			$6,026
	Construction Management	10%			$7,532
	Admin & Legal	4%			$1,506
	Contingency	10%			$7,532
				Total Opinion of Probable Improvement Cost	**$99,422**

4.3.3 NEW SEWER LINES

As the City continues to grow, additional sewer lines will be required. A number of the existing lines will be expected to carry additional flows and may have to be enlarged as the result of the result of increased usage. The costs for further expansion of the current City System are shown in Table 13, below. These costs were derived by modeling the proposed doubling of the City to the west as shown in Appendix B. The system may be near capacity during full build-out conditions with existing infrastructure; however, no flooding occurred during modeling. Due to the system being modeled under worst case scenario (if everyone was to take a shower at the same time of day), the system may be able to convey the proposed flows. ***It is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is approached.***

Table 13 – New Sewer Lines

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	New 10-inch Sewer lines	$70.00	1400	LF	$98,000
2	New Manholes	$4,500.00	6	EA	$27,000
				Subtotal Construction Cost	**$125,000**
	Engineering & Survey	8%			$10,000
	Construction Management	7%			$5,000
	Admin & Legal & Consulting	4%			$2,500
	Contingency	10%			$12,500
				Total Opinion of Probable Improvement Cost	**$155,000**

A key component used to determine the adequacy of each design alternative discussed is the potential environmental considerations. The environmental impacts are considered in two parts. First, the potential effects the proposed alternative will have on the environment during construction are considered. Whenever possible, the surface disturbance was minimized to reduce construction-related environmental impacts. Second, the anticipated performance and likelihood of failure are considered and potential environmental impacts reviewed. Alternatives that could have large environmental effects in the event of a failure or are expected to provide an unacceptable level of performance are considered inadequate. In addition to this matrix, alternate flow routing patterns are also evaluated using the same criteria noted above but are not included herein, as the potential numbers of iterations are endless.

Many of the proposed system improvements and upgrades will have potential environmental impacts that will need to be considered in the design of the proposed projects. Generally, the potential impacts due to the construction of the proposed projects are smaller than the environmental impacts if the improvements are not constructed. To evaluate the general environmental considerations that are likely to be encountered in the design of the proposed projects, an environmental concerns matrix has been developed. Potential environmental impacts shown in the matrix are based on the National Environmental Protection Agency (NEPA) and other environmental agency concerns. The potential environmental impacts identified in this analysis are not significant enough to change our recommendations at this time.

Groundwater Contamination: When existing lines are replaced through bursting or outright replacement, the effluent must be re-routed during construction. The equipment used to re-route the flows must be properly designed and special care is taken to ensure that effluent is not released in the process. Lines scheduled to be replaced must also be properly drained to prevent any residual effluent from draining into the surrounding groundwater.

Surface Water Contamination: Similar to the groundwater concerns, anytime work is being conducted on a sewer line that is near a water body, there is a potential for effluent to unintentionally drain or leak into the surface water. When working near open water bodies, special care must be taken to prevent the release of effluent into water sources.

Increase in Groundwater Levels: Currently a number of the sewer pipes permit groundwater to seep into the system. These lines are scheduled to be replaced or repaired. When the groundwater near the pipe segments can no longer seep into the system, the groundwater elevation in the area will increase. The higher groundwater levels may cause additional settlement in utility trenches, along roadways, or even cause potential water infiltration into local basements. Although of concern, these potential effects are anticipated to be generally minor at this time.

Wetland Disturbance: Some of the proposed projects are located within or near local wetlands. Due to elevation constraints, the lines cannot be rerouted. Special care and permits will be required to minimize the impact to the wetlands when these projects are under construction.

Sensitive Habitat Disruption: Similar to the wetlands concerns, some of the projects may require construction is areas that contain special habitat. Care will be required to prevent the loss of sensitive habitat areas.

Offensive Odors: Any time new sewer lines are constructed, or existing lines upgraded, there is potential for offensive odors to emanate from the effluent into the surrounding area. Potential receptors should be identified and care should be taken to minimize the effects of offensive odors during and after the sewer projects are constructed.

5. Stormwater System

The City of Epping is interested in implementing a stormwater system that meets the needs of the growing community. To date, the Epping stormwater system consists of only a few culverts used to control local flooding. Stormwater currently flows from roadways and other impervious surfaces to undeveloped low-lying properties throughout the City and along natural drainages. The City does experience flooding with the melting of snow and ice, along with heavy rains, making portions of the City unpassable or hazardous to traverse. The increase of additional impervious surfaces in the future will also potentially increase flooding without an adequate Storm infrastructure planning. Increased flooding will expedite the erosion of roads, flooding of properties and damage to buildings. In order to mitigate the anticipated higher flooding frequencies as a result of future development and protect existing structures, it is recommended that a comprehensive storm water conveyance network be established throughout the City.

Since the future growth of the City cannot be accurately predicted ***it is recommended that this report be updated in 2026 or when the population exceeds the 10-year projection and every 10 years thereafter to maintain a 25-year planning period until the full build-out potential of the City is achieved.***

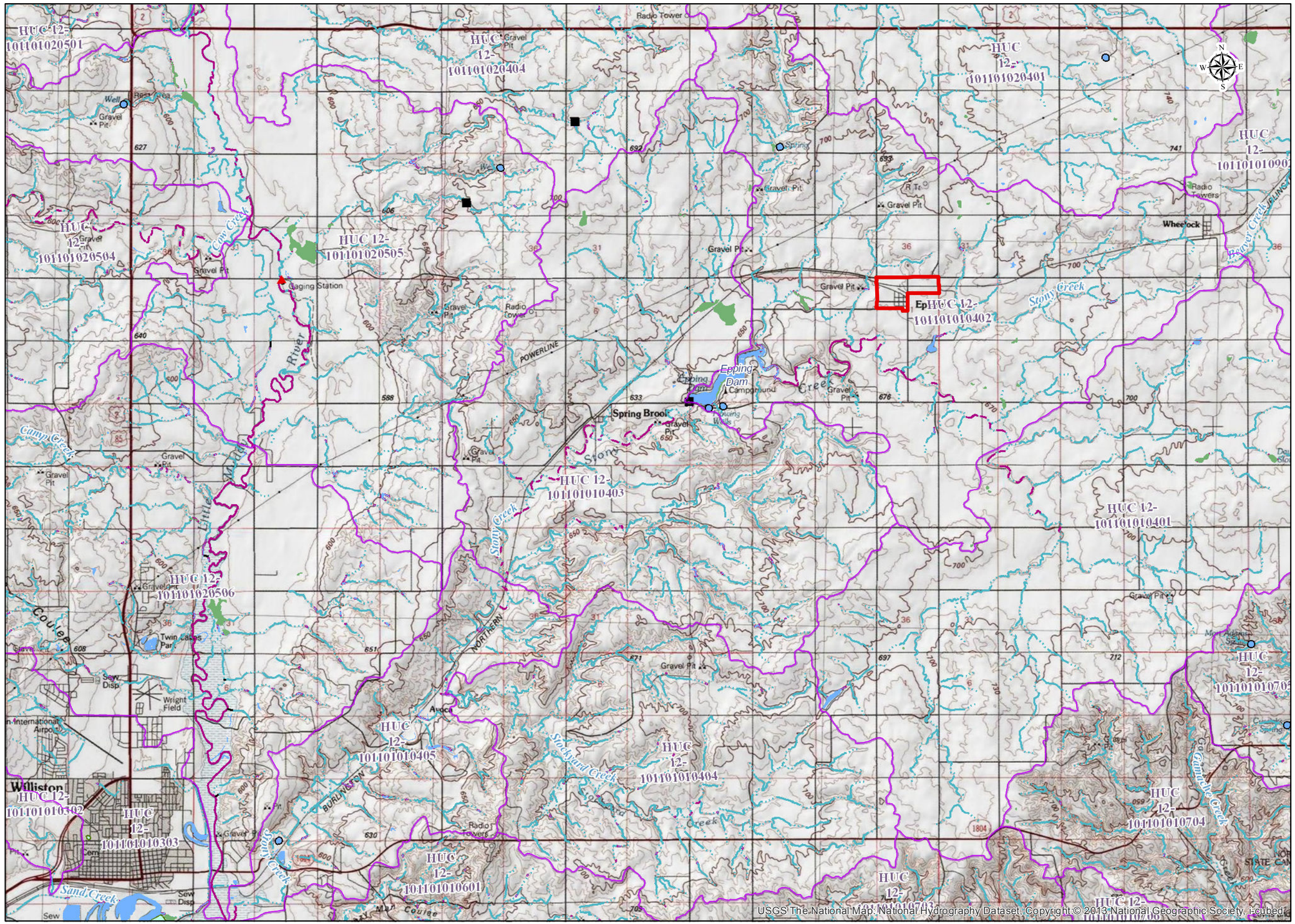
5.1 EXISTING STORM DRAIN SYSTEM

The City of Epping currently drains into Stony Creek which flows into Epping Dam approximately 3 miles southwest. Water then flows into the Missouri River as seen in Figure 10. The existing City stormwater infrastructure consists of 35 culverts scattered throughout the City as seen in Figure 11 and water generally flows southwest. There are no area retention basins throughout the City; however, the City has recently implemented policies in their zoning requirements. These policies require all new disposal of all storm water for new infrastructure through the approved stormwater and drainage way systems as set forth in the stormwater management plan. This plan includes the design and construction of the storm water detention or retention basins. Furthermore, the ordinances call for new developments to discharge at the historic rate.

As the City grows, it is anticipated that retention basins may likely be required due to higher runoff volumes of impervious surfaces to promote additional growth. Without detention basins or other methods of collecting the storm water throughout the City, it is likely that these uncontrolled discharges will become problematic if left unaddressed. Local area watersheds (basins) and flow directions are shown in Figure 12. Flow for these basins was derived using area precipitation intensity is shown in Table 14 and Figure 13 for the 24-hr storm event using the National Oceanic Atmospheric Administration (NOAA) Epping Weather Station (Site ID: 32-2735) Atlas 14 data, Volume 8, Version 2.

Table 14 – Precipitation Intensity Depth (Inches) Frequency Estimates

		Storm Duration (hours)												
		0.1	0.2	0.3	0.5	1.0	2.0	3.0	6.0	12.0	**24.0**	48.0	96.0	168.0
Return Interval (Year)	1	0.25	0.36	0.44	0.58	0.72	0.86	0.96	1.14	1.36	**1.57**	1.77	2.05	2.42
	2	0.30	0.44	0.54	0.71	0.88	1.05	1.16	1.36	1.58	**1.82**	2.08	2.41	2.81
	5	0.40	0.59	0.71	0.94	1.17	1.39	1.52	1.75	1.98	**2.26**	2.61	3.01	3.46
	10	0.49	0.71	0.87	1.15	1.42	1.70	1.85	2.10	2.35	**2.66**	3.07	3.52	4.00
	25	0.62	0.91	1.10	1.46	1.80	2.15	2.33	2.62	2.89	**3.24**	3.73	4.26	4.77
	50	0.73	1.06	1.30	1.72	2.12	2.52	2.73	3.05	3.35	**3.73**	4.27	4.84	5.38
	100	0.84	1.23	1.50	1.99	2.45	2.92	3.16	3.52	3.84	**4.25**	4.83	5.45	6.00
	200	0.96	1.41	1.72	2.28	2.81	3.35	3.62	4.02	4.37	**4.80**	5.41	6.08	6.64
	500	1.14	1.66	2.03	2.69	3.32	3.95	4.26	4.73	5.12	**5.58**	6.22	6.95	7.51
	1000	1.27	1.87	2.28	3.02	3.73	4.43	4.79	5.3	5.73	**6.20**	6.86	7.62	8.18



LEGEND

- ROADS
- STREAMS
- RAIL ROAD
- CITY BOUNDARY
- REGIONAL WATERSHEDS

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT # 15SM2260.03

SCALES

HORIZ: 1"= 1,500'
(11"X17")

0 1/2"

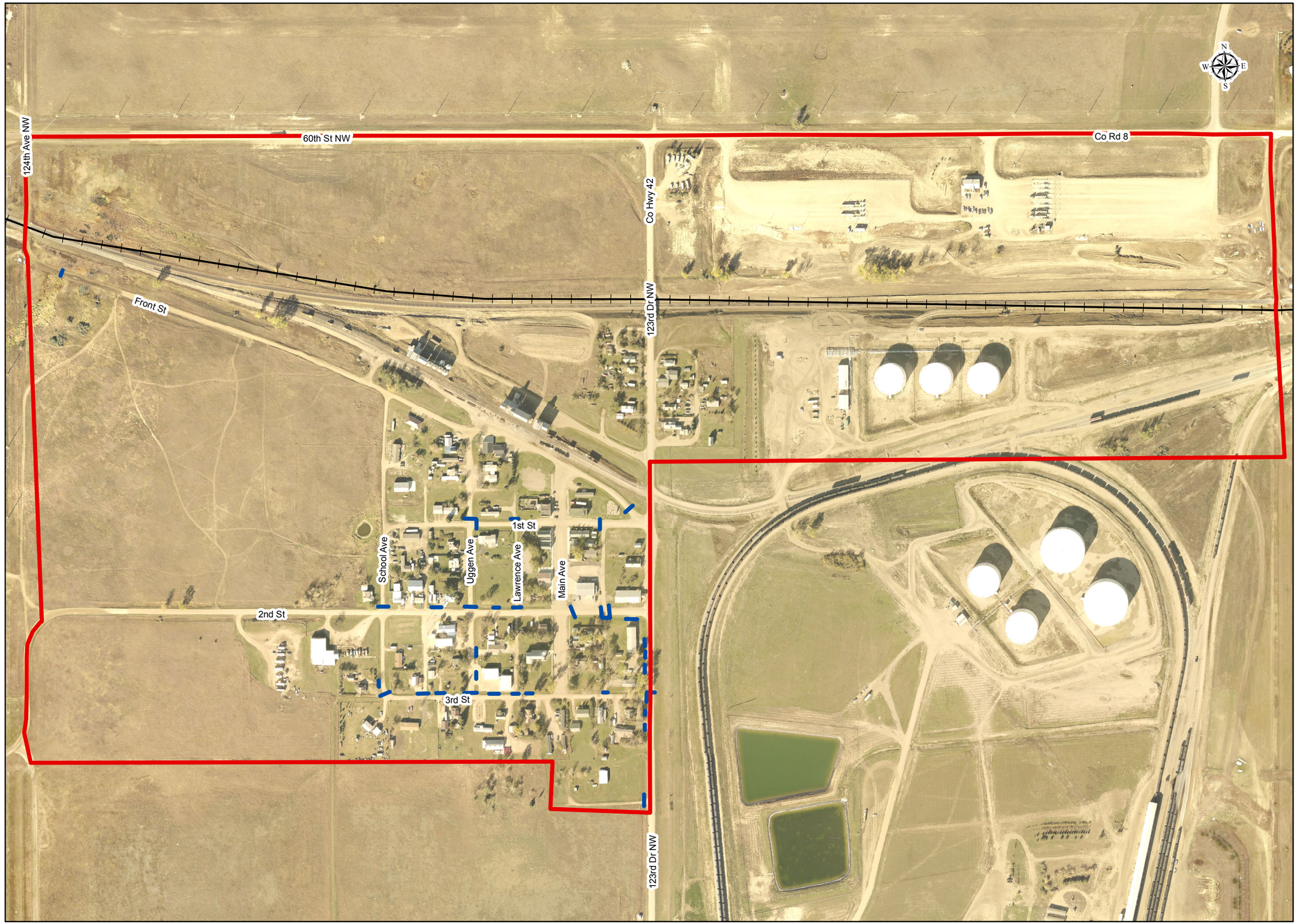
PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

EPPING AREA HYDROLOGY

PLAN SET:	FIGURE:
FINAL	10



LEGEND

- CULVERTS
- ROADS
- RAIL ROAD
- CITY BOUNDARY

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 400'
(11"X17")

0 1/2"

PROJECT NAME:

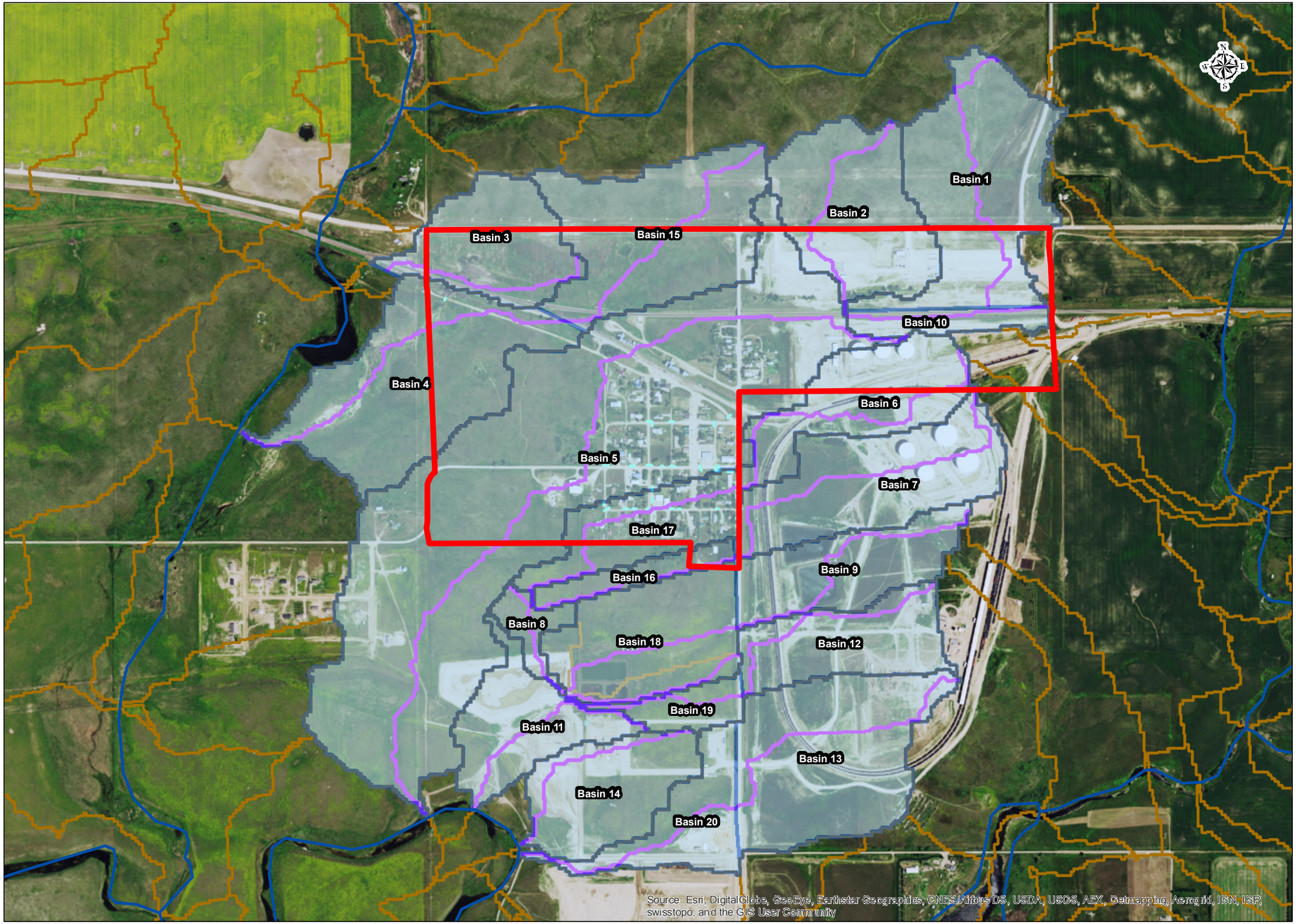
CITY OF EPPING, ND

SHEET TITLE:

EXISTING STORM SYSTEM NETWORK

PLAN SET: FINAL

FIGURE: 11



LEGEND

- LONGEST FLOW PATH
- STREAMS
- CULVERTS
- CITY BOUNDARY
- CATCHMENTS
- CITY BASINS

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 800'
(11"X17")

0 1/2"

PROJECT NAME:

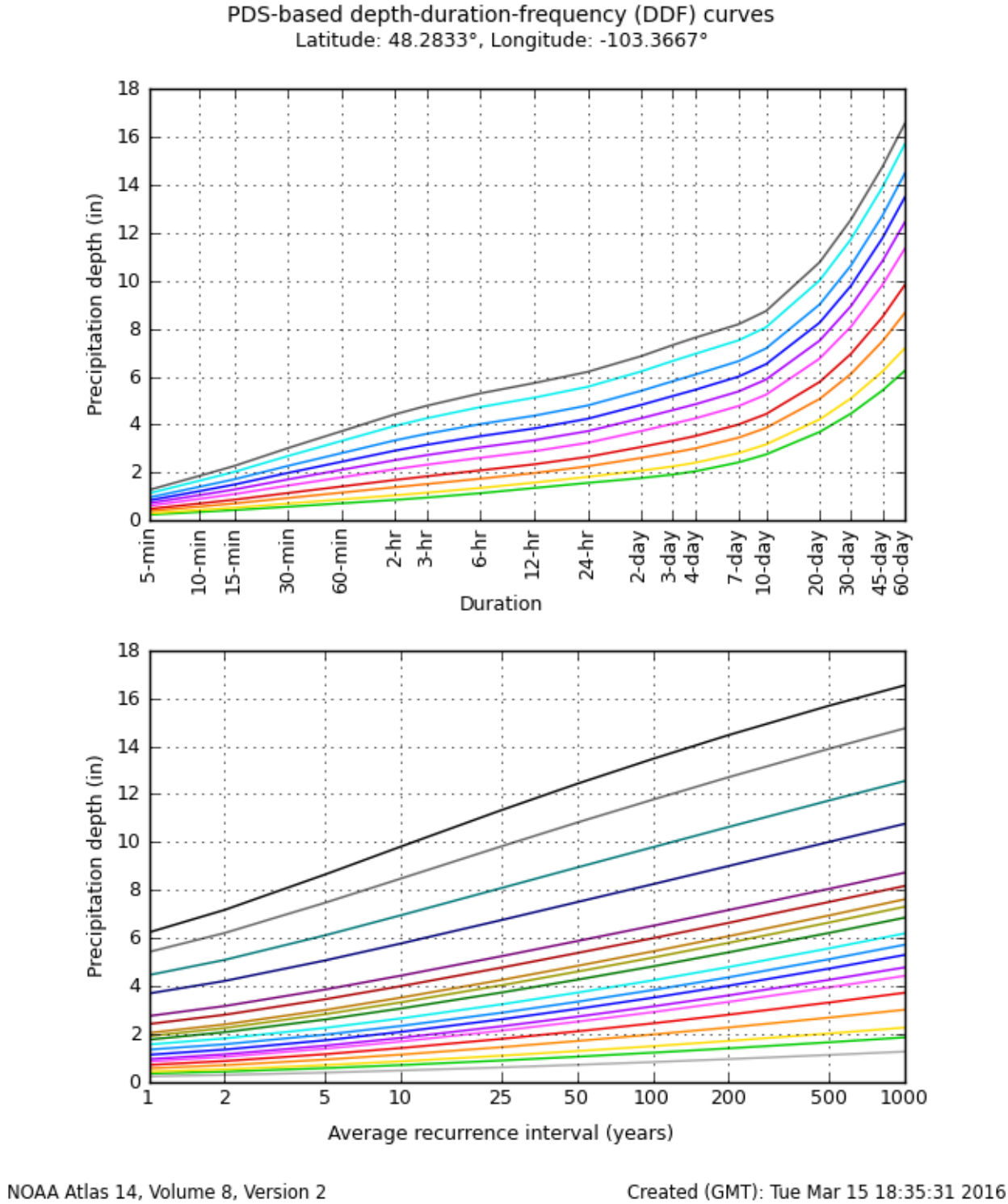
CITY OF EPPING, ND

SHEET TITLE:

EXISTING STORM SYSTEM NETWORK

PLAN SET:	FIGURE:
FINAL	12

Figure 13 – Precipitation Intensity Depth Frequency



Storm events are characterized by what is known as Level of Service (LOS). Ideally, the desired LOS would be to install a network capable of managing the largest possible flood and to thereby prevent any flood-related damage to the City under even the most extreme precipitation events. Unfortunately, to construct such a system would be extremely difficult and cost prohibitive. Alternatively, doing nothing to prevent flood-related damages can be equally expensive and have a negative impact on economic development throughout the community. Defining the optimal level of service can be reduced to a cost-benefit analysis where the "optimal" level is defined as the balance where every dollar spent on flood reduction directly translates to one dollar less in damages. The political challenges related to frequent flooding throughout the City and public perception often drive such decisions. As a result, many communities have identified their LOS as protection against storms of a given frequency.

An example of this is when all conveyance network components shall be sized to not over-top more than once every fifty years on average (50-year event), which is what Williams County has done in their Storm Water Division 1 General Provisions. Several other organizations take a more dynamic approach such as North Dakota Department of Transportation (NDDOT) has implemented Table 15 in North Dakota Administrative Code 89-14-01-03 Design flood frequency effective May 1, 2001, amended effective July 27, 2001, and amended effective January 1, 2015. ***It is recommended that the City adopt at least the NDDOT minimum standard of 25-year design requirements for their Rural System.***

Table 15 – NDDOT Design Flood Frequency

Type of Crossing	State Highway System						County	
	Urban System		Rural System				Rural System	
	Regional	Urban Roads	Principal Arterial		Minor Arterial	Major Collector	**Major Collector**	Off[4] System
			Interstate	Other				
Bridges & Reinforced Concrete Boxes	25 year[2]	25 year[2]	25 year[2]	50 year[2]	50 year[2]	25 year[2]	**25 year[2,3]**	15 year[2,3]
Roadway Culverts	25 year[2]	50 year[2]	50 year[2]	25 year[2]	25 year[2]	25 year[2]	**25 year[2,3]**	15 year[2, 3,5]
Storm Drains	10 year [1]	5 year [1]	10 year[2]	10 year[2]	10 year[2]	10 year[2]		
Underpass Storm Drains	25 year[1]	25 year[1]	50 year[2]	25 year[2]	25 year[2]	25 year[2]		

[1]Discharges must be computed using the rational method or other recognized hydrologic methods.
[2]Discharges must be computed using the United States geological survey report 92-4020 or other recognized hydrologic methods.
[3]If an overflow section is provided, the pipes and the overflow section, in combination, must pass the appropriate design event within the headwater limitations provided in this chapter.
[4] Off-system roads include all township roads.
[5] For township roads, the recurrence interval is 10-years.

Design flow accumulations for each basin were determined by utilization the TR-55 method. The hydrology techniques used in the TR-55 method are based upon unit hydrograph theory and the runoff curve number method of calculating direct runoff from the rainfall occurring over specified areas using the SCS Method for calculating the time of concentration. The TR-55 was modeled using the USDA NRCS program WinTR-55 Version 1.00.10 compiled February 2013. This method requires the watershed, channel length, and slope for the property to be determined. The critical values were determined by using data obtained from United State Geological Survey (USGS) 10M digital surface models (DEMs) in conjunction with Geographic Information Systems (GIS) software with the ArcHydro extension. Accumulative flow results for each Basin are shown in Table 16. Full stormwater model derivations are available in Appendix D along with individual basin flows.

Table 16 – Existing Basin Flows*

Basins	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Minimum 25-Year Culvert Conveyance Size (In) at Drain
Basin 1	16.36	31.2	47.94	**76.04**	101.99	131.08	36
Basin 2	12.16	23.19	35.63	**56.52**	75.81	97.43	30
Basin 3	5.79	12.9	20.5	**34.24**	47.38	62.35	24
Basin 4	14.19	34.7	57.6	**97.85**	137.05	181.84	36
Basin 5	77.09	156.14	242.25	**394.32**	535.95	695.89	60
Basin 6	6.17	13.77	21.88	**36.54**	50.57	66.55	30
Basin 7	9.91	20.76	32.37	**53.4**	73.06	95.34	30
Basin 8	22.03	49.22	78.65	**131.05**	180.64	237.22	42
Basin 9	2.95	8.75	15.23	**26.28**	37.8	51.16	24
Basin 10	1.17	3.08	5.18	**8.83**	12.52	16.78	18
Basin 11	44.8	100.11	160.24	**266.7**	368.56	484.71	54
Basin 12	7.23	14.39	22.28	**36.01**	48.78	63.12	36
Basin 13	10.43	23.27	36.98	**61.75**	85.45	112.45	30
Basin 14	5.09	11.9	19.38	**31.88**	43.67	57.22	24
Basin 15	4.31	11.03	18.97	**32.75**	45.87	60.81	24
Basin 16	11.77	24.74	38.63	**63.55**	86.92	113.42	30
Basin 17	8.95	21.56	35.38	**59.76**	83.01	109.7	30
Basin 18	7.53	19.72	33.14	**56.46**	80.07	107.27	30
Basin 19	9.26	18.65	28.92	**46.97**	63.77	82.69	30
Basin 20	15.13	33.11	52.33	**87.07**	120.09	157.66	36

*Flows are cumulative where Basin 4 includes Basin 15, Basin 5 includes Basin 1 and Basin 2, Basin 8 includes Basin 17 and Basin 16, Basin 11 includes Basin 8 and Basin 18 and Basin 19, Basin 16 includes Basin 7, Basin 17 includes Basin 6, Basin 18 includes Basin 9, Basin 19 includes Basin 12, and Basin 20 includes Basin 13.

Each Basin was evaluated at the drain point (downgradient lowest point) with minimum culvert sizes derived from Manning's equation based on installing a reinforced concrete pipe at approximately 2% slope for the 25-Year storm event. These were used to qualitatively determine the amount of flow that would be conveyed throughout the City to determine areas focuses such as by the City Lagoon systems, the main developed areas of City, and potential area contributions. The majority of the basins will be able to be sufficiently conveyed using a 30-inch pipe or less. Therefore, smaller segments of the basins will likely be able to be conveyed with the minimum culvert size of 18-inch and area swales.

However, it should be noted that the proposed development areas of this plan (areas to the east of City) are downgradient of the existing infrastructure. Any additional development will need to be evaluated with the increased stormwater conveyed by the City. Nevertheless, detailed information within the City (elevations and swale information) is not currently available for smaller watershed basin delineations in order to make accurate sizing recommendations within the existing developed areas.

It is recommended that detailed elevation information (survey or high-resolution LIDAR) on the elevation of existing stormwater infrastructure be obtained within the City jurisdiction in order to better size culverts and determine drainage patterns for a more robust future Storm Water Management Plan.

5.2 Recommended Improvements and Upgrades

The model results indicate that the City will on average be able to sufficiently conveyed stormwater though 18-inch culverts. The costs for storm drain improvements including localize roadway repair are estimated below in Table 17. These costs were derived based on the average costs of a culvert needed where each crossing was estimated to be 40-feet. However, detailed evaluations (including a survey of existing infrastructure) of each road will need to be complete before any project is bid.

Table 17 – Summary of Probable Costs of Road Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	New Culverts School Ave.	$120	280	LF	$33,600
2	New Culverts Main St.	$120	160	LF	$19,200
3	New Culverts 2nd St.	$120	320	LF	$38,400
4	New Culverts Front St.	$120	200	LF	$24,000
5	New Culverts 3rd St.	$120	320	LF	$38,400
6	New Culverts 1st St.	$120	200	LF	$24,000
7	New Culverts Uggen St.	$120	160	LF	$19,200
				Subtotal Construction Cost	**$196,800**
	Engineering & Survey	8%			$13,120
	Construction Management	7%			$6,560
	Admin & Legal	4%			$3,280
	Contingency	10%			$16,400
				Total Opinion of Probable Improvement Cost	**$244,032**

Furthermore, the costs will be augmented by roadway improvements that will include the installation of drainage swales (accounted for in earthwork estimates in Section 6 of the Transportation Plan). The recommended improvements above consist of a series of roadside swales or curbs and gutters to collect and channel the rainfall. Road swales provide a cost-effective, sustainable means to collect water that runs off roadways as well as surrounding lots and allows for infiltration and groundwater recharge. The swales can be as simple as a graded ditch along the roadway, or elaborate structures can be designed to enhance the aesthetics of the community. These swales or curb and gutter will be required on almost all roadways to provide the initial storm water collection. The swales or curb and gutter then channel the water toward a series of inlet basins, where the water enters a network of closed conduits (pipes). From this point, the water can be quickly conveyed to detention facilities and subsequently discharged.

It is recommended that the City adopt a policy to implement stormwater detention requirements on all new development. The City should also develop regional detention basins based on their existing develop to minimize their downstream impact on potential development. The City has currently developed approximately 90 acres in Basin 5 and 15 acres in Basin 17. The costs to mitigate impact for these basins are based on the representative stormwater impact metric of 0.1 acre-feet per acre (AF/AC) for retention basin sizing with costs shown in Table 19.

The representative metric of 0.1 AF/AC for detention basin sizing was developed based on reviewing several undeveloped basins (less than 200 acres) using the rational method (c values of for undeveloped 0.3 to 0.5 developed). Calculations for Basins 3,7,15 are shown in Appendix D Storm Water Model

Results. It was determined that an impact of 0.1 AF/AC would be a conservative metric for the retention of the 25-year storm event.

The costs to construct detention facilities also vary widely depending on the natural contours, type of soil, the value of the land, and the size of the basin. For the purposes of this study, the land acquisition cost was included as most of the ponds will be constructed on property owned by the City while the remainder can likely be constructed with property easements. It was also assumed that since the ponds are to be constructed in relatively flat areas that all of the storage would need to be excavated, and the inlet and outlet structures would be approximately the same cost regardless of the pond size. Other variables that comprised the unit costs are presented in Table 18.

Table 18 – Unit Costs of Detention Basins

Item	Unit Cost
Excavation	$14/CY
Inlet/outlet structure	$11,000 EA
Seeding/surface restoration	$0.15/SF
Total	**$22,000+27,991/AF**

The costs presented in Table 19 are based on City costs to mitigate future development to the west of the current developed City (downgradient). The City, when regrading for road construction projects, will be discharging all of their impervious flows. Due to not having detailed surface elevations, potential detention ponds have not been able to be accurately located.

