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Sioux Falls Wastewater Treatment and Collection System Master Plan

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HDR

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Table of Contents

Tables

Figures

Executive Summary

Wastewater Treatment and Collection System Master Plan

Sioux Falls, SD

February 2018

Table of Contents

Tables

Figures

ES 1 Project Background and Scope

This Master Plan presents a review of the existing collection system and WRF (Water Reclamation Facility) capacities, complete with a recommended capital improvements plan that reflects the timing for the following needs:

- Need to provide reliability due to age and condition, avert risk for failure for WRF, and select lift stations.
- Need to increase existing and hydraulic capacity for growth for the WRF, collection system and lift stations.
- Need to increase organic capacity for growth at the WRF.
- Need to meet future growth and regulations at the WRF.
- Need to improve WRF treatment operations.

The recommended capital improvements plan provides a long-term master planning tool for ultimate expansions of the collection system and at the WRF, while identifying a phased construction program to meet reliability, hydraulic capacity and treatment requirements for the next 20 years.

The objectives for collection system planning are to summarize the City of Sioux Falls' (City) collection system capacity analysis for the existing system and the three planning years (2026, 2036, and 2066) that are the focus of this master plan. In addition, the 100-year (2116 planning year) is examined for long-term corridor planning but not included for Capital Improvement Program (CIP) project recommendations.

The capital improvements plan will be refined as part of preliminary design efforts with project costs to match the further refined scope(s).

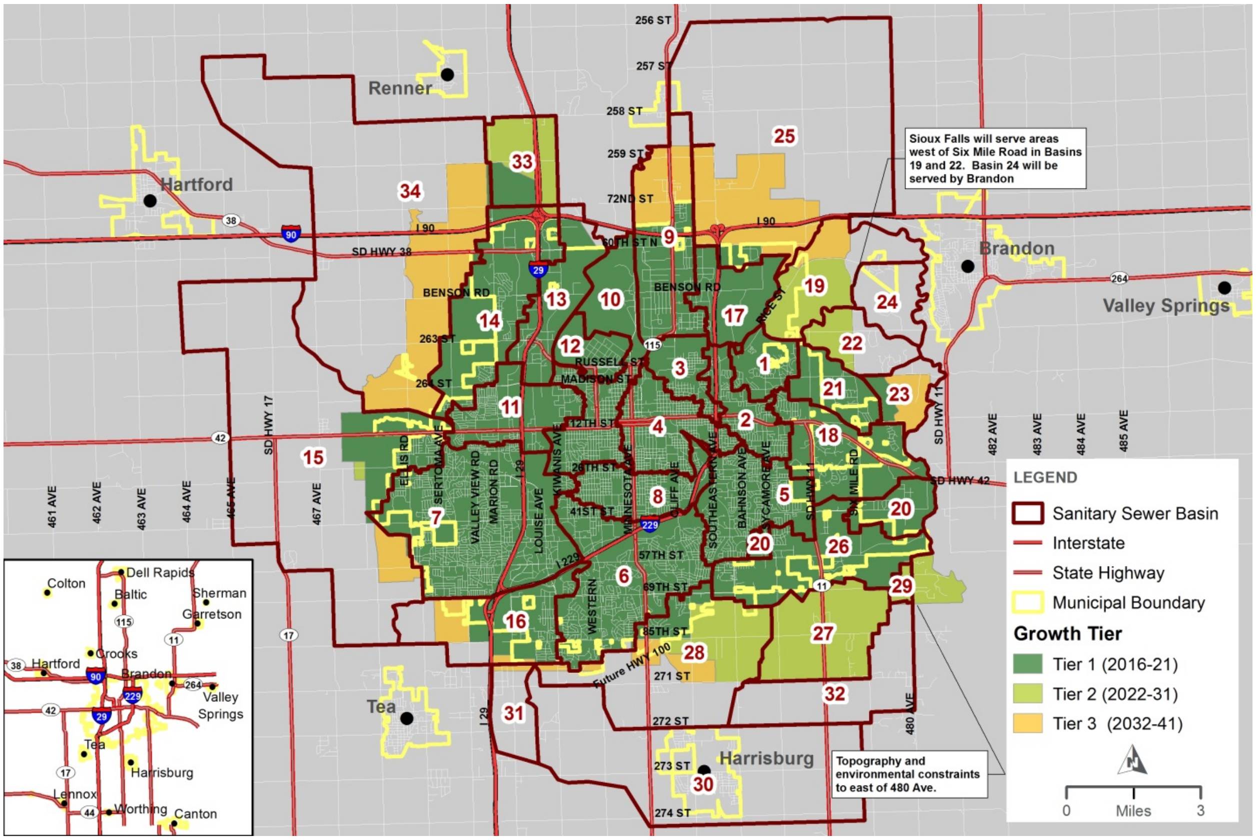
ES 2 Future Basis of Planning

Evaluation of the impacts of growth and development on wastewater service requirements is based on recent development planning documents, known development plans, land use and zoning information, undeveloped land, platting history, and unit densities. Chapter 2 presents where and when development is expected in the projected service area. From this information, concept-level locations and sizing for wastewater collection and treatment facilities is evaluated.

Wastewater flow is determined by the population served and the land use of the area to be served. Base wastewater flows are adjusted using peaking and infiltration and inflow (I/I) factors to establish design criteria for treatment capacity and collection systems. Within the Study Area, the wastewater service boundary establishes the area currently being served by the wastewater collection system, as well as the area identified as likely to be connected to the sewer system. Figure ES.1 shows the established wastewater service boundary for Sioux Falls as established by current growth tiers, which is approximately 91,000 acres for all basins (existing and within future identified service boundary).

The Shape Sioux Falls growth tiers are presented along with a regional community inset map on Figure ES.1.

Figure ES.1 Study Area Boundaries - Growth Tiers



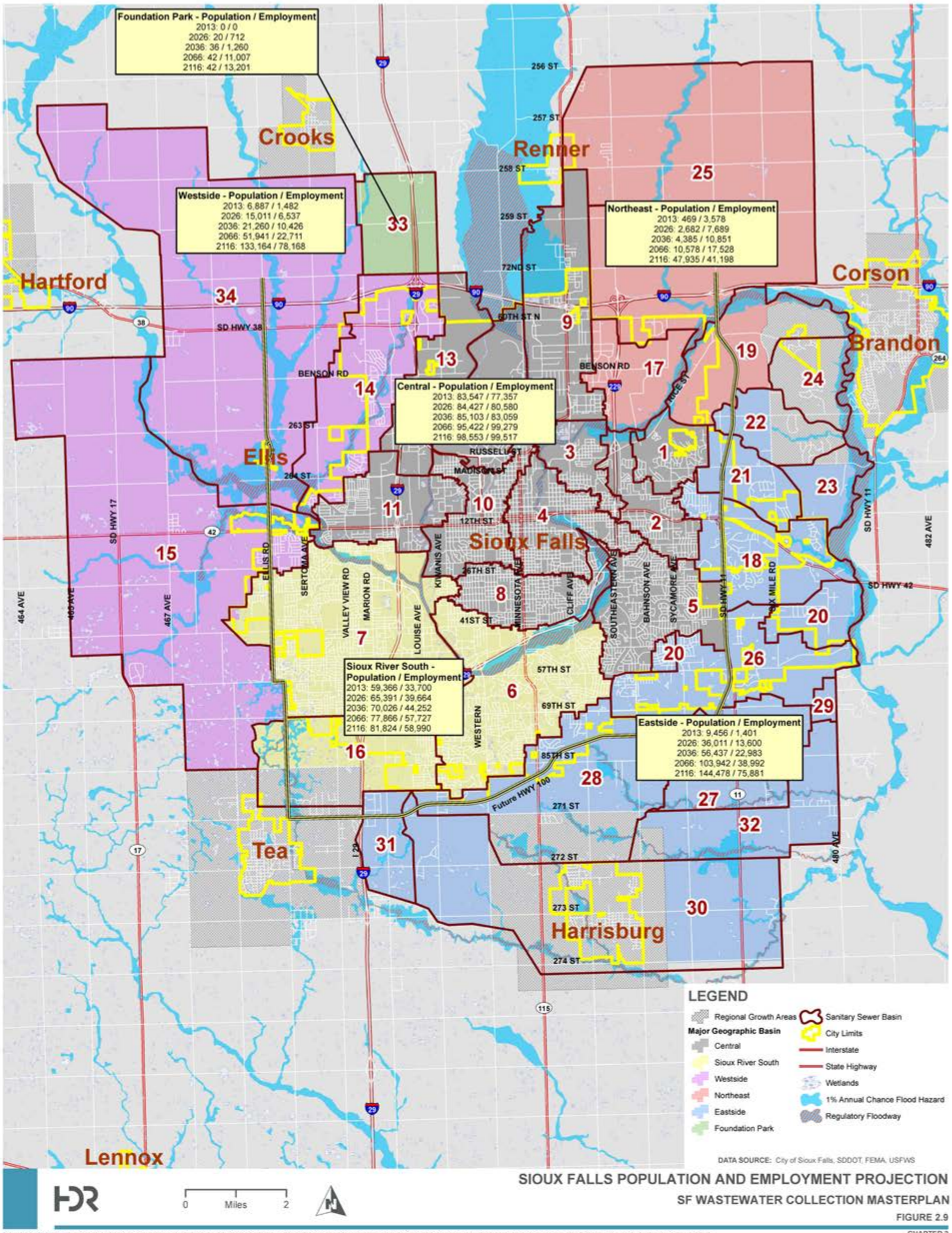
Source: Table is based 2040 Long Range Transportation Plan and Traffic Model developed Traffic Analysis Zones with Sewer Basin Boundaries.

ES 2.1 Future Sioux Falls Service Area

The master planning effort provided population and employment projections for 2026, 2036, 2066, and 2116 at various scales including at the major basins level, major geographic basins (i.e. major growth areas), and the City as a whole. This population and employment data has been compiled by the major geographic basins, i.e. East and West Side as shown in Figure ES.2. A larger format version of this figure has also been included in the Chapter 2 map pocket.

The most notable growth is expected on the East Side system, which will add over 45,000 persons to the City's population in the next twenty years. Second in growth was the West Side at a projected growth of approximately 15,000 persons. The South side will add approximately 10,000 persons in the next twenty years.

Figure ES.2 Sioux Falls Population and Employment Projections



ES 2.2 Future Sioux Falls and Regional Service Areas

The wastewater service area includes the growth areas projected in the Shape Sioux Falls 2035 plan and additional potential growth areas in the next 100 years as projected by the Sioux Falls Planning Department. The wastewater service area includes 34 major sanitary sewer basins as shown on Figure ES.2. In addition, the wastewater service area includes projected flows and loadings from existing regional customers (Brandon, Harrisburg, Renner Sanitary District, and Prairie Meadows Sanitary District) and potential additional communities (Tea, Hartford, Wall Lake Sanitary District, Lennox, Crooks, Baltic, Garretson, Valley Springs, Corson, Rowena, Canton, and Worthing). Information provided by those communities' engineers and/or population/employment data from the 2040 Long Range Transportation Plan traffic analysis zones (TAZs) was utilized to project flows and loads that are expected when a regional community ties into either the WRF or Sioux Falls' collection system.

The Shape Sioux Falls plan projected growth in three tiers:

- Tier 1: 0-5 years out (present through 2021)
- Tier 2: 6-15 years out (2022 through 2031)
- Tier 3: 16-25 years out (2032 through 2041)

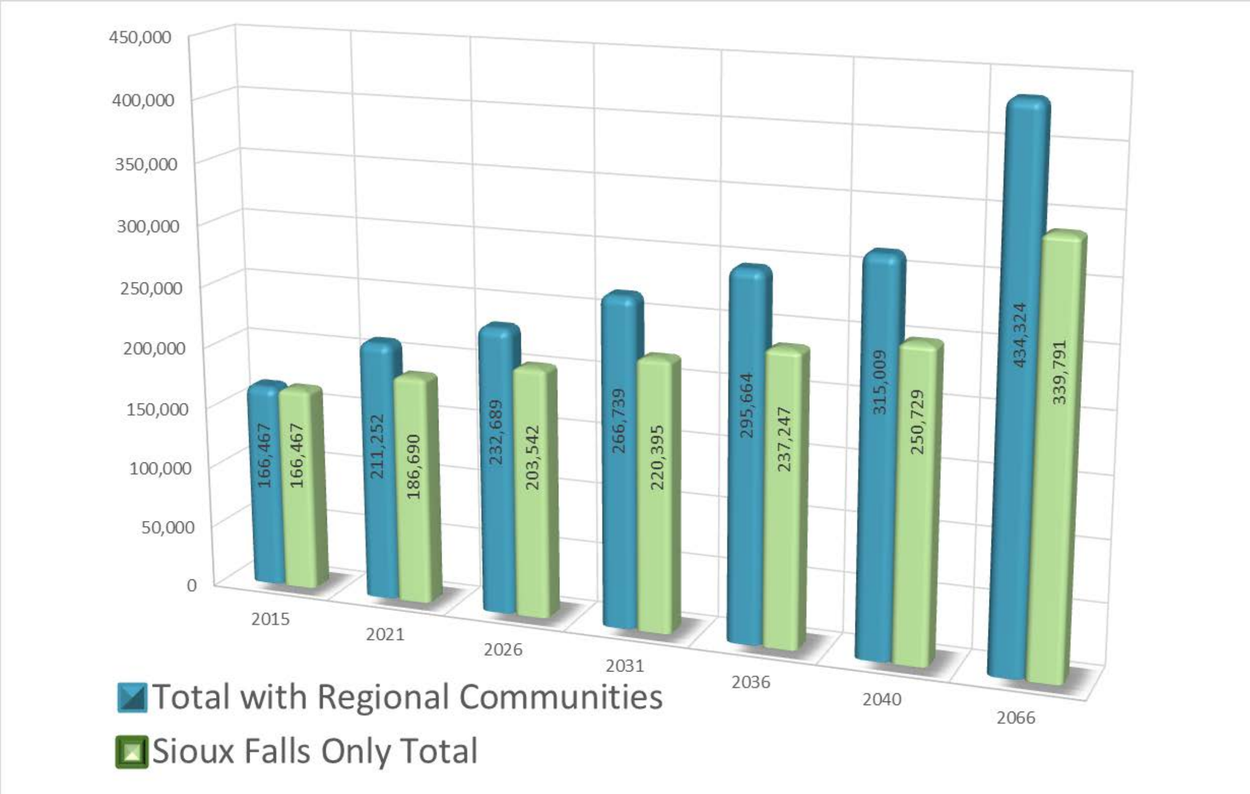
This evaluation must consider the impact to long-life infrastructure such as sewer interceptors and trunk lines. Discussions with the City's Planning Department led to the development of two additional tiers. These include:

- Tier 4: 26-50 years out (through 2066)
- Tier 5: 51-100 years out (through 2116)

The intent of developing Tiers 4 and 5 was to provide a means to spatially allocate growth to an appropriate extent and expand basins as needed to assist the decision-making processes of corridor planning for sewers, pump stations and major treatment facilities. City Planning will develop future tiers as part of the Shape Sioux Falls in the customary planning periods of 25 years or less.

A graphic of the projected total potential wastewater system population, including the City of Sioux Falls and the potential regional communities, is presented in Figure ES.3 with the projected Sioux Falls and Regional Community Growth at a total 2036 service population of over 295,000. This is nearly double the current service population.

Figure ES.3 Sioux Falls and Regional Community Growth Projections



ES 3 Collection System

ES 3.1 Collection System - Capacity Criteria

The objectives for collection system planning are to summarize the City's collection system capacity analysis for the existing system and the three planning years (2026, 2036, and 2066) that are the focus of this master plan. In addition, the 100-year (2116 planning year) is also examined for long-term corridor planning, but not included for Capital Improvement Program (CIP) project recommendations.

The capacity analysis and improvement alternatives use the collection system model discussed in detail in Chapter 5 and the associated flow projections for base sanitary flow (BSF), dry weather infiltration (DWI) allowances, and the rainfall-derived infiltration and inflow (RDII) allowances associated with the 25-year level event of service. The capacity analysis is based on the City's collection system standards.

To achieve this goal, evaluation of the existing systems is needed to prioritize the need for upgrades and/or replacement due to lack of capacity for existing and future flows.

To assess the capacity of the existing collection system and to develop a target for the design of new and future collection system infrastructure, an evaluation metric must be used to estimate a level of service associated with wet-weather event impacts. For the City, this metric is the 25-year storm event, consistent with the 2002 and 1990 City of Sioux Falls Collection Facilities Plans. This recurrence interval is considered appropriate for sanitary sewer collection system planning with many Midwest communities planning around 5 to 25 year recurrence intervals with 10 years the most common interval.

Since the calibration event (June, 2014) is 96 hours (4 days) in duration with two separate rainfall peaks, the analysis for this master plan is also a 96-hour storm with multiple peaks. This specific storm event represents two primary waves of rainfall where the first wave saturates the soils and with those antecedent soil moisture conditions, the second wave causes peak wet-weather responses in the collection system. The 25-year, 96-hour frequency storm event with the calibration rainfall pattern is considered the Evaluation Storm for this master plan and defines the level of service that the City strives to achieve in the collection system.

In addition, the objective is maintaining peak flows below 75 to 80 percent of the sewer main's capacity, particularly for new sewers. Existing sewers in areas that do not affect customer service laterals may be allowed to surcharge for short durations of time but SSOs are not permitted in the sewer system and improvements have been developed for any modeled overflow occurrences.

ES 3.1.1 Collection System Capacity Analysis

The purpose of the conveyance system analysis are to:

- Document the analysis of the existing collection system with existing wet weather flows and identify locations of capacity deficiencies.
- Document the analysis of the existing collection system with development tiers associated with the planning years (2026, 2036, and 2066) based on RDII associated with the 25-year level of service
- Determine the likely size required for future trunk sewer extensions required to serve future development based on 100-year development build out.
- Determine scenarios to route future trunk sewer extensions required to serve future development at each development tier.
- Identify and characterize hydraulic capacity issues of the existing collection system based on development tier wet weather flows with RDII associated with the 25-year levels of service.
- Develop mitigation solutions based on specified criteria for areas with hydraulic capacity issues.

Capacity-limited areas were identified by analyzing the existing collection system under flow conditions associated with the planning years (2026, 2036, and 2066) based against the established system analysis criteria. Characterizing the capacity-limited areas assists in developing and prioritizing improvement alternatives and recommendations.