Table 19 – Summary of Probable Costs of Detention Basins

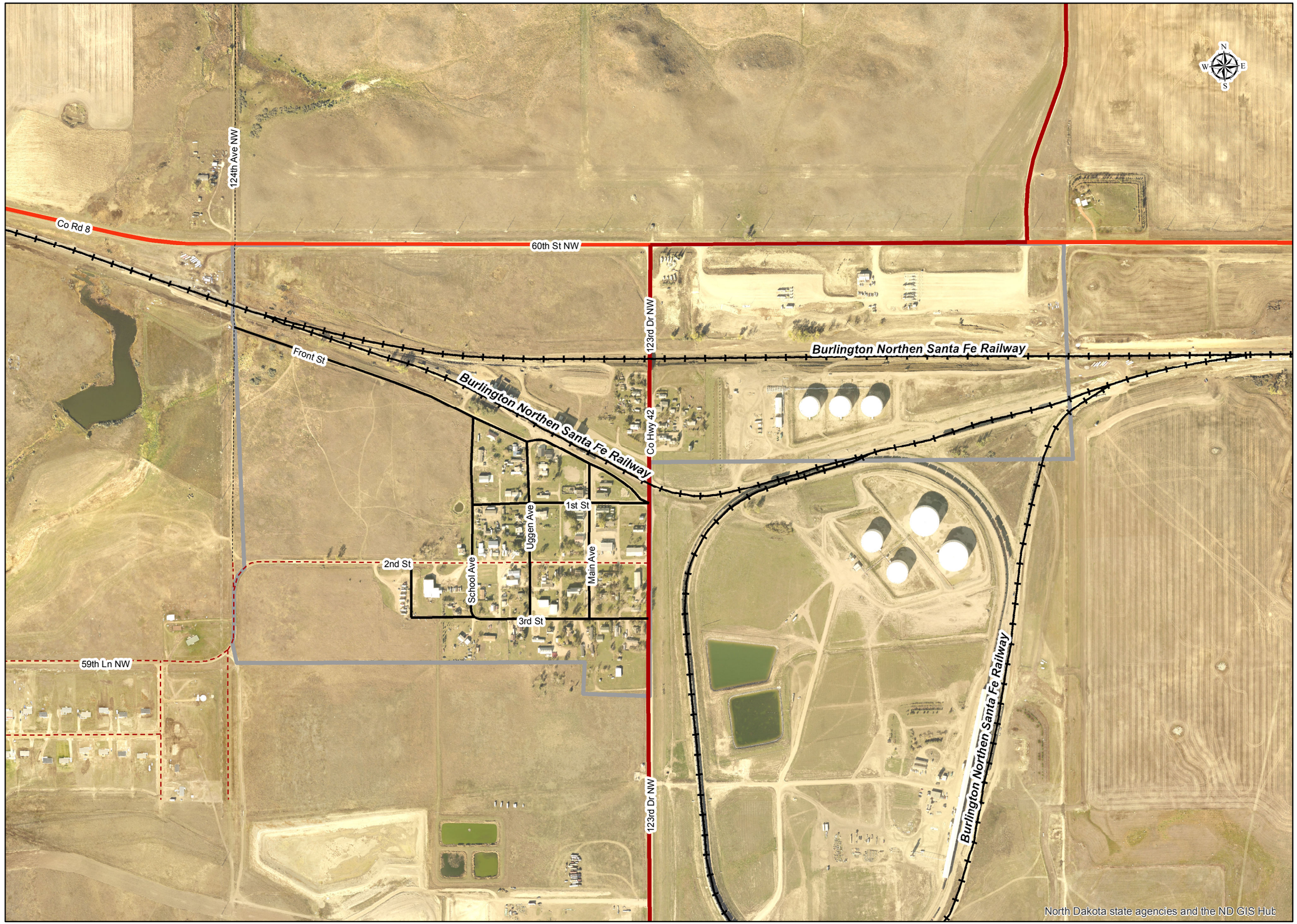
Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	Regional Detention Basin #1 (Basin 5)	$22,000+27,991/AF	9.0	AF	$244,882
2	Regional Detention Basin #2 (Basin 17)	$22,000+27,991/AF	1.5	AF	$59,147
				Subtotal Construction Cost	**$304,029**
	Engineering & Survey	8%			$24,322
	Construction Management	7%			$21,282
	Admin & Legal	4%			$12,161
	Contingency	10%			$30,103
				Total Opinion of Probable Improvement Cost	**$392,197**

6. Transportation System

The purpose of this section is to provide recommendations to correct the problems noted in the previous section as well as recommend maintenance operations to preserve or improve the existing roadway condition. There are three distinct types of recommendations: 1) routine roadway maintenance, 2) roadway replacement and improvement, and 3) roadway upgrades needed to support future growth.

6.1 Existing Transportation System

The existing roadway system in the City consists of roughly five (5) miles of two-way roadway for a total of approximately ten (10) lane miles. 60th Street NW (CR-8) serves as the major east-west transportation corridor while 123rd Drive NW (CR-42) serves as the major north-south corridors and entrances to the City. While the county roads were evaluated, they were not proposed to be improved due to these roads not being under the jurisdiction of the City. The majority of the other roadways in the City are set up on a grid pattern with Lawrence Avenue and 2nd Street as the central intersection to the grid. The only exception to the grid system within the City is Front Street on the north end of the city, and south side of the railroad. A map of the existing roadway system is shown in Figure 14.



LEGEND

- RAIL ROAD
- CITY STREET/ROAD
- STATE HIGHWAY
- COUNTY PAVED RD
- COUNTY GRAVEL RD
- GRAVEL RD
- PRAIRIE TRAIL
- CITY BOUNDARY

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 400'
(11"X17")

0 1/2"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

EXISTING ROAD SYSTEM NETWORK

PLAN SET: FINAL

FIGURE: 14

6.2 Roadway Evaluation

As part of this study, Epic Engineering surveyed all of the major roadways throughout the City and evaluated the condition of each stretch of roadway. Overall, the existing gravel surface is in poor condition with typical flaws resulting from general age and minimal maintenance and repairs. Within the network, a number of roadways remain unpaved and are maintained as dirt roads. These are typically found at the end of paved streets where they provide access to one or two residences. Often times these are dead end roads that provide no access for a public turnaround.

Seven primary criteria were taken into consideration while evaluating the roadway segments. These factors are: 1) surface condition, 2) minor cracking, 3) major cracking, 4) base failure, 5) drainage, 6) localized failures (i.e. potholes), and 7) street width. For each roadway segment (block) all seven of the above criteria were scored through visual observations from 0 to 5 with 0 indicating good condition and a 5 indicating inadequate or deteriorated condition. After ranking all of the roads throughout the City, each of the seven criteria was given a weighting factor depending on how detrimental to the overall condition of the road (i.e. base failure being very detrimental as compared to minor cracking). These weighting factors are listed below in Table 20. Finally, the product of the weighting factor and the score for the seven criteria were summed to cumulate in a single total score.

Table 20 – Criteria Weighting Factors

Criteria	Weighting Factor
Surface Condition	1
Minor Cracking	2
Major Cracking	4
Base Failure	5
Drainage	3
Localized Failures	4
Width	4

An overall score between 0 and 100 was assigned to each roadway block based on the weighted score for each condition. To simplify the interpretation of the numeric scoring, the roadways were grouped into 4 classes, or “grades”, of “A”, “B”, “C”, and “D”. All of the roads with a score below 15 categorized an “A” and are generally in good condition. All of the roads that scored between a 16 and 40 were assigned a “B”. Roads assigned a “C” scored between a 41 and 60, and roads classified as a “D” had scores above 60 and are in generally poor condition.

In addition to the primary criteria listed above, other observations were noted during the survey including the ability to turn around at dead end roads, overhanging trees, alignment, etc. These scores and other observations were then used to determine the level and timing of maintenance and repairs needed to maintain, restore, and preserve the desired roadway level of service. Table 21 present the overall condition of the City’s roadways using the methods described above. The table also presents the proposed priority as discussed in Section 6.3 Roadway Improvements.

Table 21 – Overall Roadway Conditions

Road Segment					Surface Condition	Minor Cracking	Major Cracking	Base Failure	Drain-age	Localized Failures	Width (rate)	Score	Overall Grade	Priority
Road	**To**	**From**	**Length**	**Width**	**1**	**2**	**4**	**5**	**3**	**4**	**4**			
60th St NW	124th Ave NW	123rd Dr NW	2630	28	4	5	5	5	3	5	0	88	C	NA
60th St NW	123rd Dr NW	CR 42	2387	28	3	4	2	2	3	2	0	46	A	NA
60th St NW	CR 42	City Bound.	230	28	3	4	2	2	3	2	0	46	A	NA
124th Ave NW	60th St NW	Front St	532	18	5	5	5	5	4	5	4	108	D	NA
124th Ave NW	2nd St	59th Ln NW	303	18	5	5	5	5	2	5	4	102	D	NA
123rd Dr NW	60th St NW	RR Driveway	956	24	3	4	2	2	3	2	1	50	A	NA
Front St	124th Ave NW	School Ave	1618	18	4	5	5	4	4	5	4	102	D	4
Front St	School Ave	Uggen Ave	371	18	4	5	5	5	4	5	4	107	D	4
Front St	Uggen Ave	Main St	432	24	4	5	5	5	4	5	1	95	D	4
Front St	Main St	Lawrence Ave	461	20	4	5	5	5	3	5	3	100	D	4
1st St	School Ave	Uggen Ave	354	16	5	5	5	5	4	5	4	108	D	6
1st St	Uggen Ave	Main St	386	20	4	5	5	5	3	5	3	100	D	6
1st St	Main St	Lawrence Ave	378	32	4	5	5	5	3	5	0	88	C	6
2nd St	124th Ave NW	School Ave	1233	22	4	5	5	5	2	5	2	93	C	3
2nd St	School Ave	Uggen Ave	746	24	4	5	5	5	3	5	1	92	C	3
2nd St	Uggen Ave	Main St	377	24	4	5	5	5	4	5	1	95	D	3
2nd St	Main St	Lawrence Ave	380	24	4	5	5	5	3	5	1	92	C	3
3rd St	School Ave	Uggen Ave	357	17	4	5	5	5	2	5	4	101	D	5
3rd St	Uggen Ave	Main St	376	20	4	5	5	5	2	5	3	97	D	5
3rd St	Main St	Lawrence Ave	373	18	4	5	5	5	2	5	4	101	D	5
Main St	Front St	1st St	248	58	4	5	5	5	4	5	0	91	C	2
Main St	1st St	2nd St	380	60	4	5	5	5	3	5	0	88	C	2
Main St	2nd St	3rd St	358	56	4	5	5	5	3	5	0	88	C	2
School Ave	Front St	1st St	553	12	5	5	5	5	5	5	5	115	F	1
School Ave	1st St	2nd St	369	16	4	5	5	5	4	5	4	107	D	1
School Ave	2nd St	3rd St	347	16	4	5	5	5	3	5	4	104	D	1
Lawrence Ave	City Bound.	1st St	681	28	3	4	2	2	3	2	0	46	A	NA
Lawrence Ave	1st St	2nd St	380	28	3	4	2	2	3	2	0	46	A	NA
Lawrence Ave	2nd St	3rd St	351	28	3	4	2	2	3	2	0	46	A	NA
Lawrence Ave	3rd St	City Bound.	447	28	3	4	2	2	3	2	0	46	A	NA
Uggen Ave	Front St	1st St	390	20	4	5	5	5	3	5	3	100	D	7
Uggen Ave	1st St	2nd St	378	20	4	5	5	5	3	5	3	100	D	7
Uggen Ave	2nd St	3rd St	356	22	4	5	5	5	2	5	2	93	C	7

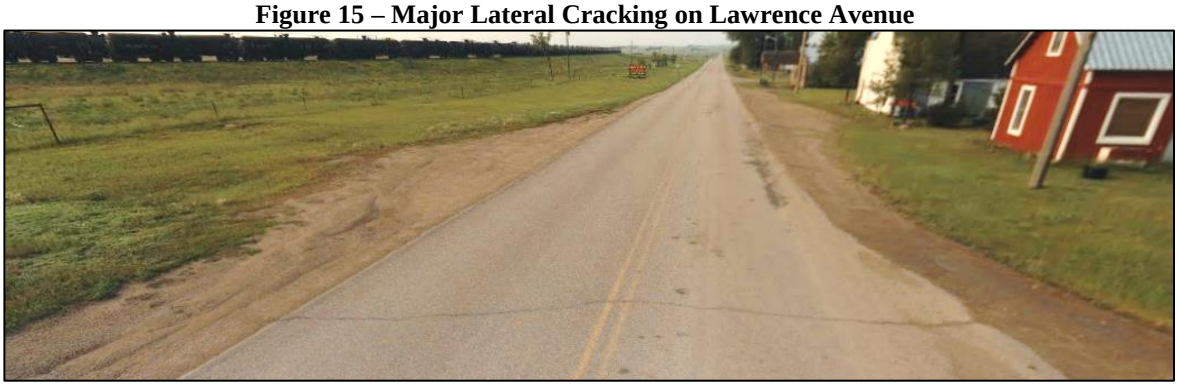
6.2.1 Minor Cracking

The most common observation noted throughout the City was minor cracking, repairs that are unsealed, roadway cuts that have not been properly sealed, and small spider cracking throughout the roadway. As water enters these cracks and freezes, the cracks will continue to expand if not managed properly. This representation is typical of numerous road cuts throughout the City.

6.2.2 Major Cracking

Another deficiency noted throughout the field investigation was major cracking. Major cracking can result from a number of causes including minor cracks that were left unrepaired for a sufficient period of time, poor base conditions allowing portions of the asphalt to shift over time, or from a low asphalt content that causes the asphalt to become rigid and cracked. Regardless of the cause, major cracking often indicates the roadway is in need of reconstruction and possibly repairs to the base. If the cracking becomes significant it will allow water to enter the road base, often resulting in base failure. Figure 15 also provides an example of major cracking within a roadway in the City where several major cracks are evident. This condition is typical in many areas throughout the City and should be addressed properly.

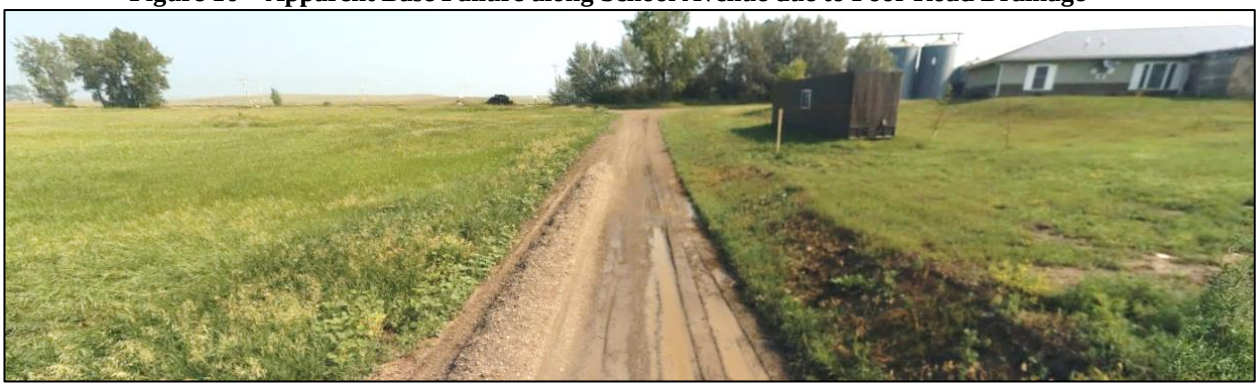
Figure 15 – Major Lateral Cracking on Lawrence Avenue



6.2.3 Poor Base

During the field investigation, a few of the roadways exhibited signs of poor base conditions. An example of base failure can be seen in Figure 16. A poor road base can result from either poor preparation or through deterioration over time due to improper drainage or water infiltration as a result of surface cracking. Regardless of the cause, repairing the condition requires that the road surface and base be fully replaced. In some instances, a pothole may form on the surface in areas where the base has completely failed. In potholed areas it may be possible to replace the base in just that section of road; however, in the vast majority of cases, full width and depth replacement of road base will produce superior results. When possible, the existing gravel surface may be pulverized (roto-milled), and the material reused as road base to reduce the need to transport material.

Figure 16 – Apparent Base Failure along School Avenue due to Poor Road Drainage



6.2.4 WATER INFILTRATION – POOR DRAINAGE

Providing proper drainage of surfaces and shoulders is critical to maintaining a quality road surface and sound roadway base. While roads can fail for a number of factors, the most prevalent failure appears to be from improper drainage throughout the City. When water is allowed to pond in or adjacent to the roadways, the freeze-thaw cycles can quickly expand minor surface imperfections into major failures. Also, water that forms puddles on the surface will infiltrate into and deteriorate the road base causing structural failures and potholing. At the time of Epic's inspection, many of the intersections on the south side of the City appeared to have low spots and generally poor drainage. In these areas, the roads were potholed or otherwise demonstrating signs of structural failure. As roadways are improved, proper surface drainage is critical to ensuring their preservation.

Figure 17 – Poor Roadway Drainage at Intersection of 1st St. and School Ave

6.2.5 ROADWAY WIDTH

As part of the field investigation, several roads were noted as not being sufficiently wide for vehicles to safely pass at the designated speed limits. None of the narrow roads are major collectors; however, narrow minor collectors and roadways that serve the local residents were noted throughout the City. The narrow widths of the minor collectors are not currently a major problem as the traffic is light and the speed limits are generally low; however, as the City continues to grow increased traffic may pose a safety concern. Table 22 lists the roadway sections with potentially problematic roadway widths, and Figure 18 provides an example.

Figure 18 – Narrow Road on School Avenue

Table 22 – Potentially Problematic Roadway Widths

Roadway	Location	Problem
124th Ave NW	From 60th St NW to Front St and 2nd St to 59th Lane NW	Narrow Road Width
Front St	From 124th Ave NW to School Ave and School Ave to Uggen Ave	Narrow Road Width
1st St	From School Ave to Uggen Ave	Narrow Road Width
3rd St	From School Ave to Uggen Ave and Main St to Lawrence Ave	Narrow Road Width
School Ave	From Front St to 3rd St	Narrow Road Width

6.2.6 PEDESTRIAN ACCESS

Very few roadways in the City have been constructed to incorporate curbing, guttering, and sidewalks. Currently, the majority of roadways that do have sidewalks on both sides of the street are located near the center of the City, specifically along Main Street. As the community and the region continue to grow, traffic throughout the area is expected to increase. The increased vehicular traffic combined with the pedestrian traffic on the minor collectors will become an increasingly dangerous combination to public safety.

At this time, the City is interested in allocating more immediate funds to improve the condition of the roadways prior to incorporating any new sidewalks. Therefore, recommendations and funds necessary to construct sidewalks have not been included in this report. It is recommended that the City plan for the eventual installation of sidewalks starting with the general vicinity of the Buffalo Trails Museum as funds become available and that this plan is updated to incorporate any updates.

In the future, it may be in the City's best interest to require all new development within the City's jurisdiction to establish pedestrian corridors within the site to promote the safe travel of pedestrians. Sidewalks could be established on one or both sides of the street, at the City's discretion. Figure 19 and Figure 20 show typical pedestrian corridor cross-sections, with the sidewalk on either side of the park strip or landscaping area. It is also relevant to note that all streets and sidewalks need to be handicap accessible. The inclusion of street lights will also increase pedestrian and vehicular access safety. ***It is recommended that the City adopts standard right-of-way widths (i.e. Williams County standards) for roadway right-of-way, asphalt width, sidewalk, parkscape, etc. for all new roadway corridors regardless of which portions of the corridor are funded.***

Figure 19 – Typical Pedestrian Corridor A

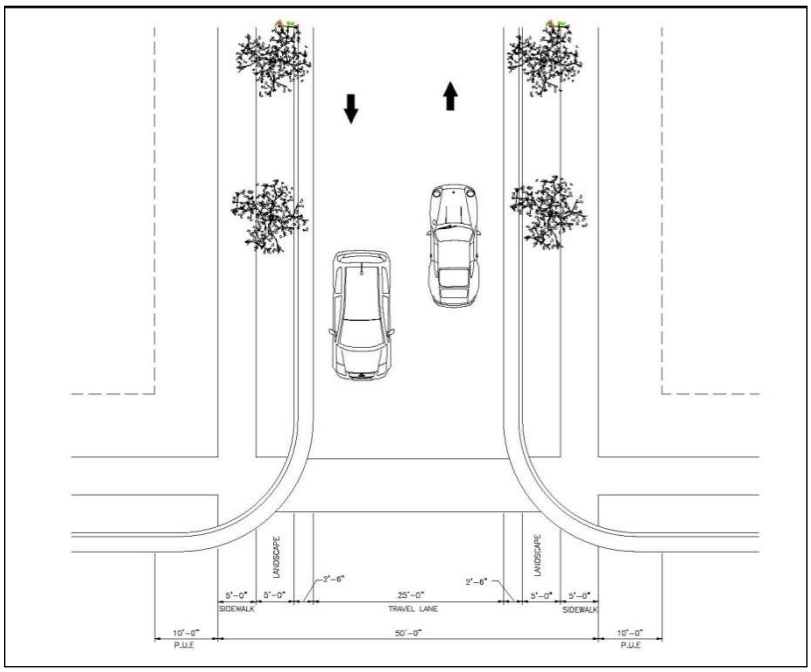
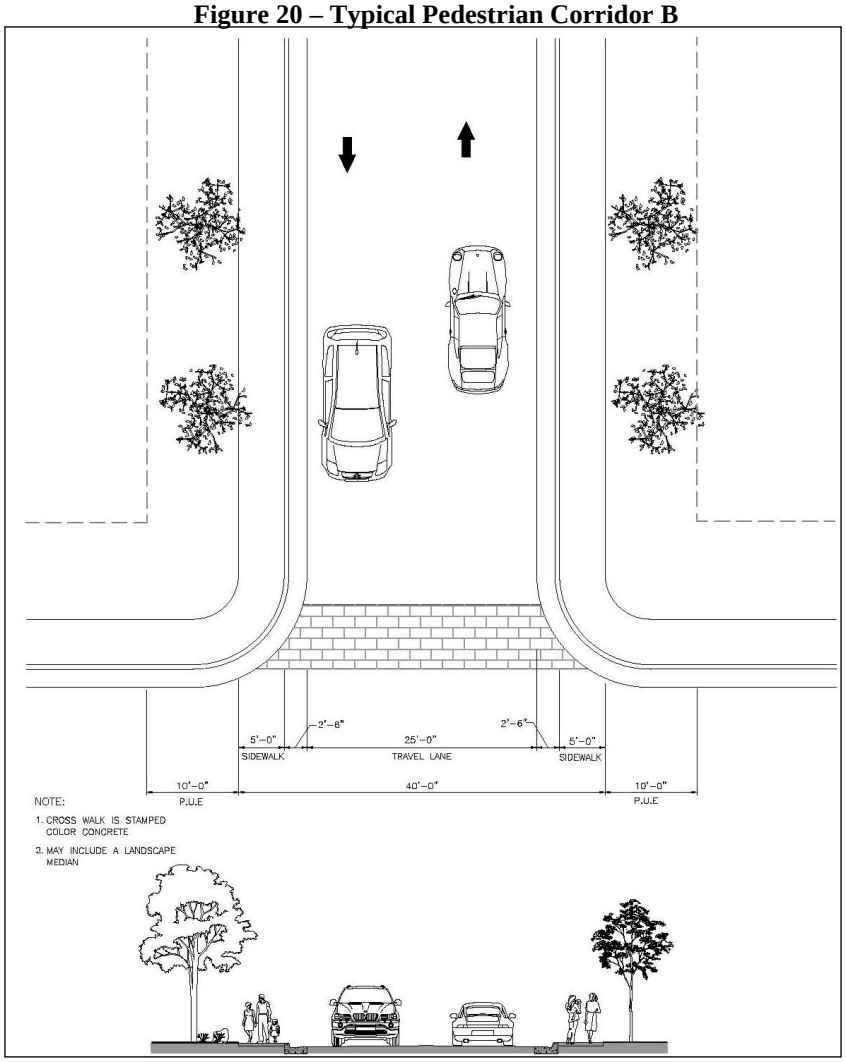


Figure 20 – Typical Pedestrian Corridor B



6.3 Roadway Improvements

After the list of recommended improvements was compiled, the recommendations were ranked in order of priority since not all of the projects can feasibly be done at one time. When ranking the road projects, consideration was taken as to how much each road was traveled. Local roads serving a few residences were not considered a high priority as compared with the through streets or major networks within the City. For the purposes of this study, through streets were considered to be of higher importance for roadway improvement than dead end streets and other minor residential roads due to the number of vehicles affected by the improvement.

Regardless of how well maintained, eventually every roadway will need to undergo major repairs as they reach the end of their service life. Some roads within the City require major repairs today while others will hopefully not require major improvements for many years and be maintained in accordance with the City's Master Plan and the availability of funding. How often major repairs will be required depends on a number of factors from vehicular volumes to maintenance and weather conditions. As reviewed in Section 6.2 and Table 21 most of the roads in the City are in poor condition. The road evaluations determined that the road in the poorest condition was School Ave. and therefore the first priority over that of the busier Main St. The list prioritizes the existing roadways as follows (Figure 21):

1. School Ave.
2. Main St.
3. 2nd St.
4. Front St.
5. 3rd St.
6. 1st St.
7. Uggen St.

Table 23 lists the costs of all the combined roadways projects (assumed all to be paved and with curb and gutter). Geogrid reinforcement was chosen to decrease costs by transportation of less aggregate and street lights were added to increase public safety and comply with possible federal funding requirements. Scheduling of the major roadway replacement should be coordinated with other improvement projects (culinary water, sewer, etc.) to minimize disturbance to new roadways and consolidate funding. The costs of those infrastructure improvements are listed in the other sections and not accounted for in the roadway improvement costs. Table 22 also notes other deficiencies such as extremely narrow roadways, turn-around at dead ends, alignment issues, and installation of curb and gutter or drainage swales, etc. ***It is recommended that drainage swales and culverts be constructed during roadway improvement projects where curb and gutter is not going to be installed to ensure proper roadway drainage***. Additional information on drainage can be found in the Stormwater Section.

There are several options available to the City in order to obtain the level of service the City has adopted for new divisions of having paved roads. There are three options presented in each of the cost estimates as described in the following:

- Option 1-Full asphalt paving with curb and gutter and streetlights
- Option 2-Full asphalt paving without curb and gutter but having street lights
- Option 3-Minimum option to obtain the level of service of asphalt roads. Regrade roads and add quality road base. Then add magnesium chloride to harden/preserve roads. When the City is able, add a chip seal layer of a few inches of asphalt. Two layers of chip seal will be required to obtain the minimum possible depth of asphalt for the service life of the road.

Table 23 – Summary of Combined Roadway Improvement Costs

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
A	Asphalt	$65.00	6354	Ton	$413,003	$413,003	-
B	Road Base (Class 5)	$50.00	4869	CY	$243,444	$243,444	$243,444
C	Excavation Costs	$3.70	19476	SY	$233,707	$233,707	$233,707
D	Geogrid Reinforcement	$20.00	29213	LF	$108,089	$108,089	-
E	Curb and Gutter	$8.00	22445	LF	$448,892	-	-
F	Misc. Mob, Marking, & Traffic Control	$12.00	11222	CY	$89,778	$89,778	$67,334
G	Streetlights*	$140,000	1	LSUM	$140,000	$140,000	-
H	Magnesium Chloride	$0.09	29213	SY	-	-	$2,629
I	2 Layers of Chip Seal	$0.35	525840	SF	-	-	$184,044
			Subtotal Construction Cost		**$1,676,91**	**$1,228,02**	**$731,158**
	Engineering & Survey	8%			$134,153	$98,242	$58,493
	Construction Management	7%			$67,077	$85,962	$51,181
	Admin & Legal	4%			$33,538	$49,121	$29,246
	Contingency	10%			$167,691	$122,802	$73,116
Total Opinion of Probable Improvement Cost					**$2,079,373**	**$1,584,148**	**$943,194**

*Streetlights may be required if federal funding is obtained.

By requiring curb and gutter throughout the City, the total costs for the project is increased by an estimated $580,000 or 137%. Additionally, the costs may be further reduced by removing streetlights and geogrid reinforcement in Option #3. By asphalting in segments when funding becomes available through chip seal, the project costs are reduced to $1.2 million dollars or 43%. It should be noted that pavement marking was removed from Option #3 due to the roads being gravel during initial road regrading. This method will not result in high-quality roads and not have as long of a service life but will serve the community better than the current road system and bring the City roads to be closer to the standards the City adopted for new developers.

LEGEND

- CITY BOUNDARY
- 1-SCHOOL AVE
- 2-MAIN ST
- 3-2ND ST
- 4-FRONT ST
- 5-3RD ST
- 6-1ST ST
- 7-UGGEN ST

DATE

2/17/16

epic ENGINEERING

REVISIONS
1.

DRAWN: KMC
DESIGNER: RDK
REVIEWED: KCW

PROJECT #
15SM2260.03

SCALES

HORIZ: 1"= 400'
(11"X17")

0 1/2"

PROJECT NAME:

CITY OF EPPING, ND

SHEET TITLE:

ROAD PRIORITIES SYSTEM NETWORK

PLAN SET:	FIGURE:
FINAL	21

6.3.1 SCHOOL AVE.

The road has the poorest quality within City limits is School Avenue, which was consistently obtained as a D or even F rating during evaluation. An example of the road's existing condition can be seen in Figure 22. Roads are recommended to be improved by paving and base stabilization. This road is also prone to have drainage problems, which is exacerbated by it being on the downward slope of the City (west side). Stormwater concerns are discussed with costs in Section 5. The probable costs of School Ave. Improvements are shown in Table 24.

Table 24 – Probable Costs of School Ave. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
1A	Asphalt	$65.00	437	Ton	$28,428	$28,428	-
1B	Road Base (Class 5)	$50.00	335	CY	$16,757	$16,757	$16,757
1C	Excavation Costs	$3.70	1341	SY	$16,087	$16,087	$16,087
1D	Geogrid Reinforcement	$20.00	2011	LF	$7,440	$7,440	-
1E	Curb and Gutter	$8.00	2539	LF	$50,778	-	-
1F	Misc. Mob, Marking, & Traffic Control	$12.00	1269	CY	$10,156	$10,156	$7,617
1G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
1H	Magnesium Chloride	$0.09	2011	SY	-	-	$181
1I	2 Layers of Chip Seal	$0.35	36195	SF	-	-	$12,668
			Subtotal Construction Cost		**$149,644**	**$98,867**	**$53,309**
	Engineering & Survey	8%			$149,644	$98,867	$4,265
	Construction Management	7%			$11,972	$7,909	$3,732
	Admin & Legal	4%			$10,475	$6,921	$2,132
	Contingency	10%			$5,986	$3,955	$5,331
			Total Opinion of Probable Improvement Cost		**$193,041**	**$127,538**	**$68,769**

Figure 22 – Example of Existing School Avenue

6.3.2 MAIN ST.

Due to Main St. being the center of the City, it is recommended to be one of the first projects worked on in order to aid in revitalizing the City. Main St. contains several businesses including the City's famous Buffalo Trails Museum and Post Office. The existing street is shown in Figure 23 with probable costs shown in Table 25. This is one of the most expensive road improvements due to the current width of the road when compared to the City's other collector streets.

Table 25 – Probable Costs of Main St. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
2A	Asphalt	$65.00	1384	Ton	$89,928	$89,928	-
2B	Road Base (Class 5)	$50.00	1060	CY	$53,008	$53,008	$53,008
2C	Excavation Costs	$3.70	4241	SY	$50,888	$50,888	$50,888
2D	Geogrid Reinforcement	$20.00	6361	LF	$23,536	$23,536	-
2E	Curb and Gutter	$8.00	1973	LF	$39,452	-	-
2F	Misc. Mob, Marking, & Traffic Control	$12.00	986	CY	$7,890	$7,890	$5,918
2G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
2H	Magnesium Chloride	$0.09	6361	SY	-	-	$572
2I	2 Layers of Chip Seal	$0.35	114498	SF	-	-	$40,074
				Subtotal Construction Cost	**$284,703**	**$245,251**	**$150,461**
	Engineering & Survey	8%			$22,776	$19,620	$12,037
	Construction Management	7%			$19,929	$17,168	$10,532
	Admin & Legal	4%			$11,388	$9,810	$6,018
	Contingency	10%			$28,470	$24,525	$15,046
				Total Opinion of Probable Improvement Cost	**$367,267**	**$316,373**	**$194,094**

Figure 23 – Example of Existing Main St.

6.3.3 2ND ST.

With 2nd Street being one of the main routes through City to the developments to the west, along with it being one of the main routes to the proposed growth area, it is therefore recommended to be one of the first roads to be improved. Figure 24 shows the existing street which is narrow and has been known to have drainage concerns. The probable costs of improvement are shown in Table 26. These costs are from Lawrence Ave. to the existing city boundary of 124th Ave NW.

Table 26 – Probable Costs of 2nd St. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
3A	Asphalt	$65.00	1527	Ton	$99,257	$99,257	-
3B	Road Base (Class 5)	$50.00	1170	CY	$58,507	$58,507	$58,507
3C	Excavation Costs	$3.70	4681	SY	$56,166	$56,166	$56,166
3D	Geogrid Reinforcement	$20.00	7021	LF	$25,977	$25,977	-
3E	Curb and Gutter	$8.00	5471	LF	$109,423	-	-
3F	Misc. Mob, Marking, & Traffic Control	$12.00	2736	CY	$21,885	$21,885	$16,413
3G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
3H	Magnesium Chloride	$0.09	7021	SY	-	-	$632
3I	2 Layers of Chip Seal	$0.35	126374	SF	-	-	$44,231
				Subtotal Construction Cost	**$391,214**	**$281,791**	**$175,950**
	Engineering & Survey	8%			$31,297	$22,543	$14,076
	Construction Management	7%			$27,385	$19,725	$12,316
	Admin & Legal	4%			$15,649	$11,272	$7,038
	Contingency	10%			$39,121	$28,179	$17,595
				Total Opinion of Probable Improvement Cost	**$504,666**	**$363,511**	**$226,975**

Figure 24 – Example of Existing 2nd St.

6.3.4 FRONT ST.

The next area to be improved for increased access to the proposed developments to the west is Front Street. This road runs parallels to the existing railroad spur street as shown in Figure 25. Table 27 shows the probable costs of improving this road. This is the largest costs out of all the proposed roadway improvement projects due to the length of the road being the longest.

Table 27 – Probable Costs of Front St. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
4A	Asphalt	$65.00	1339	Ton	$87,003	$87,003	-
4B	Road Base (Class 5)	$50.00	1026	CY	$51,284	$51,284	$51,284
4C	Excavation Costs	$3.70	4103	SY	$49,233	$49,233	$49,233
4D	Geogrid Reinforcement	$20.00	6154	LF	$22,770	$22,770	-
4E	Curb and Gutter	$8.00	5763	LF	$115,269	-	-
4F	Misc. Mob, Marking, & Traffic Control	$12.00	2882	CY	$23,054	$23,054	$17,290
4G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
4H	Magnesium Chloride	$0.09	6154	SY	-	-	$554
4I	2 Layers of Chip Seal	$0.35	110773	SF	-	-	$38,771
			Subtotal Construction Cost		**$368,612**	**$253,343**	**$157,131**
	Engineering & Survey	8%			$29,489	$20,267	$12,570
	Construction Management	7%			$25,803	$17,734	$10,999
	Admin & Legal	4%			$14,744	$10,134	$6,285
	Contingency	10%			$36,861	$25,334	$15,713
			Total Opinion of Probable Improvement Cost		**$475,510**	**$326,813**	**$202,699**

Figure 25 – Example of Existing Front St.

6.3.5 3RD ST.

Third Street is one of the City's main thoroughfares with several houses found along it. This road is part of the southern boundary of the City with the area to the south zoned commercial. This area is expected to be one of the prime areas of expected growth for the City. The existing street is shown in Figure 26 with the expected probable costs of improvement shown in Table 28.

Table 28 – Probable Costs of 3rd St. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
5A	Asphalt	$65.00	491	Ton	$31,902	$31,902	-
5B	Road Base (Class 5)	$50.00	376	CY	$18,804	$18,804	$18,804
5C	Excavation Costs	$3.70	1504	SY	$18,052	$18,052	$18,052
5D	Geogrid Reinforcement	$20.00	2257	LF	$8,349	$8,349	-
5E	Curb and Gutter	$8.00	2213	LF	$44,256	-	-
5F	Misc. Mob, Marking, & Traffic Control	$12.00	1106	CY	$8,851	$8,851	$6,638
5G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
5H	Magnesium Chloride	$0.09	2257	SY	-	-	$203
5I	2 Layers of Chip Seal	$0.35	40617	SF	-	-	$14,216
			Subtotal Construction Cost		**$150,214**	**$105,958**	**$57,914**
	Engineering & Survey	8%			$12,017	$8,477	$4,633
	Construction Management	7%			$10,515	$7,417	$4,054
	Admin & Legal	4%			$6,009	$4,238	$2,317
	Contingency	10%			$15,021	$10,596	$5,791
			Total Opinion of Probable Improvement Cost		**$193,776**	**$136,686**	**$74,709**

Figure 26 – Example of Existing 3rd St.

6.3.6 1ST ST.

While 1st St. is one of the main entrances to the City as shown in Figure 27, there are not many homes along it. The road is also in better condition than most of the City Roads (average C and D ratings); thereby, lowering its priority for improvement. Table 29 shows the probable costs of improvement.