ES 3.1.2 Wastewater Flow and Level of Service Criteria

All capacity criteria are in reference to the 25-year level of service, which for the current 2016 master plan is the 25-year, 96-hour rainfall event that is referred to as the Design Storm.

ES 3.2 Collection System - Existing Deficient Areas

For the purpose of determining potential peak flows, the InfoSWMM model was used to evaluate modeled conduits to determine if the 25-year Design Storm RDII can be transmitted through the system while satisfying hydraulic criteria.

The hydraulic problems were separated into two categories for characterization and prioritization: Type A and Type B deficient areas. These two categories are defined below.

- Type A deficient areas represent a series of under-capacity pipes that are hydraulically connected to one another.
  - For Type A hydraulic problems, the system-wide criteria is a modeled peak wet weather flow level exceeding 75 percent d/D for the collector and local systems (less than or equal to 27-inch diameter) and 80 percent d/D for the interceptor systems (30-inches diameter and greater).
- Type B deficient areas represent isolated under-capacity pipes that are not hydraulically connected to other problem locations.
  - For Type B hydraulic problems, the system wide criteria is a modeled peak wet weather flow level exceeding 75 percent d/D for the collector and local systems (less than or equal to 27-inch diameter) and 80 percent d/D for the interceptor systems (30-inches diameter and greater).

Model results for existing conditions indicate a number of areas with Type A deficiencies. These areas are identified and named in Figure ES.4.

Table ES.1 tabulates the existing collection system Type A deficient areas discussed in detail in Chapter 9. Not all of the problem areas will require CIP mitigation alternatives depending upon the impact to upstream customers and quality and availability of monitoring data affecting the confidence in the model results. CIP mitigation alternatives were vetted with the planning team and are presented in Chapter 11.

Figure ES.4 Collection - Existing System Type A Deficient Areas

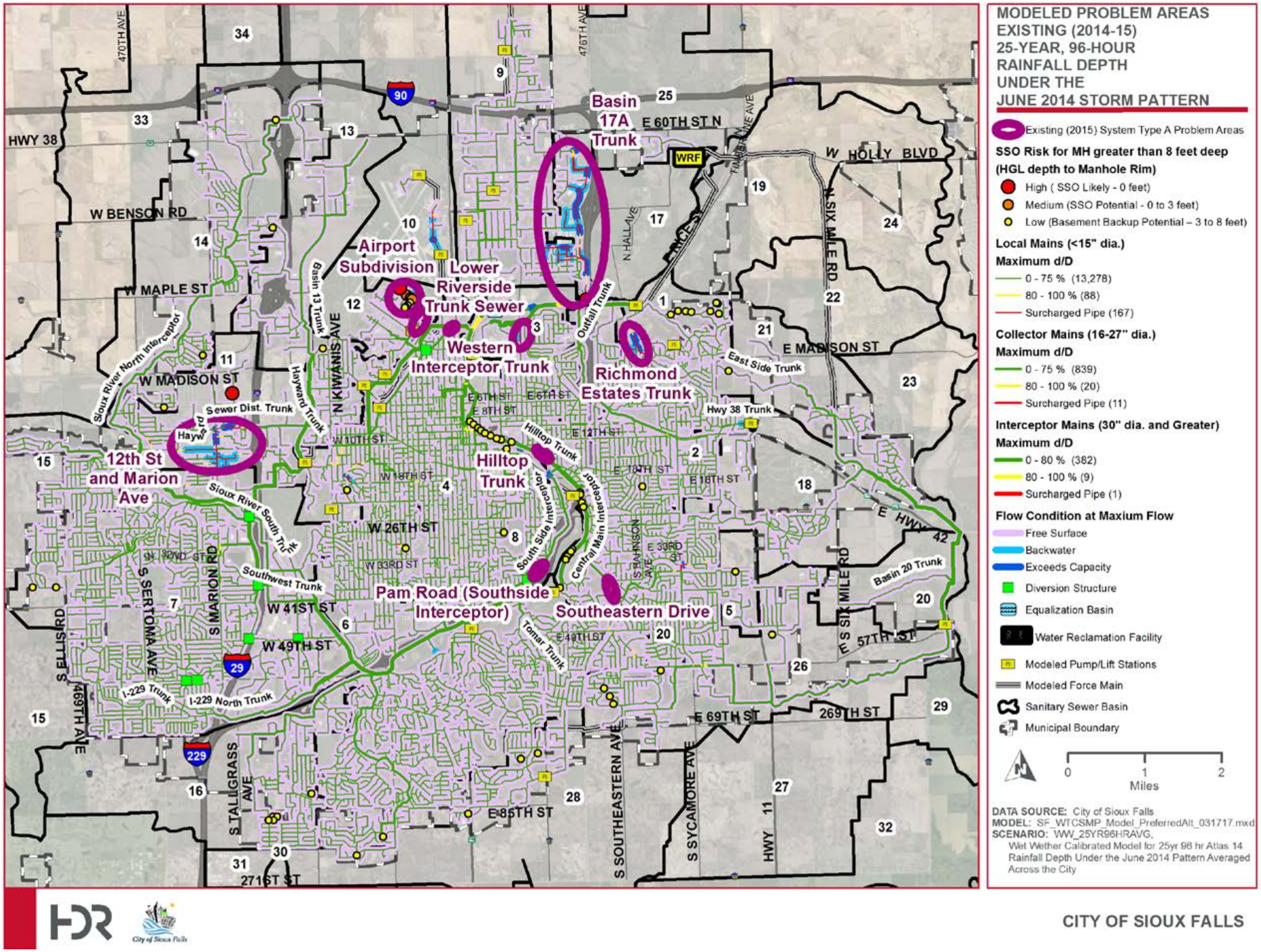


Table ES.1 Collection System - Summary of Existing System Type A Deficient Areas

Problem Area	Basin	Length of Deficiency (Capacity)	Length of Deficiency (Backwater)	Flow Monitoring Data Available*
Basin 17A Trunk (Lewis Road)	Basin 17	8-in / 4,660 ft 10-in / 4,800 ft 12-in / 1,120 ft 15-in / 470 ft 18-in / 390 ft	8-in / 8,800 ft 10-in / 660 ft 12-in / 810 ft 18-in / 1,880 ft	Flow data not available and insufficient to make CIP recommendations – need to install monitoring.
Lower Riverside Trunk Sewer	Basin 3	10-in / 320ft 12-in / 930 ft 15-in / 50 ft	10-in / 330 ft 12-in / 830 ft	Further monitoring required in Cliff Avenue.
Hilltop Trunk	Basin 4	12-in / 960 ft 15-in / 110 ft		Basin data available but localized monitoring data needed.
Richmond Estates Trunk	Basin 1	8-in / 2,030 ft	8-in / 1,740 ft	Basin data available but localized monitoring data needed.
Southeastern Drive	Basin 5	CIPP Line 1,130 ft		Data sufficient to make CIP recommendations – CIPP lining recommended.
Pam Road (Southside Interceptor)	Basin 8	16-in / 250 ft 18-in / 460 ft	18-in / 355 ft	Flow can be relieved at Duluth. Surcharging to be investigated via survey along profile. No impact to adjacent services.
Western Interceptor Trunk	Basin 10	24-in / 450 ft 30-in / 10 ft 36-in / 90 ft		Flow data not available and insufficient to make CIP recommendations – needs monitoring.
Airport Subdivision	Basin 12	8-in / 2,900 ft 18-in / 320 ft 21-in / 210 ft	8-in / 2,080 ft	Flow data not available and insufficient to make CIP recommendations.
12th St and Marion Rd	Basin 11	8-in / 3,010 ft 10-in / 470 ft 12-in / 3,020 ft	8-in / 4,630 ft 10-in / 2,050 ft 12-in / 480 ft	Basin data available but localized monitoring data needed.

ES 3.2.1 Existing Collection System Type B Deficient Areas

All capacity deficient pipes in Figure ES.4 that are not contained in a Type A deficient area represent a Type B deficient area. Type B areas are isolated under capacity pipes that are not hydraulically connected to other problem locations. Type B problems often result from isolated flat pipe slopes limiting the capacity of single pipe segments. Type B areas are locations where CCTV, localized flow monitoring, and invert survey are recommended to validate the problem extent before any design is begun. Based on the results from the capacity validation activities and actual upstream growth, they could be considered for capacity increases, if necessary. In areas of the system with little upstream growth and future additional flow, some of the Type B problems may be addressed through decreased RDII contribution as the local and local collector systems are rehabilitated. Neither pipe improvement alternatives nor costs were developed for Type B problems.

ES 3.3 Collection System – Growth Service Area Alternative Selection

ES 3.3.1 Alternative Comparison

Combinations of the vetted collection alternatives to address future growth areas were examined and consolidated into thirteen (13) different scenarios. These scenarios were further refined down to eight (8) of the scenarios, representing the basis of analysis for this master plan. These vetted scenarios are listed in Table ES.2. The five scenarios removed were deemed not practical due to excessive sewer replacement or excessive equalization requirements. For reference, the advantages and disadvantages for each analyzed model scenario are summarized in Section 9.6.3 in Chapter 9.

Table ES.2 Collection System - Model Scenarios

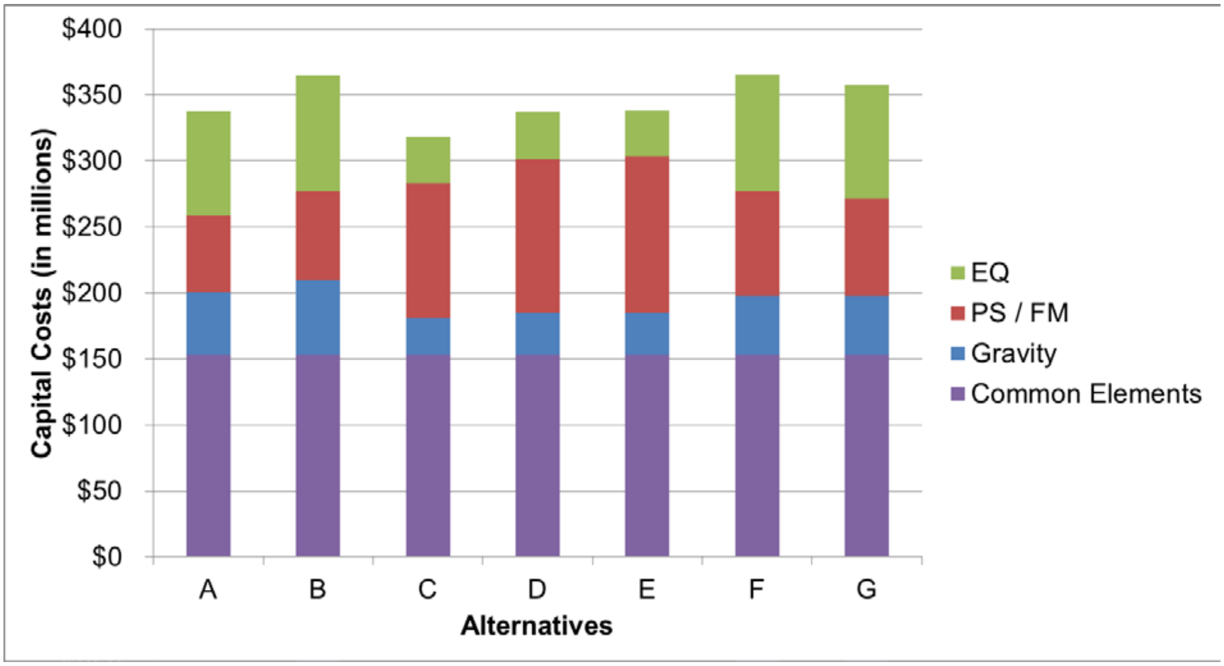
Model Scenario	CIP Costing ID	City of Tea and Basin 16	Basin 15 and Basin 34	Basin 33 (Foundation Park)	City of Renner	Basins 30 and 31	Basin 28	Basins 27 and 28	ESSS and PS 240
Scenario 1: Base	A	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 2 (Flow through the City)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Assumes Option 3 through 2066 and then Gravity through Basin 30 in 2116	Assumes Option 3 (Gravity to Basin 27)	Assumes Option 2 (FM directly to PS240 through 2066)	Assumes Option 2 (PS240 sized for ESSS and Basins 27, 28, 30, and 31 flows) for both 2066 and 2116
Scenario 4	B	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 2 (Flow through the City)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 2 (Basin 30 and 31 direct connection to SRS)	Option 2 (Basin 28 to Basin 26 Trunk)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)
<u>Scenario 6</u> ***<u>(Selected for Long-Term)</u>***	**<u>C</u>**	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 1 (FM to the north)	Option 1 (Direct Flow to WRF)	Option 1 (Flow to Basin 9)	Option 3 (Basin 30 and 31 to future Basin 28 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 2 (PS240 sized for ESSS and Basins 27, 28, 30, and 31 flows)
Scenario 9	D	Option 1 (Tie into and upsize I-229 Trunk– Tea to Basin 7R)	Option 3 (FM to the south)	Option 1 (Direct Flow to WRF)	Option 2 (Flow to Basin 25)	Option 3 (Basin 30 and 31 to future Basin 28 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 3 (PS240 sized for ESSS and Basins 15, 27, 28, 30, 31, and 34 flows for 2026, 2036, and 2066)
Scenario 10	E	Option 1 (Tie into and upsize I-229 Trunk– Tea to Basin 7R)	Option 3 (FM to the south)	Option 1 (Direct Flow to WRF)	Option 2 (Flow to Basin 25)	Option 2 (Basin 30 and 31 direct connection to SRS)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 3 (PS240 sized for ESSS and Basins 15, 27, 28, 30, 31, and 34 flows for 2026, 2036, and 2066)

Table ES.2 Collection System – Model Scenarios

Model Scenario	CIP Costing ID	City of Tea and Basin 16	Basin 15 and Basin 34	Basin 33 (Foundation Park)	City of Renner	Basins 30 and 31	Basin 28	Basins 27 and 28	ESSS and PS 240
Scenario 11	F	Option 1 (Tie into and upsize I-229 Trunk–Tea to Basin 7R)	Option 4 (Flow through the City with EQ prior to entering)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 2 (Basin 30 and 31 direct connection to SRS)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)
Scenario 12 (Selected for Short-Term but Exceeds System Capacity in Long-Term)	**G**	Option 2 (Tie into and parallel I-229 Trunk–Tea to Basin 7R)	Option 4 (Flow through the City with EQ prior to entering)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 1 (Basin 30 and 31 to Basin 6 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)
Scenario 13	H	Option 1 (Tie into and upsize I-229 Trunk–Tea to Basin 7R)	Option 4 (Flow through the City with EQ prior to entering)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 1 (Basin 30 and 31 to Basin 6 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)

Figure ES.5 provides a comparative cost breakdown for the future CIP alternatives (A thru G) for sewer extensions, with these comparisons graphed in Figure ES.5. Costs, however, are not the only consideration when choosing a preferred alternative and recommended plan. Other considerations include development timing, constructability and maintenance, impact to existing infrastructure, and longevity. Equalization of wet weather peak flow rates, for instance, while generally requiring large upfront costs, can ease burdens on sizing of other infrastructure components, as well as mitigating impacts to existing infrastructure.

Figure ES.5 Collection - Capital Costs Alternative Evaluation (In Millions of Dollars)



ES 3.3.2 Selected Alternatives for Growth Areas

The preferred alternative is a combination of Alternative G, which is the interim (2026, 2036) option and Alternative C, which is the preferred 2066 option, refer to Figures ES.6 and ES.7, respectively. The description, as summarized in Table ES.3, is developed based on the Chapter 9 discussion of advantages and disadvantages, as well and conversations with the City. This collective preferred alternative is the basis for the recommended plan associated with each development group for these trunk sewer extensions.

A key advantage of the selected alternative is that the West Side flows will be equalized and conveyed through the City for the first 20 years, decreasing the immediate CIP impact, and when growth hits the 20 year projections, pumping via a long forcemain around the north side of the city will be required.

2036 Future Trunk Sewer Extensions Recommended Plan

Basin	Diameter	Length (ft)
Basin 7	12-in	3,707
	18-in	10,517
	30-in	720
Basin 7 Total		**14,944**
Basin 9	8-in	4,926
Basin 9 Total		**4,926**
Basin 14	54-in	1,202
Basin 14 Total		**1,202**
Basin 15	12-in	35,678
	21-in	2,406
	30-in	1,063
	36-in	2,778
	42-in	21,845
Basin 15 Total		**63,770**
Basin 16	21-in	6,000
	24-in	2,925
	30-in	4,948
Basin 16 Total		**13,873**
Basin 17	18-in	20,332
Basin 17 Total		**20,332**
Basin 18	8-in	2,800
	12-in	11,807
	18-in	559
	21-in	3,067
	24-in	241
	42-in	2,198
Basin 18 Total		**20,672**
Basin 19	12-in	16,730
	27-in	11,462
	42-in	2,426
	48-in	1,012
Basin 19 Total		**31,630**
Basin 21	8-in	1,049
Basin 21 Total		**1,049**
Basin 22	12-in	13,397
Basin 22 Total		**13,397**
Basin 23	12-in	6,552
	15-in	2,416
	18-in	6,378
	21-in	1,934
Basin 23 Total		**17,281**
Basin 25	12-in	31,325
	27-in	12,099
	30-in	1,000
	36-in	4,709
	48-in	3,825
	56-in	3,341
Basin 25 Total		**56,299**

Basin	Diameter	Length (ft)
Basin 26	8-in	177
	12-in	5,226
	24-in	89
	30-in	47,781
	42-in	2,054
Basin 26 Total		**55,327**
Basin 27	12-in	43,167
	18-in	12,250
	21-in	2,000
	27-in	22,276
	36-in	109
Basin 27 Total		**79,803**
Basin 28	12-in	42,308
	15-in	3,561
	21-in	7,000
	27-in	20,777
Basin 28 Total		**73,646**
Basin 29	8-in	3,181
	12-in	7,272
Basin 29 Total		**10,454**
Basin 30	8-in	7,253
	12-in	7,901
	18-in	9,447
	27-in	4,434
	36-in	21
Basin 30 Total		**29,056**
Basin 31	12-in	5,000
Basin 31 Total		**5,000**
Basin 33	8-in	9,336
	10-in	10,551
	12-in	11,340
	15-in	6,747
	21-in	3,149
Basin 33 Total		**41,122**
Basin 34	12-in	13,714
	18-in	827
	21-in	1,246
	24-in	2,349
	27-in	17,700
	30-in	10,426
	36-in	3,400
	42-in	5,435
	48-in	4,929
	54-in	12,661
Basin 34 Total		**72,645**