Table 29 – Probable Costs of 1st St. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
6A	Asphalt	$65.00	616	Ton	$40,031	$40,031	-
6B	Road Base (Class 5)	$50.00	472	CY	$23,596	$23,596	$23,596
6C	Excavation Costs	$3.70	1888	SY	$22,652	$22,652	$22,652
6D	Geogrid Reinforcement	$20.00	2832	LF	$10,477	$10,477	-
6E	Curb and Gutter	$8.00	2236	LF	$44,724	-	-
6F	Misc. Mob, Marking, & Traffic Control	$12.00	1118	CY	$8,945	$8,945	$6,709
6G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
6H	Magnesium Chloride	$0.09	2832	SY	-	-	$255
6I	2 Layers of Chip Seal	$0.35	50967	SF	-	-	$17,839
				Subtotal Construction Cost	**$170,425**	**$125,700**	**$71,050**
	Engineering & Survey	8%			$13,634	$10,056	$5,684
	Construction Management	7%			$11,930	$8,799	$4,974
	Admin & Legal	4%			$6,817	$5,028	$2,842
	Contingency	10%			$17,042	$12,570	$7,105
				Total Opinion of Probable Improvement Cost	**$219,848**	**$162,153**	**$91,655**

Figure 27 – Example of Existing 1st St.

6.3.7 UGGEN ST.

Uggen St. is the last of the proposed street improvements due to it being in the best condition (average C and D ratings) and it being a minor collector for the City. Figure 28 shows the streets existing condition and Table 30 shows the probable costs of improvement.

Table 30 – Probable Costs of Uggen St. Improvements

Item No.	Description	Unit Price	Estimated Quantity	Unit	Option #1	Option #2	Option #3 (Rec)
7A	Asphalt	$65.00	561	Ton	$36,455	$36,455	-
7B	Road Base (Class 5)	$50.00	430	CY	$21,488	$21,488	$21,488
7C	Excavation Costs	$3.70	1719	SY	$20,629	$20,629	$20,629
7D	Geogrid Reinforcement	$20.00	2579	LF	$9,541	$9,541	-
7E	Curb and Gutter	$8.00	2250	LF	$44,990	-	-
7F	Misc. Mob, Marking, & Traffic Control	$12.00	1125	CY	$8,998	$8,998	$6,749
7G	Streetlights	$20,000	1	LSUM	$20,000	$20,000	-
7H	Magnesium Chloride	$0.09	2579	SY	-	-	$232
7I	2 Layers of Chip Seal	$0.35	46415	SF	-	-	$16,245
				Subtotal Construction Cost	**$162,101**	**$117,111**	**$65,343**
	Engineering & Survey	8%			$12,968	$9,368	$5,227
	Construction Management	7%			$11,347	$8,198	$4,574
	Admin & Legal	4%			$6,484	$4,684	$2,614
	Contingency	10%			$16,210	$11,711	$6,534
				Total Opinion of Probable Improvement Cost	**$209,110**	**$151,073**	**$84,292**

Figure 28 – Example of Existing Uggen St.

6.3.8 RECOMMENDED MAINTENANCE

After paving each road, continuous maintenance is essential to preserve the roads and minimize costs to the City. In addition, performing routine maintenance on a frequent and regular schedule is critical to ensuring that existing and future roads in the City continue to serve the community for many years. No matter how well a roadway is initially constructed it will quickly deteriorate without proper maintenance. This section is intended to provide the City with guidance necessary to create an effective maintenance plan to ensure the roadway network can continue to serve the community for years to come. These maintenance strategies are to be implemented after the road is paved.

Crack sealing is a process where hot asphalt or tar is laid in narrow strips along cleaned cracks in the asphalt. This process seals the cracks and prevents water from entering the crack and infiltrating into the road base. When roadways are properly crack sealed they can be expected to last for many years. When cracks are not promptly and properly sealed, however, water infiltration can quickly cause damage to the asphalt and road base, requiring major repairs. Initial crack sealing is likely to be relatively expensive and time-consuming because it has not been done routinely. After the initial crack sealing, annual sealing events should be completed quickly in order to minimize maintenance costs and to ensure properly sealed roadways. As part of the annual maintenance crack sealing process, drainage swales and curb and gutter should be cleaned to ensure proper drainage is maintained along the roadway network. A common source of cracking is caused by roadway cuts for repairs or infrastructure improvements. It is recommended that the City adopt a requirement that each road cut shall be repaired and the saw cuts properly sealed in accordance with AASHTO standards.

In addition to sealing the cracks on an annual basis, the local roads that have not been paved could be coated with sealing chemicals (i.e. magnesium-chloride) annually or as needed in order to maintain the integrity of the roads. For paved roads, the seal coating rejuvenates oxidized asphalt, seals the surface from water intrusion, maintains the roadway flexibility, and can improve safety by providing a uniform color across the road surface.

Much like the local roads, the City's minor collector roads should also be sealed to extend the life of the asphalt surface and protect them from water infiltration. However, a seal coating is not robust enough to hold up to heavier traffic volumes. On the minor collectors, the sealing should be completed using a process known as "chip and seal." The idea behind the chip and seal process is that the seal coating is placed over the roadway and is covered by small rocks, or "chips", which are compacted into the seal coat and covered by a second coat of sealer. This process protects the original road surface and provides a durable wear surface to protect the sealant for approximately three to five years.

7. Additional Projects

There are several additional projects, that the City has interest in including:

- Gas Station/Convenience Store
- Fire Protection
- Basic EMS Services
- Park Development

Many of these projects may be combined with other project endeavors. Park development may be partnered with new developers or by a later Recreational Area Masterplan that details the City's parks, playgrounds, and open space policies. The Gas Station/Convenience store may be partnered with area businesses with incentives to develop appropriate services. Basic EMS services may be provided by cross-trained firefighter personnel. The firefighter station is the only one that is discussed in this masterplan as a project proposed to be directly implemented by this plan.

7.1 New Fire Station/Public Safety Building

The City can provide fire protection through its current fire station but improvements are needed to increase the station's efficiency and underground storage. Current underground storage is sufficient for only small fires and not adequate to fight larger fires. With the continued expansion of the City's boundaries, it is imperative that these needs be address. The probable costs of the proposed Fire Station/Public Safety Building are shown in Table 31. This improvement will be able to better accommodate the City's goals, provide additional storage space, and will complement their growing needs. Furthermore, the addition of a fire house and fire flow capacity for and around the City would be an asset to the community, especially as industrial and area businesses develop around the City.

Table 31 – New Fire Station

Item No.	Description	Unit Price	Estimated Quantity	Unit	Total Cost
1	Fire Station/Public Safety Building	$250,000	1	EA	$250,000
				Subtotal Construction Cost	**$250,000**
	Engineering & Survey	8%			$20,000
	Construction Management	7%			$17,500
	Admin & Legal	4%			$10,000
	Contingency	10%			$25,000
				Total Opinion of Probable Improvement Cost	**$322,500**

8. Project Prioritization

Overall the City needs to make improvements to a number of systems in order to meet current and projected demands. The most frequently noted problems can be corrected by adopting an operations and maintenance plan along with completing some replacement and improvement projects. These improvements will restore deficiencies in the existing infrastructure, accommodate future growth, and provide for safe infrastructure systems throughout the City. In order to fund projects necessary for future growth, it is recommended that the City evaluate a combination of increase user rates for general improvements and repairs, altered rate structure, and obtain government assistance as discussed in the following section.

Throughout the Master Plan process, several large projects were suggested. Due to the large amount of infrastructure projects proposed, it is pivotal that the projects become prioritized based on the order of importance. The proposed order of implementation of all projects is presented below:

1. School Ave.
2. Lagoon Stabilization/Sewer Inspections
3. Main St.
4. Fire Suppression System
5. New Fire Station/Public Safety Building
6. 2nd St.
7. Front St.
8. 3rd St.
9. 1st. St.
10. Uggen St.
11. Storm Water Reginal Detention Basins
12. New Development
    a. New Sewers
    b. New Waterlines
    c. Expanded Lagoons

While the following projects are not specifically addressed in this master plan, they may be accommodated with several area projects and City incentives such as for the Gas Station development at the north end of the City. The new Fire Station may be also able to provide EMS services through cross-trained firefighters. The proposed development to the east of the City may be able to develop an area recreational facility along the existing pond.

8.1 Funding Alternatives

Acquiring sufficient funds to construct all of the recommended construction projects is a considerable task for a community the size of Epping. A number of the recommended projects outlined in this report are required in the immediate future. The City does not presently have the required funds to construct these projects in the immediate future. In order to complete the necessary projects in the recommended timeframe, a combination of increased user rates along with government grants and low-interest loans will be required. ***It is recommended that the City implement a funding program for the proposed improvements consisting of a combination increase in user rates for general improvements and repairs, altered rate structure, and government assistance.***

As noted, the total cost to construct the recommended improvements for the existing system deficiencies is **$2.16 million dollars**. Part of the planned improvements are intended to improve and maintain the existing level of service for the current residents while other listed improvments the remainder are intended to maintain the existing level of service as future residents impact the City's systems.

Loans

An alternative to fund the construction of the recommendations would be to obtain a low-interest loan to allow the City to construct a large portion of the system as one construction project. For example, the first major project may be to construct all of the “high priority” items such as the roadway improvements. This option would likely result in more favorable construction costs and allow the City to benefit from the improvements sooner. However, the City would still be responsible to re-pay the loan which may create a burden on the City.

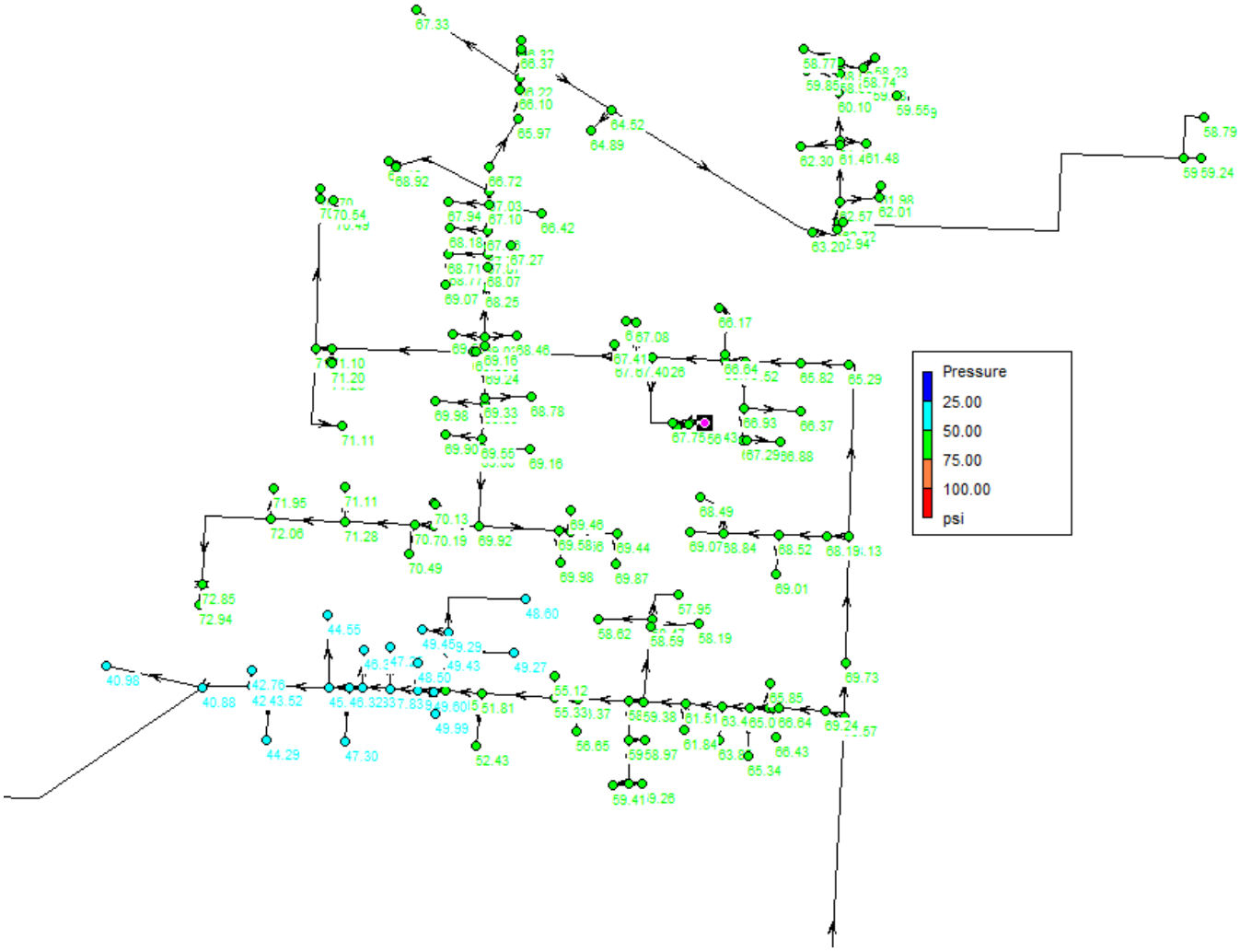
Grants

Grants are often an alternative to reduce the economic burden on a community while allowing for the construction of major improvements. Unfortunately, very few funding agencies will provide grants to construct 100% of a project and instead often require the community to contribute a portion of the funds through loans or cash on hand.

To mitigate the financial impact on the community and expedite the most critical projects, we recommend the City request a combination of government grants and interest-free loans to complete the projects. Increasing the user rates will empower the City to repair and upgrade many portions of the City through internal funds. By requesting grants and loans, the City will be able to complete more of the required projects earlier than would be otherwise possible. Combining internal funding with grants and loans will provide the City will the means to update, upgrade and maintain the existing systems in a manner that will protect the public health and safety as well as the surrounding environment.

APPENDIX A

CULINARY MODEL RESULTS



Existing System Model Results

Node ID	Elevation (FT)	Demand (GPM)	Head (FT)	Pressure (PSI)
Junc J-10	2158.469	0	2428.15	116.62
Junc J-103	2229.835	0	2428.11	85.74
Junc J-111	2220.711	0	2428.13	89.69
Junc J-114	2215.002	0	2428.11	92.16
Junc J-116	2218.686	0	2428.12	90.57
Junc J-117	2209.943	0	2428.11	94.34
Junc J-119	2206.293	0	2428.11	95.92
Junc J-12	2209.854	0	2428.15	94.4
Junc J-120	2204.192	0	2428.15	96.85
Junc J-127	2208.068	0	2428.15	95.17
Junc J-128	2208.192	0	2428.15	95.12
Junc J-129	2209.17	0	2428.15	94.69
Junc J-130	2209.505	0	2428.15	94.55
Junc J-132	2211.33	0	2428.15	93.76
Junc J-133	2209.299	0	2428.15	94.64
Junc J-143	2210.22	0	2428.11	94.22
Junc J-15	2195.326	0	2428.15	100.68
Junc J-155	2211.918	0	2428.16	93.51
Junc J-156	2211.49	0	2428.11	93.68
Junc J-158	2194.256	0	2428.15	101.14
Junc J-159	2194.225	0	2428.15	101.16
Junc J-16	2207.44	0	2428.15	95.44
Junc J-162	2218.408	0	2428.11	90.68
Junc J-164	2218.059	0	2428.11	90.83
Junc J-167	2213.959	0	2428.11	92.61
Junc J-168	2212.021	0	2428.15	93.46
Junc J-170	2206.745	0	2428.15	95.74
Junc J-173	2208.604	0	2428.15	94.94
Junc J-174	2210.156	0	2428.15	94.27
Junc J-175	2211.513	0	2428.15	93.68
Junc J-176	2206.168	0	2428.15	95.99
Junc J-179	2219.334	0	2428.13	90.29
Junc J-184	2206.559	0	2428.15	95.82
Junc J-185	2239.129	0	2428.11	81.72
Junc J-186	2238.584	0	2428.11	81.96
Junc J-2	2214.048	0	2428.11	92.57
Junc J-23	2217.531	0	2428.14	91.08
Junc J-24	2218.747	0	2428.12	90.54
Junc J-26	2212.484	0	2428.11	93.25
Junc J-27	2210.373	0	2428.11	94.16
Junc J-28	2211.467	0	2428.11	93.69
Junc J-31	2225.791	0	2428.11	87.49
Junc J-35	2216.624	0	2428.14	91.47
Junc J-36	2235.999	0	2428.11	83.08
Junc J-37	2211.112	0	2428.15	93.86
Junc J-38	2215.367	0	2428.11	92
Junc J-44	2214.238	0	2428.11	92.49
Junc J-45	2210.167	0	2428.15	94.26
Junc J-46	2211.598	0	2428.15	93.65
Junc J-47	2211.323	0	2428.15	93.77