Existing System 2036 CIP

Basin	Type A Hydraulic Deficiency Area for CIP	Diameter	Length (ft)
1	Richmond Estates Trunk	12-in	1,989
3	Lower Riverside Trunk Sewer	12-in	787
		15-in	936
		18-in	2,998
		21-in	1,289
		24-in	332
		36-in	971
5	Southeastern Drive	Lining Project	2,926
7	Southwest Trunk	15-in	557
		18-in	226
10	Sioux River North Upstream of PS 215	15-in	460

2036 Recommended Plan Future Development Trunk Sewer Extension Components	
Basins 30 and 31	**Option 1 (Basin 30 and 31 to Basin 6 Trunk):** • Basin 30/31 PS and EQ • Forcemain from PS and EQ to upstream point of 15-inch Basin 6 Trunk Sewer • Gravity sewer upgrades from upstream point of 15-inch Basin 6 Trunk Sewer to Sioux River South Interceptor
Westside	**Option 4 (Flow through the City with EQ prior to entering)** • Basin 15/34 EQ at connection • Max Flow through City
Basin 28	**Option 3 (Tie to the Basin 27 and 28 PS and EQ):** • Gravity main to Basin 27/28 PS and EQ
Basins 27 and 28	**Option 2 (Basin 27 and 28 directly to PS240):** • Basin 27/28 PS and EQ • Forcemain from PS and EQ directly to PS240
Tea and Basin 16 Flows	**Option 2 (Tie into and parallel I-229 Trunk):** • Tea Flows are equalized to max day flow; Basin 16 future flows are NOT equalized • I-229 Trunk upsized or paralled to carry future flows
Basin 33	**Option 2 (Transfer Flow through Basin 13):** • EQ • Flow through Basin 13
Renner	**Option 2 (Flow to Basin 25):** • Flow through Basin 25

2036 FUTURE DEVELOPMENT EXTENSION RECOMMENDED PLAN WITH 2036 CIP ON THE EXISTING SYSTEM

FUTURE 2036 CONDITIONS, RECOMMEND PLAN FOR FUTURE EXTENSIONS
FUTURE 2036 BASE SANITARY FLOW WITH TIERS 1, 2, AND 3 DEVELOPMENT EXTENT

Figure ES.6 Collection – Selected Collection Alternative G (Interim (2026, 2036) Option)

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2066 Future Trunk Sewer Extensions Recommended Plan

Basin	Diameter	Length (ft)
Basin 7	12-in	3,707
	18-in	10,517
	30-in	720
Basin 7 Total		**14,944**
Basin 9	8-in	8,148
Basin 9 Total		**8,148**
Basin 14	24-in	39,434
	54-in	1,202
Basin 14 Total		**40,636**
Basin 15	12-in	56,245
	15-in	3,580
	18-in	40
	21-in	20,848
	24-in	8,799
	30-in	1,811
	36-in	2,778
	42-in	21,845
Basin 15 Total		**115,947**
Basin 16	12-in	6,104
	15-in	2,000
	18-in	3,000
	21-in	7,111
	24-in	2,925
	30-in	4,948
Basin 16 Total		**26,087**
Basin 17	18-in	18,922
Basin 17 Total		**18,922**
Basin 18	8-in	2,800
	12-in	11,807
	21-in	3,067
	24-in	241
	42-in	2,198
Basin 18 Total		**20,113**
Basin 19	12-in	16,730
	27-in	11,462
	42-in	2,426
	48-in	1,012
Basin 19 Total		**31,630**
Basin 21	8-in	1,049
Basin 21 Total		**1,049**
Basin 22	8-in	5,492
	12-in	13,397
Basin 22 Total		**18,888**
Basin 23	12-in	6,552
	15-in	2,416
	18-in	6,511
	21-in	1,934
Basin 23 Total		**17,414**
Basin 25	12-in	31,325
	27-in	12,099
	30-in	1,000
	36-in	4,709
	48-in	3,825
	56-in	3,341
Basin 25 Total		**56,299**

Basin	Diameter	Length (ft)
Basin 26	8-in	3,844
	8-in	177
	12-in	6,340
	18-in	1,410
	24-in	89
	36-in	47,781
Basin 26 Total		**59,641**
Basin 27	12-in	43,167
	18-in	12,250
	21-in	2,000
	27-in	22,276
	36-in	109
Basin 27 Total		**79,803**
Basin 28	12-in	42,308
	15-in	3,561
	18-in	9,447
	21-in	7,000
	27-in	20,777
Basin 28 Total		**83,093**
Basin 29	8-in	3,181
	12-in	7,272
Basin 29 Total		**10,454**
Basin 30	8-in	7,253
	12-in	7,901
	24-in	1,673
	27-in	8,434
	36-in	21
Basin 30 Total		**25,282**
Basin 31	12-in	10,000
	27-in	1,000
Basin 31 Total		**11,000**
Basin 32	8-in	16,159
	12-in	11,267
	21-in	2,000
	27-in	1,508
Basin 32 Total		**30,933**
Basin 33	6-in	7,996
	10-in	2,555
	12-in	10,227
	15-in	6,747
	18-in	914
	21-in	3,149
Basin 33 Total		**31,587**
Basin 34	12-in	43,958
	18-in	2,491
	21-in	7,984
	24-in	27,215
	27-in	31,679
	30-in	19,029
	36-in	5,400
	42-in	7,489
	48-in	4,929
	54-in	12,618
	60-in	120
Basin 34 Total		**162,912**

Existing System 2066 CIP

Basin	Type A Hydraulic Deficiency Area for CIP	Diameter	Length (ft)
1	Richmond Estates Trunk	12-in	1,989
3	Lower Riverside Trunk Sewer	12-in	787
		15-in	936
		18-in	2,998
		21-in	1,289
		24-in	332
		36-in	971
5	Southeastern Drive	Lining Project	2,926
7	Southwest Trunk	15-in	557
		18-in	226
10	Sioux River North Upstream of PS 215	15-in	460

2066 Recommended Plan Future Development Trunk Sewer Extension Components

Basins 30 and 31	**Option 3 (Basin 30 and 31 to future Basin 28 Trunk) :** • Basin 30/31 PS and EQ • Forcemain from PS and EQ to upstream point of future Basin 28 Trunk Sewer • Gravity sewer upgrades from upstream point of future Basin 28 Trunk Sewer to Future PS 32
Westside	**Option 1 (FM to the north)** • Basin 15/34 EQ at Pump Station • Forcemain around the north side of town
Basin 28	**Option 3 (Tie to the Basin 27 and 28 PS and EQ):** • Gravity main to Basin 27/28 PS and EQ
Basins 27 and 28	**Option 2 (Basin 27 and 28 directly to PS240):** • Basin 27/28 PS and EQ • Forcemain from PS and EQ directly to PS240
Tea and Basin 16 Flows	**Option 1 Option 1 (Tie into and upsize I-229 Trunk):** • Tea Flows are equalized to max day flow; Basin 16 future • I-229 Trunk upsized or paralled to carry future flows
Basin 33	**Option 1 (Direct Flow to WRF):** • EQ • Forcemain to directly to WRF
Renner	**Option 1:** • Flow through Basin 9

0 3,000 6,000
Feet

2066 FUTURE DEVELOPMENT EXTENSION RECOMMENDED PLAN WITH 2066 CIP ON THE EXISTING SYSTEM

FUTURE 2066 CONDITIONS, RECOMMEND PLAN FOR FUTURE EXTENSIONS
FUTURE 2066 BASE SANITARY FLOW WITH TIERS 1, 2, 3, AND 4 DEVELOPMENT EXTENT

Figure ES.7 Collection – Selected Collection Alternative C (2036 and Beyond Option)

PATH: H:\GIS\PROJECTS\CITY_SIOUX_FALLS\275541_SF_COLLECTIONS_MASTERPLAN\7.0_GIS_MODELS\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\TM FIGURES\TM_11\MODEL2066_REC_PLAN_WITH2066CIP.MXD - USER: KVANDEKA - DATE: 2/20/2018

Table ES.3 Collection System - Preferred Alternative for Future Trunk Sewer Extension

Major Development Group	Preferred (2066) Option	Interim (2026,2036) Option
City of Tea and Basin 16	Tie into and upsize or parallel I-229 Trunk (needed by 2036 with Tea to Basin 7R) *(Option 1 or 2)*	Same as preferred 2066 option
Westside Basin 15 and Basin 34	Pump station and force main to the north (with EQ) *(Option 1)*	Flow through the City with EQ *(Option 4)*
Basin 33 (Foundation Park)	EQ (by 2066), pump station and force main to transfer flow through Basin 13 *(Option 2)*	Same as preferred 2066 option
City of Renner	Pump station and force main to future Basin 25 Trunk *(Option 2)*	Pump station and force main to future Upgraded Basin 9 Trunk *(Option 1)*
Basins 30 and 31	Pump station and force main to transfer flow through Basin 6 *(Option 1)*	Same as preferred 2066 option
Basin 28	Gravity to future Basin 27 Trunk *(Option 3)*	Same as preferred 2066 option
Basins 27 and 28	Direct connection to PS 240 with pump station and force main *(Option 2)*	Same as preferred 2066 option
ESSS and PS 240	Flows from ESSS and Basins 27/28/29/32 with pump station and force main to WRF *(Option 1)*	Flows from ESSS and Basins 27/28/29/30/31/32 with pump station and force main to WRF *(Option 2)*

ES 3.4 Collection System – Recommended Improvements for Selected Plan

Model results for the recommended plan indicate a number of areas that have Type A deficiencies to existing sanitary collection sewers. These areas are identified and named in Figure ES.8 .

Figure ES.8 Collection - Tiers 1-4 Collection System Type A Deficient Areas

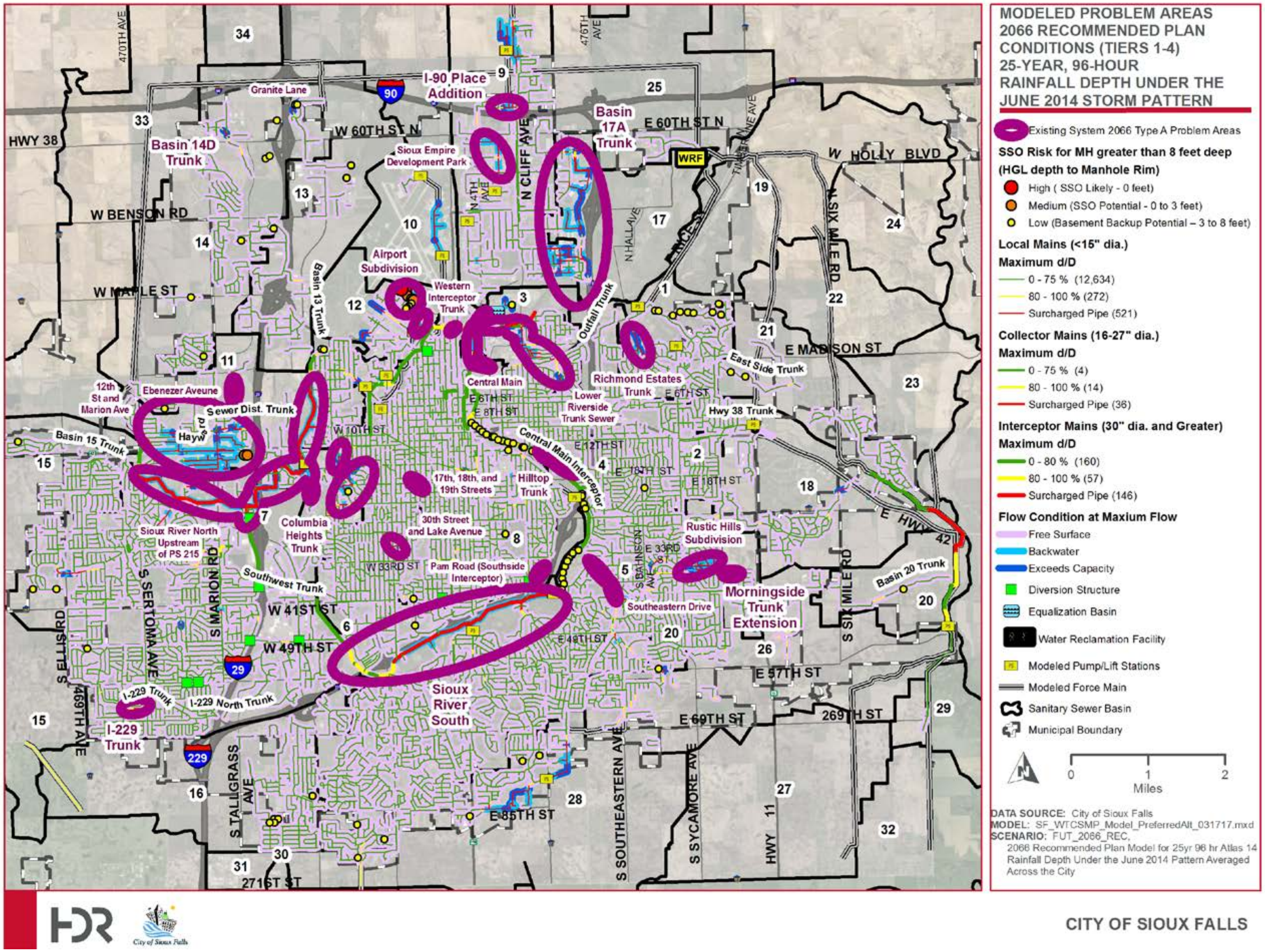


Table ES.4 summarizes the existing collection system Type A deficient areas discussed in this section. Not all of the problem areas will require CIP mitigation, depending on the impacts to upstream users and quality and availability of monitoring data impacting the confidence in the model results. The selected CIP mitigation is discussed in Chapter 11 and summarized in following executive summary sections.

Table ES.4 Summary of 50-Year Build-out (Future) Collection System Type A Problem Areas

Problem Area	Basin	Length of Capacity Limitation)	Length of Backwater Impact	Flow Monitoring Data Available*	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded
I-90 Place Addition	Basin 9	8-in / 1,280 ft	10-in / 2,250 ft	Medium	No	Yes
Sioux Empire Development Park	Basin 9	15-in / 770 ft 18-in / 700 ft	18-in / 3,530 ft	Medium	No	Yes
Basin 17A Trunk (Lewis Road)	Basin 17	8-in / 6,630 ft 10-in / 3,680 ft 12-in / 420 ft 15-in / 470 ft 18-in / 390 ft	8-in / 10,500 ft 10-in / 1,050 ft 12-in / 810 ft 18-in / 1,880 ft	Low	Yes	Yes
Lower Riverside Trunk Sewer	Basin 3	10-in / 320ft 12-in / 930 ft 15-in / 50 ft	10-in / 330 ft 12-in / 830 ft	High	Yes – similar to existing.	Yes – similar to existing.
Hilltop Trunk	Basin 4	12-in / 2,110 ft	10-in / 330 ft 12-in / 640 ft 15-in / 110 ft	Medium	Yes	Yes
Richmond Estates Trunk	Basin 1	8-in / 2,030 ft	8-in / 1,740 ft	Medium	Yes	Yes
Southeastern Drive	Basin 5	24-in / 2,200 ft	15-in / 380 ft 18-in / 710 ft 24-in / 350 ft	High	Yes	Yes
Pam Road (Southside Interceptor)	Basin 8	16-in / 250 ft 18-in / 420 ft	18-in / 620 ft	High	Yes	Yes
Western Interceptor Trunk	Basin 10	24-in / 450 ft 32-in / 180 ft 36-in / 50 ft	24-in / 140 ft 30-in / 10 ft 36-in / 80 ft	Low	Yes	Yes
Central Main	Basins 3 and 4	60-in / 450 ft	8-in / 190 ft 18-in / 720 ft 24-in / 710 ft 48-in / 530 ft 60-in / 3,040 ft	High	Yes	Yes
Airport Subdivision	Basin 12	8-in / 2,900 ft 18-in / 800 ft	8-in / 2,080 ft 18-in / 960 ft 21-in / 210 ft	Low	Yes	Yes

Table ES.4 Summary of 50-Year Build-out (Future) Collection System Type A Problem Areas

Problem Area	Basin	Length of Capacity Limitation)	Length of Backwater Impact	Flow Monitoring Data Available*	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded
12th St and Marion Rd	Basin 11	8-in / 2,510 ft 10-in / 470 ft 12-in / 3,110 ft	8-in / 18,900 ft 10-in / 3,970 ft 12-in / 480 ft	Medium	Yes	Yes
Ebenezer Avenue	Basin 11	8-in / 1,720 ft		Medium	No	Yes
Sioux River North Upstream of PS 215	Basins 10 and 11	10-in / 460 ft 12-in / 1,670 ft 30-in / 1,450 ft 36-in / 430 ft 42-in / 3,990 ft	8-in / 520 ft 10-in / 1,270 ft 12-in / 830 ft 18-in / 950 ft 30-in / 230 ft 36-in / 11,200 ft 42-in / 5,880 ft	High	No	No
Columbia Heights Trunk	Basin 10	8-in / 330 ft 12-in / 1,710 ft	8-in / 850 ft 10-in / 390 ft 12-in / 1,130 ft	Low	Yes	Yes
17th, 18th, and 19th Streets	Basin 10	8-in / 150 ft 10-in / 600 ft	8-in / 40 ft 10-in / 820 ft	Low	Yes	Yes
30th Street and Lake Avenue	Basin 8	8-in / 660 ft	8-in / 260ft 12-in / 340 ft	Medium	Yes	Yes
I-229 Trunk	Basin 7	12-in / 650 ft	12-in / 410 ft	Medium	No	No
Sioux River South	Basins 6 and 7	48-in / 400 ft 54-in / 180 ft	10-in / 480 ft 15-in / 750 ft 24-in / 1,030 ft 36-in / 2,080 ft 48-in / 530 ft 54-in / 14,330 ft	Medium	No	Yes
Rustic Hills Subdivision	Basin 5	8-in / 2,200 ft 10-in / 770 ft	8-in / 3,400 ft	Medium	Yes	Yes
Morningside Trunk Extension	Basin 5	8-in / 990 ft	8-in / 430 ft	Medium	Yes – Verify contributing area in the model.	Yes - Verify contributing area in the model.