Node ID	Elevation (FT)	Demand (GPM)	Head (FT)	Pressure (PSI)
Junc J-51	2230.304	0	2428.11	85.54
Junc J-53	2219.158	0	2428.12	90.36
Junc J-54	2204.496	0	2428.23	96.75
Junc J-55	2421.899	0	2431.9	4.32
Junc J-56	2210.349	0	2428.15	94.18
Junc J-57	2211.774	0	2428.15	93.57
Junc J-59	2214.6	0	2428.11	92.33
Junc J-60	2221.198	0	2428.13	89.48
Junc J-65	2237.631	0	2428.11	82.37
Junc J-66	2215.885	0	2428.14	91.79
Junc J-68	2208.574	0	2428.15	94.95
Junc J-70	2213.913	0	2428.11	92.63
Junc J-72	2215.347	0	2428.14	92.02
Junc J-73	2220.25	0	2428.13	89.89
Junc J-74	2212.214	0	2428.11	93.36
Junc J-75	2232.88	0	2428.11	84.42
Junc J-76	2239.663	0	2428.11	81.49
Junc J-78	2204.502	0	2428.15	96.71
Junc J-79	2232.864	0	2428.11	84.43
Junc J-8	2214.524	0	2428.11	92.36
Junc J-80	2207.792	0	2428.15	95.29
Junc J-81	2210.56	0	2428.11	94.08
Junc J-82	2210.353	0	2428.11	94.17
Junc J-85	2213.948	0	2428.11	92.61
Junc J-86	2213.119	0	2428.11	92.97
Junc J-88	2219.474	0	2428.12	90.23
Junc J-89	2208.137	0	2428.11	95.13
Junc J-9	2188.49	0	2428.15	103.64
Junc J-90	2204.779	0	2428.15	96.59
Junc J-91	2222.429	0	2428.11	88.94
Junc J-92	2219.988	0	2428.11	90
Junc J-93	2219	0	2428.11	90.43
Junc J-94	2219.82	0	2428.11	90.07
Junc J-95	2217.181	0	2428.11	91.21
Junc J-96	2217.581	0	2428.11	91.04
Junc J-97	2221.865	0	2428.11	89.19
Junc J-98	2221.624	0	2428.11	89.29
Junc J-99	2221.451	0	2428.11	89.37
Junc M-1	2213.077	0.31	2428.11	92.99
Junc M-10	2231.654	0.31	2428.11	84.95
Junc M-11	2219.609	0.14	2428.12	90.17
Junc M-12	2212.688	0.31	2428.15	93.17
Junc M-13	2219.192	0.49	2428.11	90.34
Junc M-14	2219.424	0.31	2428.11	90.24
Junc M-15	2206.034	0.83	2428.11	96.03
Junc M-16	2216.651	0.49	2428.14	91.46
Junc M-17	2207.121	0.31	2428.15	95.58
Junc M-18	2220.327	0.49	2428.13	89.86
Junc M-19	2211.782	0.31	2428.11	93.55
Junc M-2	2215.161	0.31	2428.11	92.09

Node ID	Elevation (FT)	Demand (GPM)	Head (FT)	Pressure (PSI)
Junc M-20	2210.339	0.31	2428.11	94.17
Junc M-21	2215.855	0.31	2428.11	91.79
Junc M-22	2210.315	0.31	2428.11	94.18
Junc M-23	2204.293	0.31	2428.15	96.8
Junc M-24	2237.383	0.31	2428.11	82.48
Junc M-25	2218.969	0.31	2428.12	90.44
Junc M-26	2209.65	0	2428.15	94.49
Junc M-27	2211.582	0.69	2428.15	93.65
Junc M-28	2212.236	0.31	2428.15	93.37
Junc M-29	2212.986	0.31	2428.11	93.03
Junc M-3	2214.952	0	2428.11	92.18
Junc M-30	2215.477	0.08	2428.14	91.96
Junc M-31	2203.572	1.11	2428.15	97.11
Junc M-32	2218.316	0.28	2428.12	90.73
Junc M-33	2210.508	0.31	2428.11	94.1
Junc M-34	2208.382	0.31	2428.11	95.02
Junc M-35	2221.383	0.31	2428.11	89.4
Junc M-36	2216.683	0.31	2428.11	91.43
Junc M-37	2214.179	0.31	2428.11	92.51
Junc M-38	2211.73	0.31	2428.15	93.59
Junc M-39	2204.708	0.31	2428.15	96.62
Junc M-4	2221.991	0.31	2428.13	89.14
Junc M-40	2208.84	0.31	2428.15	94.84
Junc M-41	2210.415	0.31	2428.15	94.16
Junc M-42	2211.403	0.31	2428.15	93.73
Junc M-43	2210.327	0.31	2428.15	94.19
Junc M-44	2210.67	0.31	2428.15	94.05
Junc M-45	2207.159	0.31	2428.15	95.56
Junc M-46	2202.974	0.31	2428.15	97.37
Junc M-47	2208.546	0.31	2428.15	94.96
Junc M-48	2209.503	0.31	2428.15	94.55
Junc M-49	2208.754	0.31	2428.15	94.87
Junc M-5	2219.113	0.31	2428.12	90.38
Junc M-50	2208.418	0.31	2428.15	95.02
Junc M-51	2213.247	0.31	2428.11	92.92
Junc M-52	2221.524	0.31	2428.13	89.34
Junc M-53	2217.862	0.31	2428.11	90.92
Junc M-54	2215.959	0.31	2428.11	91.74
Junc M-55	2216.087	0.31	2428.11	91.69
Junc M-56	2217.315	0.31	2428.11	91.16
Junc M-57	2211.973	0.31	2428.11	93.47
Junc M-58	2213.204	0.31	2428.15	92.95
Junc M-59	2213.223	0.31	2428.11	92.93
Junc M-6	2224.904	0.49	2428.11	87.87
Junc M-60	2210.199	0.31	2428.15	94.25
Junc M-61	2207.938	0.31	2428.15	95.23
Junc M-62	2208.771	0.31	2428.15	94.87
Junc M-63	2208.945	0.31	2428.15	94.79
Junc M-64	2232.812	0.31	2428.11	84.45
Junc M-65	2230.917	0.31	2428.11	85.27

Node ID	Elevation (FT)	Demand (GPM)	Head (FT)	Pressure (PSI)
Junc M-66	2236.57	0.31	2428.11	82.83
Junc M-67	2239.062	0.31	2428.11	81.75
Junc M-68	2240.289	0.31	2428.11	81.22
Junc M-69	2238.324	0.31	2428.11	82.07
Junc M-7	2214.279	0.31	2428.11	92.47
Junc M-8	2212.611	0.31	2428.11	93.19
Junc M-9	2209.792	0.31	2428.15	94.43
Junc V-10	2224.072	0	2428.13	88.24
Junc V-11	2214.855	0	2428.11	92.22
Junc V-14	2204.793	0	2428.23	96.62
Junc V-15	2213.835	0	2428.15	92.68
Junc V-16	2219.883	0	2428.12	90.05
Junc V-17	2192.761	0	2428.15	101.79
Junc V-2	2199.145	0	2428.15	99.03
Junc V-21	2204.987	0	2428.23	96.54
Junc V-22	2239.117	0	2428.11	81.73
Junc V-23	2211.847	0	2428.11	93.52
Junc V-24	2229.943	0	2428.11	85.69
Junc V-25	2220.706	0	2428.11	89.69
Junc V-26	2218.693	0	2428.12	90.56
Junc V-28	2220.917	0	2428.13	89.6
Junc V-29	2229.439	0	2428.11	85.91
Junc V-3	2239.035	0	2428.11	81.76
Junc V-30	2221.518	0	2428.11	89.34
Junc V-31	2215.547	0	2428.11	91.92
Junc V-32	2228.841	0	2428.11	86.17
Junc V-33	2218.665	0	2428.12	90.58
Junc V-37	2212.259	0	2428.16	93.36
Junc V-38	2214.551	0	2428.11	92.35
Junc V-39	2195.957	0	2428.15	100.41
Junc V-4	2237.995	0	2428.11	82.21
Junc V-41	2215.278	0	2428.11	92.04
Junc V-42	2214.595	0	2428.11	92.33
Junc V-44	2215.571	0	2428.11	91.91
Junc V-45	2219.421	0	2428.13	90.25
Junc V-46	2215.079	0	2428.11	92.12
Junc V-47	2212.621	0	2428.11	93.19
Junc V-49	2210.334	0	2428.11	94.18
Junc V-51	2217.377	0	2428.14	91.14
Junc V-52	2218.242	0	2428.12	90.76
Junc V-53	2237.253	0	2428.11	82.53
Junc V-54	2193.271	0	2428.15	101.57
Junc V-58	2222.839	0	2428.13	88.78
Junc V-6	2211.721	0	2428.15	93.59
Junc V-7	2206.298	0	2428.11	95.92
Junc V-8	2222.143	0	2428.11	89.07