**High – Data sufficient to make CIP recommendations*
Medium – Basin data available but localized monitoring data needed
Low – Data not available and insufficient to make CIP recommendations

ES 3.4.1 Collection System Deficiency Improvements

This section discusses hydraulic improvement alternatives associated with Type A deficient areas identified in the previous sections. While numerous problem areas have been identified and discussed for both existing and future (2066) conditions, not all problem areas require a CIP project hydraulic improvement alternative.

The hydraulic deficient areas of the previous section were grouped into three tiers to establish which areas were analyzed as a potential CIP project area, which areas should be monitored as targets for potential inflow and infiltration (I/I) reduction, and which areas require further flow monitoring and study. These tiers are defined as follows:

- Tier 1 project areas address Type A problems and have the highest priority and represent areas of high model confidence and pipes that have diameters 18 inches and greater. Tier 1 project areas are analyzed as a potential CIP project area.
- Tier 2 project areas address Type A problems but have lower priority compared to Tier 1 project areas and represent areas of medium model confidence and pipes that have diameters of less than 18 inches. Tier 2 project areas should be monitored, potentially surveyed, and are targets for potential I/I reduction
- Tier 3 project areas address Type A problems but have the lowest priority compared to Tiers 1 and 2 project areas and represent areas of low model confidence. Tier 3 project areas require further flow monitoring and study prior to CIP project recommendations.

Tier 1 project areas are considered high priority improvements as they resolve severe hydraulic deficiencies. They are anticipated to have a high benefit to the collection system. The Type A problem areas, grouped by tier, are shown in Table ES.5. This table also rates problem extent, SSO risk, and lateral backup risk.

Table ES.5 Collection System –Type A Deficient Areas Grouped by Priority Tier

Problem Area	Basin	Flow Monitoring Data Available*	CIP	2015 Problem Area? d/D Exceeded	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded	Problem Extent**	SSO Risk***	Lateral Backup Risk****	Priority Tier
Type A, Tier 1 Hydraulically Deficient Areas Areas where Model Confidence is Medium or High and Pipe Diameters are 18 Inches and Greater										
Lower Riverside Trunk Sewer	Basin 3	High	Recommend Further Monitoring	Yes	Yes	Yes	Medium	High	High	Tier 1
Central Main	Basins 3 & 4	High	Recommend Further Monitoring	No	Yes	Yes	Medium	Medium	Low	Tier 1
Southeastern Drive	Basin 5	High	Yes	Yes	Yes	Yes	Medium	Low	Low	Tier 1
Sioux River North Upstream of PS 215	Basins 10 & 11	High	Yes	No	No	No	High	Low	Low	Tier 1
Pam Road (Southside Interceptor)	Basin 8	High	No – Investigate profile via survey.	Yes	Yes	Yes	Low	Low	Low	Tier 1
Sioux River South	Basins 6 & 7	Medium	No – Surcharging does not impact sewer laterals.	No	No	Yes	Medium	Low	Low	Tier 1
Richmond Estates Trunk	Basin 1	Medium	Yes	Yes	Yes	Yes	High	High	High	Tier 1
Type A, Tier 2 Hydraulically Deficient Areas Areas where Model Confidence is Medium and Pipe Diameters are Less than 15 Inches NO CIP Projects Alternatives are Developed Areas Should be Monitored and be a Target for I/I Reduction										
I-90 Place Addition	Basin 9	Medium	No	No	No	Yes	Medium	Low	High	Tier 2
Sioux Empire Development Park	Basin 9	Medium	No	No	No	Yes	High	Low	Low	Tier 2
Hilltop Trunk	Basin 4	Medium	No– monitor and target for I/I reduction	Yes	Yes	Yes	Low	Medium	High	Tier 2
12th St and Marion Rd	Basin 11	Medium	No – monitor and target for I/I reduction	Yes	Yes	Yes	High	Medium	Medium	Tier 2

Table ES.5 Collection System –Type A Deficient Areas Grouped by Priority Tier

Problem Area	Basin	Flow Monitoring Data Available*	CIP	2015 Problem Area? d/D Exceeded	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded	Problem Extent**	SSO Risk***	Lateral Backup Risk****	Priority Tier
Ebenezer Avenue	Basin 11	Medium	No	No	No	Yes	Low	Low	Medium	Tier 2
30th Street and Lake Avenue	Basin 8	Medium	No	No	Yes	Yes	Low	Low	High	Tier 2
I-229 Trunk	Basin 7	Medium	No	No	No	No	Low	Medium	Low	Tier 2
Rustic Hills Subdivision	Basin 5	Medium	No	No	Yes	Yes	High	Low	Medium	Tier 2
Morningside Trunk Extension	Basin 5	Medium	No	No	Yes	Yes	Medium	Low	Low	Tier 2
Type A, Tier 3 Hydraulically Deficient Areas Areas where Model Confidence Low NO CIP Projects Alternatives are Developed Flow Monitoring Data Should be Obtained with the Capture of a Significant Wet Weather Event										
Basin 17A Trunk (Lewis Road)	Basin 17	Low	No	Yes	Yes	Yes	High	High	High	Tier 3
Western Interceptor Trunk	Basin 10	Low	No	Yes	Yes	Yes	Medium	Low	Low	Tier 3
Airport Subdivision	Basin 12	Low	No	Yes	Yes	Yes	High	High	High	Tier 3
Columbia Heights Trunk	Basin 10	Low	No	No	Yes	Yes	High	Medium	High	Tier 3
17th, 18th, and 19th Streets	Basin 10	Low	No	No	Yes	Yes	Medium	Low	Low	Tier 3

*Flow Monitoring Data Available **
High – Data sufficient to make CIP recommendations
Medium – Basin data available but localized monitoring data needed
Low – Data not available and insufficient to make CIP recommendations

*Problem Extent***
High – Hydraulic deficiency impacts a large number of pipes
Medium – Hydraulic deficiency impacts a more than 3 pipe segments but less than 8 number of pipes
Low – Hydraulic deficiency impacts a less than 3 pipe segments

*SSO Risk****
High – SSO likely
Medium –SSO potential
Low – basement backup potential

*Lateral Backup Risk*****
High – Hydraulic deficiency likely to impact lateral
Medium – Hydraulic deficiency may impact laterals
Low – Hydraulic deficiency not likely to impact laterals

ES 3.4.2 Summary Existing System Deficiency Improvements for Tiers 1-4

Based on the model development described in Chapter 5, the existing collection system was analyzed for hydraulic deficiencies under existing and future (2066) conditions. However, the problem extents in the 2026 and 2036 planning years were also examined (Table ES.6). For most of the Type A, Tier 1 areas, the 2026 hydraulic deficiency extents are the same as the 2066 planning year.

Table ES.7 summarizes the existing system deficiency improvements based on 2066 projected flows. Future development expansion scenarios were also analyzed with a preferred alternative developed for each planning year (Table ES.6).

Table ES.6 Collection System – Problem Extent Comparisons for Type A, Tier 1 Deficient Areas between Planning Years

Problem Area	2015	2026	2036	2066
Lower Riverside Trunk Sewer	Problem extent restricted to a few pipes	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem
Central Main	No issue	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem but no impact to laterals
Southeastern Drive	Problem extent restricted to a few pipes	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem
Sioux River North Upstream of PS 215	No issue	Backups start	Backups get worse	Backups get worse
Pam Road (Southside Interceptor)	Flow can be relieved at Duluth. Surcharging to be investigated via survey along profile. No impact to adjacent services.	See note on Year 2015.	See note on Year 2015.	See note on Year 2015.
Sioux River South	No issue	d/D criteria gets violated	Some surcharging close to LS	Surcharging along the line but no impact to laterals or services at design storm.
Richmond Estates Trunk	Problem extent similar to 2066	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem

Table ES.7 Collection System - Summary of Existing System Tiers 1-4 Deficiency Improvements

Problem Location	Existing Pipe Diameter(s)	Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size	CIP Cost Developed
Lower Riverside Trunk Sewer	8-,10-,12-,15-, 30-and 36-inch	12-inch	787	None - Need to Monitor Degree of Surcharge - There is no appreciable change in flow from 2013 to 2066 from growth. Surcharging shows on Cliff Ave. without John Morrell flow. Primary impact is permitted point load discharge from John Morrell.
		15-inch	936	
		18-inch	2,998	
		21-inch	1,289	
		24-inch	332	
		36-inch	971	
Central Main	8-, 18-, 24-,48- and 60-inch	60-inch	369	None – Continue to monitor and evaluate; no impact to adjacent services. Problem Area has minimal impact on connecting laterals other than the East Side Trunk Sewer.
		66-inch	2,458	
		72-inch	536	
Southeastern Drive	15-,18- and 24-inch	CIPP Lining Recommended	2,926	Yes – CIP is lining and allow minimal surcharging along profile; no impact to adjacent services
Sioux River North Upstream of PS 215	8-,10-,12-,18-, 30-, 36-, and 42-inch	1.6 MG of Equalization Recommended		Yes
		15-inch	460	
Pam Road (Southside Interceptor)	18-inch	18-inch	428	None – flow can be relieved at Duluth, surcharging will continue to surcharge along profile. No impact to adjacent services.
		24-inch	540	
Sioux River South	10-, 15-, 24-, 36-, 48-, and 54-inch	Surcharge occurs but no impact to incoming services.		None - no impact to adjacent services
Richmond Estates Trunk	8-inch	12-inch	1,990	Yes

ES 3.5 Existing System Sewer Capacity Related CIP Recommendations

ES 3.5.1 Immediate (2017-2021)

Table ES.8 summarizes immediate projects through 2021.