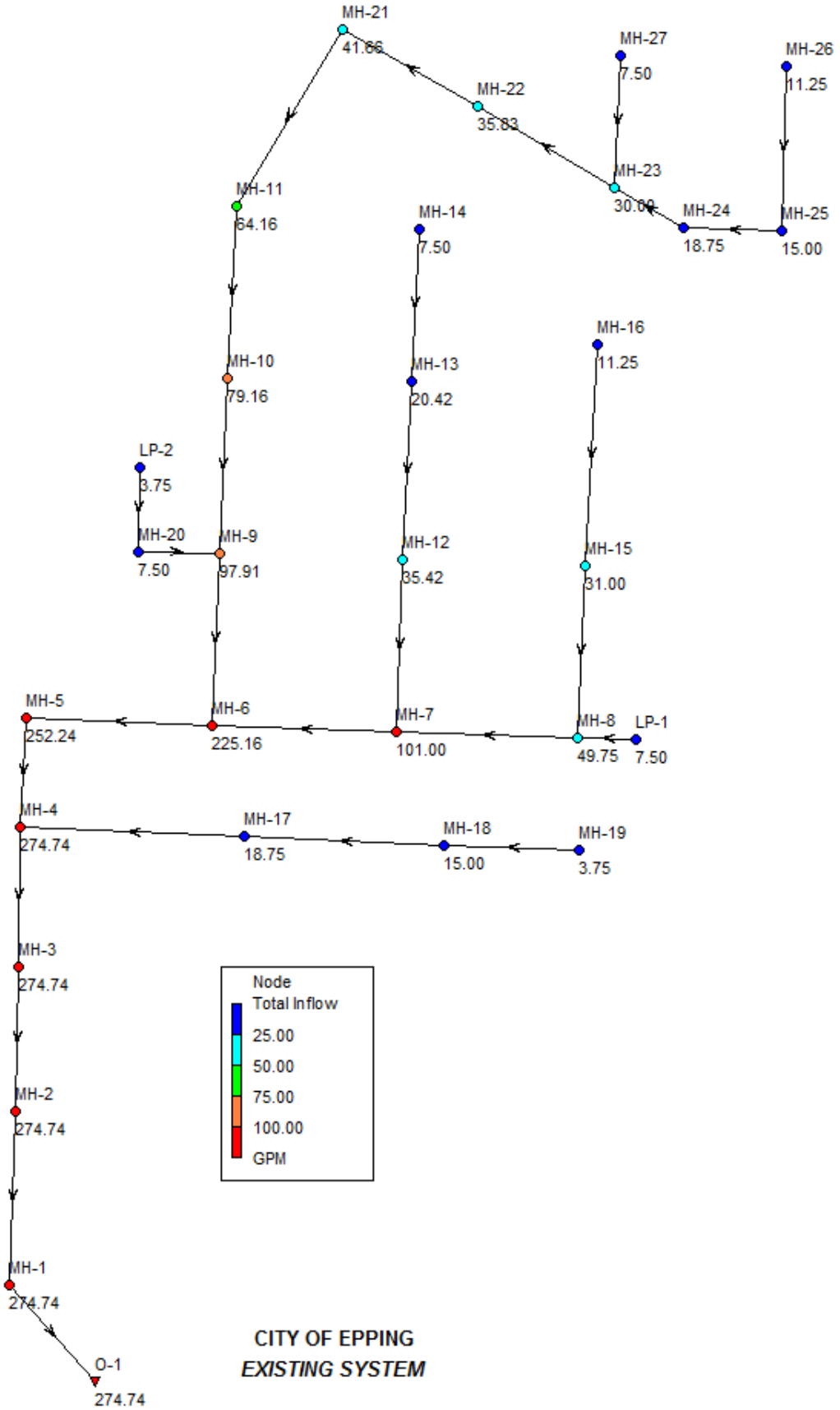
APPENDIX B

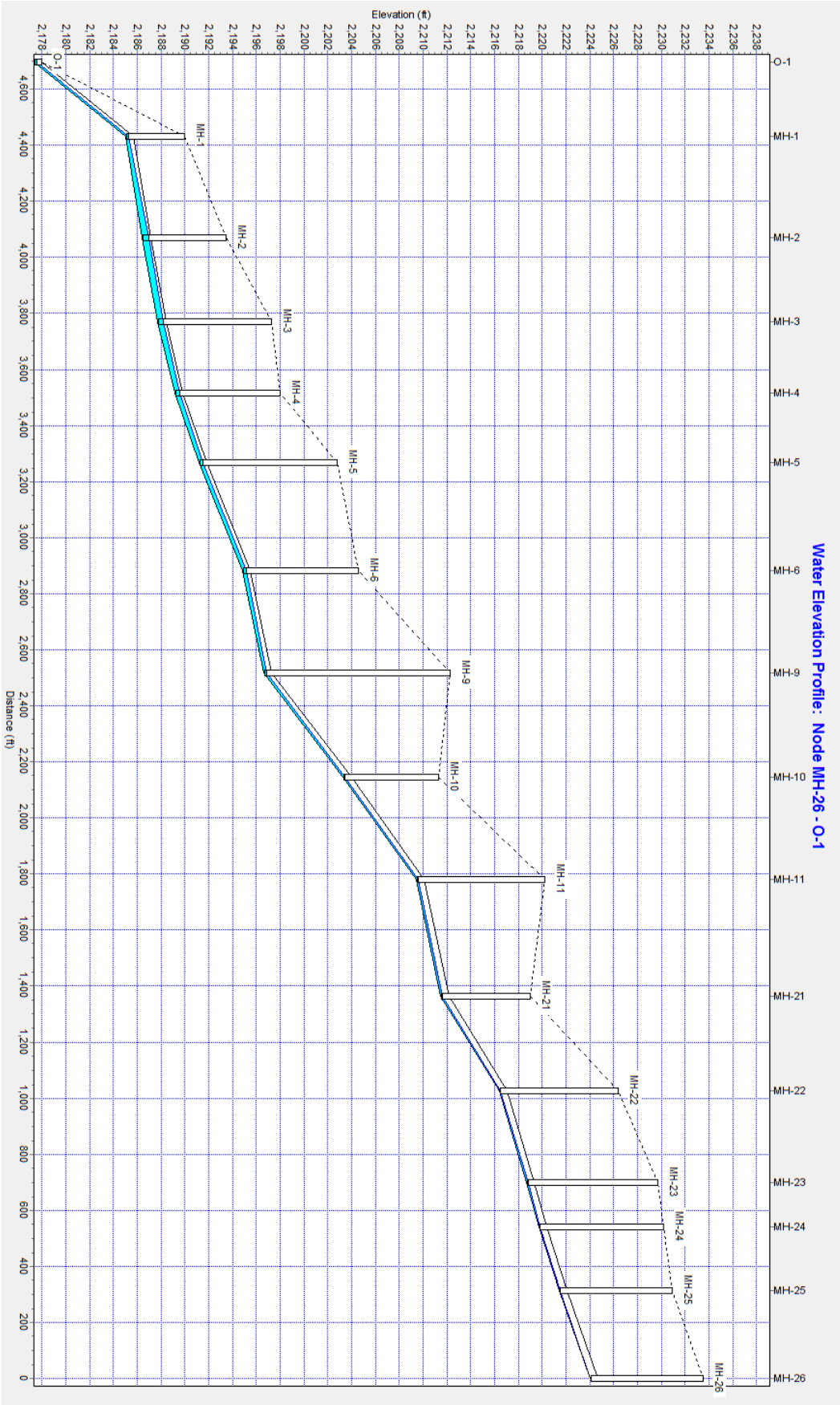
SANITARY SEWER MODEL RESULTS

Existing System Results

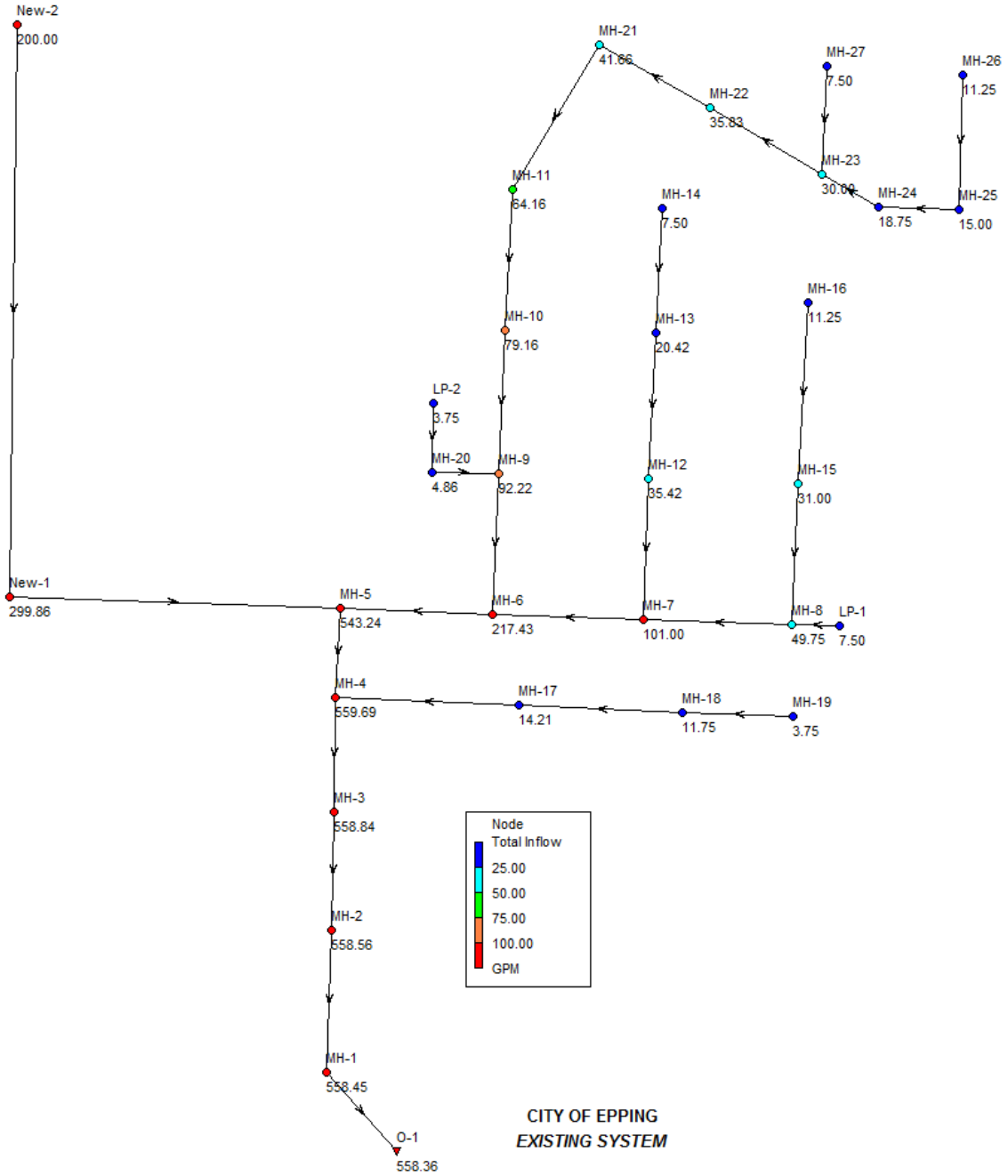
Proposed System Results

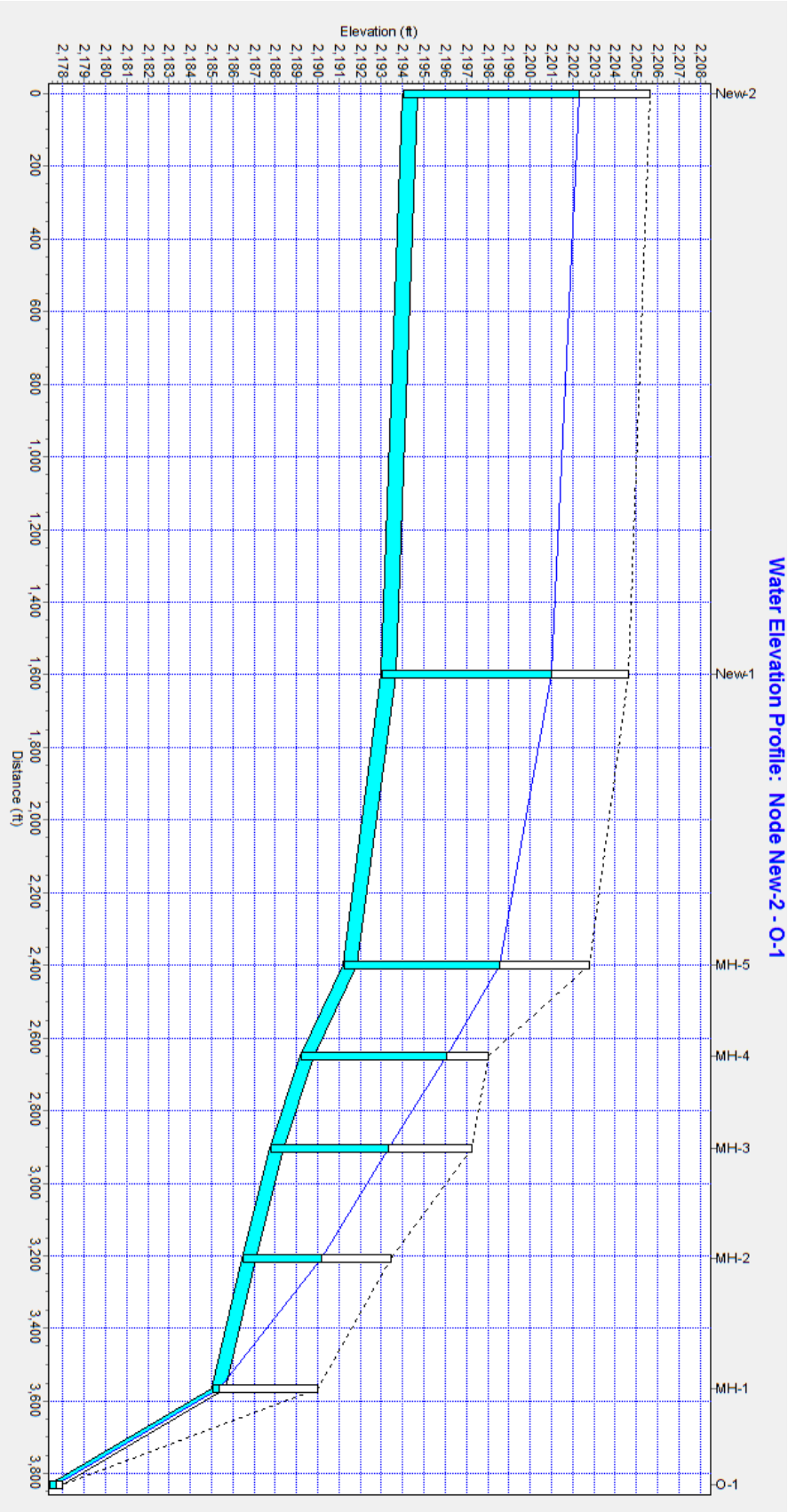
Existing System Model Results




Water Elevation Profile: Node MH-26 - O-1
Elevation (ft)
Distance (ft)
O-1
MH-1
MH-2
MH-3
MH-4
MH-5
MH-6
MH-9
MH-10
MH-11
MH-21
MH-22
MH-23
MH-24
MH-25
MH-26

Proposed System Model Results




Water Elevation Profile: Node New-2 - O-1
Elevation (ft)
Distance (ft)
New-2
New-1
MH-5
MH-4
MH-3
MH-2
MH-1
O-1

APPENDIX C

LAGOON ANALYSIS RESULTS

Existing Lagoon Sizing

Proposed Lagoon Sizing

Existing Capacity Cell No. 1

Existing Capacity Cell No. 2&3

Proposed Capacity Cell No. 1

Proposed Capacity Cell No. 2&3

Existing Lagoon Sizing

Epping Wastewater Lagoon

Population	200.0	Population
Wastewater Per Capita	75.0	gpd/person
Population Wastewater Inflow	15,000.0	gal/day
Commercial Wastewater Inflow	2,610.0	gal/day
Total Inflow	17,610.0	gal/day
	2,354.1	ft³/day

180 day Pond Volume (Neglecting Infil, Precip, etc)

3,169,800.0	gal
423,740.6	ft³

365 day Pond Volume (Neglecting Infil, Precip, etc)

6,427,650.0	gal
859,251.8	ft³

Average Infiltration

0.00	ft^3/acre	Max allowable is 6,500 gallons per acre per day per state code

10 year Max Annual Precipitation

14.41	in	http://www.usclimatedata.com/climate/myton/utah/united-states/usut0177
0.039479452	in/day	

Average Annual Evaporation

0	in/year	from Figure 4.10 page 99 of Hydrology and Water Quantity Control (Martin Wanielista, 1990)
0	in/day	

Storage Pond Loading

Flow in vs. Flow out @ 12' depth	in/day	area (ft²)	volume (ft³)/day
Wastewater Inflow			2,354.11
Precipitation	0.039	348,760.00	1,147.40
Total Inflows			3,501.52
Evaporation	0.0000	326,298.72	0.00
Infiltration	0.00	7.49	0.00
Total Outflows			0.00
		Net Loading	3,501.52

180 day Pond Volume

4,714,772.7	gal
630,273.4	ft³

365 day Pond Volume

9,560,511.3	gal
1,278,054.5	ft³

Suspended Solids

0.2	lb/person/day - Assumed E
40	lb/day for whole site
80	lb/ft^3 - Density Assumed
0.5	ft^3/day
3,831,913	days to Fill Primary Pond
10,498	years to Fill Primary Pond

BOD5

300	mg/L
0.000661	lb/L
0.00250	lb/gal
0.1878	lb/person/day
37.55	lb/day total

Max Depth Pond Size

Bottom Dimensions	Length	418.00		Width	397.00 ft
	Depth	8.00	ft		
	Slopes	4	:1		
Top Dimensions	Length	482.00		Width	461 ft
	Top Area	222,202	ft^2		
	Bottom Area	165,946	ft^2		
	Pond Top Area	5.10	Acres		
	Pond Volume	1,547,128	ft^3		

Phase I Final Pond Size With Freeboard

Bottom Dimensions	Length	418.00		Width	397.00 ft
	Depth	10.00	ft		
	Slopes	3	:1		
	Freeboard	2	ft		
Top Dimensions	Length	478.00		Width	457 ft
	Top Area	218,446	ft^2		
	Bottom Area	165,946	ft^2		
	Pond Top Area	5.01	Acres		
	Pond Volume	1,915,957	ft^3		

Proposed Lagoon Sizing

Epping Wastewater Lagoon

Population	419.0	Population
Wastewater Per Capita	75.0	gpd/person
Population Wastewater Inflow	31,425.0	gal/day
Commercial Wastewater Inflow	3,915.0	gal/day
Total Inflow	35,340.0	gal/day
	4,724.3	ft³/day

180 day Pond Volume (Neglecting Infill, Precip, etc)

6,361,200.0	gal
850,368.7	ft³

365 day Pond Volume (Neglecting Infill, Precip, etc)

12,899,100.0	gal
1,724,358.9	ft³

Average Infiltration

0.00	ft^3/acre	Max allowable is 6,500 gallons per acre per day per state code

10 year Max Annual Precipitation

14.41	in	http://www.usclimatedata.com/climate/myton/utah/united-states/usut0177
0.039479452	in/day	

Average Annual Evaporation

0	in/year	from Figure 4.10 page 99 of Hydrology and Water Quantity Control (Martin Wanielista, 1990)
0	in/day	

Storage Pond Loading

Flow in vs. Flow out @ 12' depth	in/day	area (ft²)	volume (ft³)/day
Wastewater Inflow			4,724.27
Precipitation	0.039	348,760.00	1,147.40
Total Inflows			5,871.68
Evaporation	0.0000	326,298.72	0.00
Infiltration	0.00	7.49	0.00
Total Outflows			0.00
		Net Loading	5,871.68

180 day Pond Volume

7,906,172.7	gal
1,056,901.6	ft³

365 day Pond Volume

16,031,961.3	gal
2,143,161.5	ft³

Suspended Solids

0.2	lb/person/day - Assumed E
83.8	lb/day for whole site
80	lb/ft^3 - Density Assumed
1.0475	ft^3/day
1,829,075	days to Fill Primary Pond
5,011	years to Fill Primary Pond

BOD5

300	mg/L	from Table 3-15 "Wastewater Engineering Metcalf & Eddy 4th Edition"
0.000661	lb/L	
0.00250	lb/gal	
0.1878	lb/person/day	
78.68	lb/day total	

Max Depth Pond Size

Bottom Dimensions	Length	418.00		Width	397.00 ft
	Depth	8.00 ft			
	Slopes	4 :1			
Top Dimensions	Length	482.00		Width	461 ft
	Top Area	222,202 ft^2			
	Bottom Area	165,946 ft^2			
	Pond Top Area	5.10 Acres			
	Pond Volume	1,547,128 ft^3			

Phase I Final Pond Size With Freeboard

Bottom Dimensions	Length	418.00		Width	397.00 ft
	Depth	10.00 ft			
	Slopes	3 :1			
	Freeboard	2 ft			
Top Dimensions	Length	478.00		Width	457 ft
	Top Area	218,446 ft^2			
	Bottom Area	165,946 ft^2			
	Pond Top Area	5.01 Acres			
	Pond Volume	1,915,957 ft^3			

Existing Capacity Cell No. 1

Epping Existing Lagoon

Wastewater inflow				
From WWTF:	35,340.0	gal/day	4,724.3	ft³
From Others:	0.0	gal/day	0.0	ft³
Total:	35,340.0	gal/day		
	4,724.3	ft³/day		
Required 180 day Pond Volume (Neglecting Infil, Precip, etc)				
	6,361,200.0	gal		
	850,368.7	ft³		

Max Depth Pond Size (No Freeboard)

Bottom Dimensions	Length	145.0	Width	145.0	ft
	Depth	5.0 ft			
	Slopes	4 :1			
Max Use Volume	Length	185.0	Width	185.0	ft
	Top Area	34,225 ft²			
	Bottom Area	21,025 ft²			
	Pond Top Area	0.79 Acres			
	Pond Bottom Area	0.48 Acres			
	Pond Volume	119625.00 ft³			
		894,857 gal			

Pond Size With Freeboard

Bottom Dimensions	Length	145.0	Width	145.0	ft
	Depth	5.0 ft			
	Slopes	4 :1			
	Freeboard	3 ft			
Top Dimensions	Length	209.0	Width	209.0	ft
	Top Area	43,681.0 ft²			
	Bottom Area	21,025.0 ft²			
	Pond Top Area	1.00 Acres			
	Pond Bottom Area	0.48 Acres			
	Pond Volume	205,320.0 ft³			
		1,535,900 gal			

Existing Capacity Cell No. 2&3

Epping Existing Lagoon

Wastewater inflow				
From WWTF:	35,340.0	gal/day	4,724.3	ft^3
From Others:	0.0	gal/day	0.0	ft^3
Total:	35,340.0	gal/day		
	4,724.3	ft^3/day		
Required 180 day Pond Volume (Neglecting Infil, Precip, etc)				
	6,361,200.0	gal		
	850,368.7	ft^3		

Max Depth Pond Size (No Freeboard)

Bottom Dimensions	Length	354.0	Width	124.0	ft
	Depth	5.0 ft			
	Slopes	4 :1			
Max Use Volume	Length	394.0	Width	164.0	ft
	Top Area	64,616 ft^2			
	Bottom Area	43,896 ft^2			
	Pond Top Area	1.48 Acres			
	Pond Bottom Area	1.01 Acres			
	Pond Volume	231880.00 ft^3			
		1,734,583 gal			

Pond Size With Freeboard

Bottom Dimensions	Length	354.0	Width	124.0	ft
	Depth	5.0 ft			
	Slopes	4 :1			
	Freeboard	3 ft			
Top Dimensions	Length	418.0	Width	188.0	ft
	Top Area	78,584.0 ft^2			
	Bottom Area	43,896.0 ft^2			
	Pond Top Area	1.80 Acres			
	Pond Bottom Area	1.01 Acres			
	Pond Volume	382,912.0 ft^3			
		2,864,381 gal			

Proposed Capacity Cell No. 1

Projected Existing Lagoon

Wastewater inflow				
From WWTF:	17,610.0	gal/day	2,354.1	ft^3
From Others:	0.0	gal/day	0.0	ft^3
Total:	17,610.0	gal/day		
	2,354.1	ft^3/day		
Required 180 day Pond Volume (Neglecting Infil, Precip, etc)				
	3,169,800.0	gal		
	423,740.6	ft^3		

Max Depth Pond Size (No Freeboard)

Bottom Dimensions	Length	354.0	Width	124.0	ft
	Depth	5.0 ft			
	Slopes	4 :1			
Max Use Volume	Length	394.0	Width	164.0	ft
	Top Area	64,616 ft^2			
	Bottom Area	43,896 ft^2			
	Pond Top Area	1.48 Acres			
	Pond Bottom Area	1.01 Acres			
	Pond Volume	231880.00 ft^3			
		1,734,583 gal			

Pond Size With Freeboard

Bottom Dimensions	Length	354.0	Width	124.0	ft
	Depth	5.0 ft			
	Slopes	4 :1			
	Freeboard	3 ft			
Top Dimensions	Length	418.0	Width	188.0	ft
	Top Area	78,584.0 ft^2			
	Bottom Area	43,896.0 ft^2			
	Pond Top Area	1.80 Acres			
	Pond Bottom Area	1.01 Acres			
	Pond Volume	382,912.0 ft^3			
		2,864,381 gal			

Proposed Capacity Cell No. 2&3

Projected Existing Lagoon

Wastewater inflow				
From WWTF:	17,610.0	gal/day	2,354.1	ft^3
From Others:	0.0	gal/day	0.0	ft^3
Total:	17,610.0	gal/day		
	2,354.1	ft^3/day		
Required 180 day Pond Volume (Neglecting Infil, Precip, etc)				
	3,169,800.0	gal		
	423,740.6	ft^3		

Max Depth Pond Size (No Freeboard)

Bottom Dimensions	Length	145.0		Width	145.0	ft
	Depth	5.0	ft			
	Slopes	4	:1			
Max Use Volume	Length	185.0		Width	185.0	ft
	Top Area	34,225	ft^2			
	Bottom Area	21,025	ft^2			
	Pond Top Area	0.79	Acres			
	Pond Bottom Area	0.48	Acres			
	Pond Volume	119625.00	ft^3			
		894,857	gal			

Pond Size With Freeboard

Bottom Dimensions	Length	145.0		Width	145.0	ft
	Depth	5.0	ft			
	Slopes	4	:1			
	Freeboard	3	ft			
Top Dimensions	Length	209.0		Width	209.0	ft
	Top Area	43,681.0	ft^2			
	Bottom Area	21,025.0	ft^2			
	Pond Top Area	1.00	Acres			
	Pond Bottom Area	0.48	Acres			
	Pond Volume	205,320.0	ft^3			
		1,535,900	gal			

APPENDIX D

STORM WATER MODEL RESULTS

Soil Conditions

Crop Classification

Basin Soil CN Value Derivation

Individual Basin Details

Theoretical Detention Basin Sizing Using Rational Method for Basins 3,7,15

Soil Conditions

Soil Group	Description
A	Well-drained sand and gravel with high permeability
B	Moderate to well-drained with moderately fine to moderately coarse texture and moderate permeability
C	Poor to moderately well-drained with moderately fine to fine texture and slow permeability
D	Poorly drained, clay soils with high swelling potential, permanent high water table, clay or shallow soils over nearly impervious layer

Soil types partly determine infiltration, evapotranspiration, and runoff rates. Sand, silt, clay, and decaying materials are the primary particles of soil. The U.S. Department of Agriculture defines soil in terms of percentage sand, silt, and clay. Another description used in classifying soil texture is loam, which is soil composed of a relatively even distribution of sand, silt, and clay.

Soil texture is related to infiltration and the Soil Conservation Service (SCS) hydrologic soil grouping, which describes a soil's runoff potential. There are four SCS hydrologic soil groups. The table below describes the different soil groups. To calculate the runoff generated for a given area using the SCS TR-20 Method, a curve number must be determined for the tributary area. Soils that are well-drained (Group A) will have a lower curve number and poorly drained soils (Group D) will have a higher curve number indicating more runoff potential.

Crop Classification

Crop	Cover Classification	A	B	C	D
Alfalfa	Straight Row Good	67	78	85	89
Barley	Straight Row Good	67	78	85	89
Barren	Bare Soil	77	86	91	94
Canola	Straight Row Good	67	78	85	89
Corn	Straight Row Good	67	78	85	89
Deciduous Forest	Good Woods	30	55	70	77
Developed/Low Intensity	Farmsteads	59	74	82	86
Developed/Med Intensity	Farmsteads	59	74	82	86
Developed/Open Space	Farmsteads	59	74	82	86
Durum Wheat	Straight Row Good	67	78	85	89
Evergreen Forest	Good Woods	30	55	70	77
Fallow/Idle Cropland	Bair Soil	77	86	91	94
Grassland Herbaceous	Fair Herbaceous	63	71	81	89
Herbaceous Wetlands	Poor Herbaceous	75	80	87	93
Open Water	Water	0	0	0	0
Other Hay/Non-Alfalfa	Straight Row Good	67	78	85	89
Shrubland	Fair Sage Brush	45	51	63	70
Spring Wheat	Straight Row Good	67	78	85	89
Sunflower	Straight Row Good	67	78	85	89
Winter Wheat	Straight Row Good	67	78	85	89
Woody Wetlands	Woods Poor	45	66	77	83

On September 25th, 2015, the USDA/NRCS published the 15th version of their soil survey for Williams County, North Dakota. Another important factor besides soil type is the existing vegetation. An area that is heavily vegetated will have a lower curve number than an area that is sparsely vegetated. The USDA National Agricultural Statistics Service published the 2014 National Crop Data Layer that contains information for the land cover of the area. Since much of the land is being utilized for crops, the soil condition was considered good due to the farmers' maintenance. These two values were used to derive weighted Basin Curve Number (CN values) for the basins as shown in the following table.

An additional factor in determining runoff coefficients is the slope where moderate to steep slopes will yield higher curve number than flat slopes. The average slope of the basins around the City of Epping is 0.3% with a minimum slope of 0.1% and a maximum slope of 58%. The soils and crop information was dynamically combined in order to obtain the corresponding curve number for each tributary area for hydraulic modeling. These Basin CN components based on soil and ground cover can be viewed in the following tables.

Basin Soil CN Value Derivation

Basin Information	Sum of Acres	Percentage of Total	Weighted CN Value
Basin 1	**48.14**	**100%**	**74.3**
B	48.14	100%	74.3
Barley	0.22	0%	0.4
Barren	0.05	0%	0.1
Developed/Low Intensity	1.49	3%	2.3
Developed/Open Space	4.59	10%	7.1
Durum Wheat	0.39	1%	0.6
Fallow/Idle Cropland	8.81	18%	15.7
Grassland Herbaceous	32.24	67%	47.5
Spring Wheat	0.12	0%	0.2
Winter Wheat	0.22	0%	0.4
Basin 2	**35.78**	**100%**	**74.9**
B	35.78	100%	74.9
Developed/Low Intensity	0.15	0%	0.3
Developed/Open Space	2.64	7%	5.5
Durum Wheat	3.47	10%	7.6
Fallow/Idle Cropland	6.90	19%	16.6
Grassland Herbaceous	21.96	61%	43.6
Spring Wheat	0.67	2%	1.5
Basin 3	**26.35**	**100%**	**71.9**
B	23.67	90%	64.6
Developed/Low Intensity	1.60	6%	4.5
Developed/Med Intensity	0.44	2%	1.2
Developed/Open Space	4.80	18%	13.5
Grassland Herbaceous	16.83	64%	45.4
B/D	2.68	10%	7.3
Developed/Open Space	0.78	3%	2.2
Grassland Herbaceous	1.90	7%	5.1
Basin 4	**53.80**	**100%**	**70.7**
B	39.80	74%	52.9
Deciduous Forest	0.55	1%	0.6
Developed/Low Intensity	0.40	1%	0.5
Developed/Open Space	5.51	10%	7.6
Grassland Herbaceous	30.75	57%	40.6
Other Hay/Non-Alfalfa	2.28	4%	3.3
Shrubland	0.32	0%	0.3
B/D	14.00	26%	17.8
Deciduous Forest	2.52	5%	2.5
Developed/Open Space	1.56	3%	2.2
Grassland Herbaceous	7.96	15%	10.5
Other Hay/Non-Alfalfa	0.76	1%	1.1
Woody Wetlands	1.19	2%	1.5
Basin 5	**188.18**	**100%**	**72.1**
B	188.18	100%	72.1
Alfalfa	0.75	0%	0.3
Barren	2.30	1%	1.0
Canola	0.22	0%	0.1
Deciduous Forest	1.33	1%	0.4
Developed/Low Intensity	11.14	6%	4.4
Developed/Med Intensity	0.88	0%	0.3
Developed/Open Space	27.36	15%	10.8
Durum Wheat	0.92	0%	0.4
Fallow/Idle Cropland	4.31	2%	2.0
Grassland Herbaceous	138.65	74%	52.3

Basin Information	Sum of Acres	Percentage of Total	Weighted CN Value
Shrubland	0.07	0%	0.0
Woody Wetlands	0.22	0%	0.1
Basin 6	**28.12**	**100%**	**71.6**
B	28.12	100%	71.6
Barren	0.54	2%	1.6
Developed/Open Space	3.84	14%	10.1
Grassland Herbaceous	22.93	82%	57.9
Herbaceous Wetlands	0.22	1%	0.6
Other Hay/Non Alfalfa	0.22	1%	0.6
Shrubland	0.37	1%	0.7
Basin 7	**38.39**	**100%**	**72.6**
B	38.39	100%	72.6
Alfalfa	2.62	7%	5.3
Barley	0.22	1%	0.5
Barren	2.00	5%	4.5
Canola	0.16	0%	0.3
Corn	0.17	0%	0.3
Developed/Open Space	2.66	7%	5.1
Grassland Herbaceous	29.43	77%	54.4
Other Hay/Non-Alfalfa	0.89	2%	1.8
Shrubland	0.22	1%	0.3
Basin 8	**5.96**	**100%**	**71.5**
B	5.96	100%	71.5
Alfalfa	0.08	1%	1.0
Grassland Herbaceous	5.56	93%	66.2
Other Hay/Non-Alfalfa	0.32	5%	4.2
Basin 9	**25.30**	**100%**	**68.0**
B	25.30	100%	68.0
Alfalfa	4.44	18%	13.7

Basin Information	Sum of Acres	Percentage of Total	Weighted CN Value
Corn	0.13	0%	0.4
Developed/Open Space	1.00	4%	3.0
Grassland Herbaceous	18.18	72%	51.0
Open Water	1.56	6%	0.0
Grand Total	705.09	2000%	1435.5
Basin 10	**7.86**	**100%**	**69.5**
B	7.86	100%	69.5
Alfalfa	0.22	3%	2.2
Deciduous Forest	0.22	3%	1.5
Developed/Open Space	0.47	6%	4.4
Evergreen Forest	0.17	2%	1.2
Grassland Herbaceous	6.55	83%	59.2
Open Water	0.13	2%	0.0
Other Hay/Non Alfalfa	0.10	1%	1.0
Basin 11	**23.16**	**100%**	**71.6**
B	23.16	100%	71.6
Alfalfa	0.73	3%	2.5
Grassland Herbaceous	21.07	91%	64.6
Other Hay/Non-Alfalfa	1.36	6%	4.6
Basin 12	**24.27**	**100%**	**72.9**
B	24.27	100%	72.9
Alfalfa	2.77	11%	8.9
Corn	0.56	2%	1.8
Developed/Low Intensity	0.22	1%	0.7
Developed/Open Space	4.82	20%	14.7
Grassland Herbaceous	14.86	61%	43.5
Other Hay/Non-Alfalfa	1.05	4%	3.4
Basin 13	**47.52**	**100%**	**73.8**
B	47.52	100%	73.8

Basin Information	Sum of Acres	Percentage of Total	Weighted CN Value
Alfalfa	15.36	32%	25.2
Corn	0.33	1%	0.5
Developed/Low Intensity	0.18	0%	0.3
Developed/Open Space	2.59	5%	4.0
Grassland Herbaceous	26.99	57%	40.3
Other Hay/Non-Alfalfa	1.62	3%	2.7
Spring Wheat	0.22	0%	0.4
Sunflower	0.22	0%	0.4
Basin 14	**25.85**	**100%**	**71.4**
B	25.85	100%	71.4
Alfalfa	0.89	3%	2.7
Grassland Herbaceous	24.30	94%	66.7
Other Hay/Non Alfalfa	0.67	3%	2.0
Basin 15	**46.27**	**100%**	**71.6**
B	46.27	100%	71.6
Developed/Low Intensity	3.23	7%	5.2
Developed/Open Space	6.12	13%	9.8
Grassland Herbaceous	36.91	80%	56.6
Basin 16	**7.55**	**100%**	**71.8**
B	7.55	100%	71.8
Alfalfa	0.30	4%	3.1
Developed/Open Space	0.65	9%	6.4
Grassland Herbaceous	6.28	83%	59.1
Other Hay/Non-Alfalfa	0.31	4%	3.2
Basin 17	**21.55**	**100%**	**72.5**
B	21.55	100%	72.5
Alfalfa	0.59	3%	2.1
Developed/Low Intensity	2.05	10%	7.0
Developed/Open Space	7.31	34%	25.1

Basin Information	Sum of Acres	Percentage of Total	Weighted CN Value
Grassland Herbaceous	11.47	53%	37.8
Other Hay/Non Alfalfa	0.13	1%	0.5
Basin 18	**24.94**	**100%**	**69.9**
B	24.94	100%	69.9
Deciduous Forest	0.16	1%	0.3
Developed/Low Intensity	0.44	2%	1.3
Developed/Open Space	1.59	6%	4.7
Evergreen Forest	0.50	2%	1.1
Grassland Herbaceous	21.12	85%	60.1
Open Water	0.24	1%	0.0
Other Hay/Non-Alfalfa	0.44	2%	1.4
Shrubland	0.44	2%	0.9
Basin 19	**7.88**	**100%**	**70.8**
B	7.88	100%	70.8
Deciduous Forest	0.07	1%	0.5
Developed/Open Space	1.23	16%	11.5
Grassland Herbaceous	6.29	80%	56.6
Open Water	0.08	1%	0.0
Other Hay/Non Alfalfa	0.22	3%	2.2
Basin 20	**18.20**	**100%**	**72.0**
B	18.20	100%	72.0
Alfalfa	0.22	1%	1.0
Developed/Low Intensity	0.47	3%	1.9
Developed/Open Space	5.15	28%	20.9
Grassland Herbaceous	12.36	68%	48.2

Individual Basin Details

Flows are for only for rain event only and not the cumulative effects of the Basins

Basins	Sum Area of Acres	Weighted CN Value	Calculated Tc (Hour)	Tc Value Used (Hour)	2-Year Storm (CFS)	5-Year Storm (CFS)	10-Year Storm (CFS)	25-Year Storm (CFS)	50-Year Storm (CFS)	100-Year Storm (CFS)
Basin 1	48.14	74.3	0.098	0.1	16.36	31.2	47.94	76.04	101.99	131.08
Basin 2	35.78	74.9	0.048	0.1	12.16	23.19	35.63	56.52	75.81	97.43
Basin 3	26.35	71.9	0.069	0.1	5.79	12.9	20.5	34.24	47.38	62.35
Basin 4	53.80	70.7	0.076	0.1	9.88	23.67	38.63	65.1	91.18	121.03
Basin 5	188.18	72.1	0.096	0.1	48.57	101.75	158.68	261.76	358.15	467.38
Basin 6	28.12	71.6	0.067	0.1	6.17	13.77	21.88	36.54	50.57	66.55
Basin 7	38.39	72.6	0.092	0.1	9.91	20.76	32.37	53.4	73.06	95.34
Basin 8	5.96	71.5	0.055	0.1	1.31	2.92	4.64	7.74	10.71	14.1
Basin 9	25.30	68.0	0.090	0.1	2.95	8.75	15.23	26.28	37.8	51.16
Basin 10	7.86	69.5	0.048	0.1	1.17	3.08	5.18	8.83	12.52	16.78
Basin 11	23.16	71.6	0.044	0.1	5.98	12.52	19.53	32.22	44.08	57.53
Basin 12	24.27	72.9	0.075	0.1	7.23	14.39	22.28	36.01	48.78	63.12
Basin 13	47.52	73.8	0.068	0.1	10.43	23.27	36.98	61.75	85.45	112.45
Basin 14	25.85	71.4	0.058	0.1	5.09	11.9	19.38	31.88	43.67	57.22
Basin 15	46.27	71.6	0.138	0.14	4.31	11.03	18.97	32.75	45.87	60.81
Basin 16	7.55	71.8	0.505	0.51	1.86	3.98	6.26	10.15	13.86	18.08
Basin 17	21.55	72.5	0.122	0.12	2.78	7.79	13.5	23.22	32.44	43.15
Basin 18	24.94	69.9	0.136	0.14	4.58	10.97	17.91	30.18	42.27	56.11
Basin 19	7.88	70.8	0.027	0.1	2.03	4.26	6.64	10.96	14.99	19.57
Basin 20	18.20	72.0	0.095	0.1	4.7	9.84	15.35	25.32	34.64	45.21

Theoretical Basin Size Using Rational Method Calculations

Site Parameters				
Project	Basin #3			
Location	Epping, ND			
Site Conditions				
Cover	Area (acres)	C Value	Weighted average	Comments
Total Area:	26.35	0.5	13.175	Developed
Discharge				
Allowable Discharge	1.067	CFS		Based on 0.3 curve number&25-yr

25 Year Storm Detention Basin Sizing Calculations: Rational Method

Duration	*Intensity*	*Area*	*C*	*Flow*	*Volume in*	*Volume out*	*Detention*
Hour	in/hr	Acre		CFS	ft^3	ft^3	ft^3
0.083	7.440	26.35	0.500	98.02	29407	320	29,086
0.17	5.460	26.35	0.500	71.94	43161	640	42,521
0.25	4.400	26.35	0.500	57.97	52173	960	51,213
0.5	2.920	26.35	0.500	38.47	69248	1921	67,327
1	1.800	26.35	0.500	23.72	85374	3842	81,532
2	1.075	26.35	0.500	14.16	101975	7684	94,291
3	0.777	26.35	0.500	10.23	110512	11525	98,986
6	0.437	26.35	0.500	5.75	124267	23051	101,216
12	0.241	26.35	0.500	3.17	137073	46102	90,971
24	0.135	26.35	0.500	1.78	153673	92204	61,469
48	0.078	26.35	0.500	1.02	176914	184408	(7,494)
96	0.044	26.35	0.500	0.58	202052	368816	(166,764)

25 Year Detention Volume Required: 101,216 ft^3 OR 2.32 AF

<u>Representative Metric</u> 0.088 AF/AC

Theoretical Basin Size Using Rational Method Calculations

Site Parameters				
Project	Basin #7			
Location	Epping, ND			
Site Conditions				
Cover	Area (acres)	C Value	Weighted average	Comments
Total Area:	38.39	0.5	19.195	Developed
Discharge				
Allowable Discharge	1.555	CFS		Based on 0.3 curve number&25-yr

25 Year Storm Detention Basin Sizing Calculations: Rational Method

Duration	*Intensity*	*Area*	*C*	*Flow*	*Volume in*	*Volume out*	*Detention*
Hour	in/hr	Acre		CFS	ft^3	ft^3	ft^3
0.083	7.440	38.39	0.500	142.81	42843	320	42,523
0.17	5.460	38.39	0.500	104.80	62883	640	62,243
0.25	4.400	38.39	0.500	84.46	76012	960	75,052
0.5	2.920	38.39	0.500	56.05	100889	1921	98,968
1	1.800	38.39	0.500	34.55	124384	3842	120,542
2	1.075	38.39	0.500	20.63	148569	7684	140,886
3	0.777	38.39	0.500	14.91	161008	11525	149,482
6	0.437	38.39	0.500	8.38	181047	23051	157,996
12	0.241	38.39	0.500	4.62	199705	46102	153,603
24	0.135	38.39	0.500	2.59	223890	92204	131,687
48	0.078	38.39	0.500	1.49	257750	184408	73,343
96	0.044	38.39	0.500	0.85	294375	368816	(74,441)

25 Year Detention Volume Required: 157,996 ft^3 OR 3.63 AF

<u>Representative Metric</u> 0.094 AF/AC

Theoretical Basin Size Using Rational Method Calculations

Site Parameters				
Project	Basin #15			
Location	Epping, ND			
Site Conditions				
Cover	Area (acres)	C Value	Weighted average	Comments
Total Area:	46.27	0.5	23.135	Developed
Discharge				
Allowable Discharge	1.874	CFS		Based on 0.3 curve number&25-yr

25 Year Storm Detention Basin Sizing Calculations: Rational Method

Duration	*Intensity*	*Area*	*C*	*Flow*	*Volume in*	*Volume out*	*Detention*
Hour	in/hr	Acre		CFS	ft^3	ft^3	ft^3
0.083	7.440	46.27	0.500	172.12	51637	320	51,317
0.17	5.460	46.27	0.500	126.32	75790	640	75,150
0.25	4.400	46.27	0.500	101.79	91615	960	90,654
0.5	2.920	46.27	0.500	67.55	121598	1921	119,677
1	1.800	46.27	0.500	41.64	149915	3842	146,073
2	1.075	46.27	0.500	24.87	179065	7684	171,381
3	0.777	46.27	0.500	17.97	194056	11525	182,531
6	0.437	46.27	0.500	10.10	218209	23051	195,158
12	0.241	46.27	0.500	5.57	240697	46102	194,595
24	0.135	46.27	0.500	3.12	269847	92204	177,643
48	0.078	46.27	0.500	1.80	310657	184408	126,249
96	0.044	46.27	0.500	1.03	354798	368816	(14,017)

25 Year Detention Volume Required: 195,158 ft^3 OR 4.48 AF

<u>Representative Metric</u> 0.097 AF/AC