Table ES.8 Existing System – Immediate Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Lower Riverside Trunk Sewer	Sanitary Sewer	Need to Monitor Degree of Surcharge
Southeastern Drive	CIPP Line Sanitary Sewer	$1,400,000
Pam Road (Southside Interceptor)	Sanitary Sewer	Monitor, survey sewer profile and Continue to Maintain
Richmond Estates Trunk	Sanitary Sewer	$1,200,000
Pump Station 240	Lift Station and Forcemain	$39,000,000
Pump Station 240 Equalization	Growth	$5,200,000
Diamond Valley PS Upgrades	Growth	$250,000

ES 3.5.2 Tier 2, or Near-Term (2022-2031)

Table ES.9 summarizes near-term projects.

Table ES.9 Near-Term Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Central Main	Sanitary Sewer	No impact to adjacent services Monitor and Continue to Maintain

ES 3.5.3 Tier 3, or Mid-term (2032-2041)

Table ES.10 summarizes mid-term projects.

Table ES.10 Mid-Term Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Sioux River South Trunk Relief		Monitor and Continue to Maintain

ES 3.5.4 Long-term (2041-2066)

Table ES.11 summarizes long-term projects through 2066.

Table ES.11 Long-Term Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Sioux River North Upstream of PS 215	Sanitary Sewer	Monitor, Beyond CIP Planning Period
Sioux River North of PS 215	Equalization	$7,000,000
Renner Forcemain	Lift Station and Forcemain	Further Study Recommended

ES 3.5.5 Summary of Recommended Lift Station and Force Main Condition Improvements

Table ES.12 is a summary of the High Priority and Medium Priority improvements and estimated project cost for the lift stations and forcemains. A condition assessment of the lift stations was conducted to determine the estimated remaining useful life of the facilities' components and was documented in Chapter 3 - Existing Wastewater System Facilities. The condition assessment included review of the following areas:

- Process equipment and operation
- Architectural condition
- Structural condition
- Mechanical condition
- Electrical condition
- Instrumentation condition

Many of the facilities are over 50 years old and have significant signs of age related deterioration. As part of the condition assessment, a schedule for replacement and/or renovation was developed. The drivers for the schedule are the estimated remaining useful life, reliability, and risk of failure for each item and coordination with future improvements.

It is recommended that the estimated remaining useful life of items be reviewed annually and the replacement/renovation schedule revised accordingly.

Appendix 3.B -Table 3.1 categorizes lift station age and condition driven needs determined by onsite condition assessment which are reflected in Chapter 3 and described in detail in the associated appendices. Within the guidelines presented in that chapter, it also presents the timeline and incorporates an order of magnitude budget in terms of project costs for each.

Improvements for the existing aging facilities were identified from the lift station condition assessment and reliability review were ranked with a priority system based on the following rankings.

- High Priority (0 – 5 Years) Capital Improvements: High priority items are recommended to be addressed immediately and completed within the next five years (2017 – 2021) as the CIP budget allows. These are improvements required to reliably continue to treat the flow to meet the current permit. These improvements address items such as safety, treatment and hydraulic capacity items, reliability, operations and energy minimization.
- Medium Priority (5 – 10 Years) Capital Improvements: Medium priority items are to be completed by 2026. These are phased improvements required to reliably continue to treat the flow to meet the current permit. These improvements also address safety, treatment and hydraulic capacity items, reliability, operations and energy minimization but were allocated at least five more years of life.
- Low Priority Plant Modifications to meet Other Needs: Low Priority improvements that are necessary to continue to meet the needs for the WRF to operate effectively and meet the effluent permit limits. These items have been given Low Priority designations due to the remaining life. Low priority items are planned for completion in 2027 – 2036. These items should be monitored during project planning, as it may be prudent to include various items in larger projects to take advantage of the economy of scale.

It is recommended to include the high and medium priority lift station items in the Immediate (2017-2021) category.

Table ES.12 Lift Stations Near-Term Improvements Summary

New Project No.	Proposed Capital Improvements	Construction Cost	Project Cost
Lift Station High/Medium Condition Items			
Lift Station PS-201, or 2nd & Brookings	Standby Generator	$65,000	$81,000
Lift Station PS-203, or Cherokee and "C"	Renovate and Upgrade Lift Station	$747,000	$926,000
Lift Station PS-204, or Modern Press	Upgrade Electrical and Provide Davit Crane Bases	$44,000	$55,000
Lift Station PS-205, or 6th and Hawthorne	Safe Access Maintenance Lift	$65,000	$81,000
Lift Station PS-205, or 6th and Hawthorne	Standby Generator and Controls Upgrades	$114,000	$141,000
Lift Station PS-206, or Burnside	Complete Lift Station Rebuild	$244,000	$303,000
Lift Station PS-213, or 23rd and Kiwanis	Standby Generator	$65,000	$81,000
Lift Station PS-218, or Tuthill	Upgrade Lift Station to Address Flooding Issues and Electrical Panel Corrosion	$298,000	$370,000
Lift Station PS-220, or Rock Island, Riverside Park	Complete Short-term Improvements - Replace Wall Piping Seals and Relocate Heater.	$839,000	$1,040,000
Lift Station PS-221, or Madison and Vail	Standby Generator	$65,000	$81,000
Lift Station PS-224, or 50th Street North	Replace Existing Pumps with Dry-Pit Flygt N-Pumps or Recessed Impeller Pumps	$122,000	$151,000
	Lift Station Improvements Items	**$2,670,000**	**$3,310,000**

ES 3.6 Growth Related Capital Improvement Recommendations

This section provides a summary of the capital improvements cost for the growth related projects by implementation timeframe. The CIP is broken down into three time steps to conform to Chapter 2 and the Shape Sioux Falls plan.

The projected growth is in three tiers as indicated on the figures referenced throughout this chapter:

- Tier 1, or Immediate (2017 thru 2021)
- Tier 2, or Near-Term (2022 thru 2031)
- Tier 3, or Mid-Term (2032 thru 2041)
- Tier 4, or Long-Term (2041 thru 2066) (used only for sizing trunk lines)

Table ES.13 summarizes the description, and anticipated timeframe of the capital improvement cost recommendations.

For reference, Figures ES.6 and ES.7 show the location, description, and anticipated timeframe of the capital improvement recommendations.

Table ES.14 summarizes the cost per acre for recommended growth infrastructure at build-out and has been developed based on the following assumptions:

- Basin 15:
    - o 1,200 acres has been removed from Basin 15 area shown in map since cost recovery has been previously assessed at totaling $2,601,000 ($2,167.46/acre*1,200 acres).
- Basin 17:
    - o Cost recovery previously set at $3,110 per acre in 2015.
- East Side Sanitary Sewer (ESSS):
    - o Cost recovery previously set at $4,297 per acre in 2004.

Table ES.13 Capital Improvements Summary for Recommended Growth Infrastructure

Description	Recommended Capital Improvements for Tiers 1-3 Infrastructure											
Facilities Costing Summary	Tier 1 and 2 Estimated Cost (Millions)						Tier 3 Estimated Cost (Millions)					
	Trunk Sewer	EQ Basin	Force Main	Pump Station	Total	Approx. Area Served (ACRE)	Trunk Sewer	EQ Basin	Force Main	Pump Station	Total	Approx. Area Served (ACRE)
Basins 15[1]	$19.1	EQ tied to Basin 34	-	-		1,146	$11.5	EQ tied to Basin 34	-	-		481
Basins 34[1]	$0.2	$18.4	-	-		15	$55.1	-	-	-		3,464
Basins 15/34 Subtotal: [1]	$19.3	$18.4	_	_	$37.7	1,161	$66.6	-	_	_	$66.6	3,945
Basin 16	$12.6	-	-	-	$12.6	287	$2.7	-	-	-	$2.7	368
Basin 17	$4.2	-	-	-	$4.2	1,063	NA					
Basin 18	$6.0	-	-	-	$6.0	611	NA					
Basins 19/22	$15.0	-	$6.7	$2.3	$24.0	1,386	$1.2	-	-	-	$1.2	555
Basin 23[1]	$6.2	-	-	-	$6.2	218	$2.5	-	$2.7	$4.8	$10.0	672
Basin 25	NA						$34.3	-	-	-	$34.3	2,442
Basin 26	$2.5	-	-	-	$2.5	304	NA					
Basins 27/28[1]	$54.3	$11.2	$20.3	5.6	$91.4	5,472	$3.1	-	-	-	$3.1	448
Basin 29	$2.5	-	$5.7	$1.9	$10.1	187	NA					
Basins 30/31	$6.2	$4.3	$3.1	$2.4	$16.0	1,410	NA					
Basin 32	NA											
Basin 33 (Foundation Park)	$7.3	$4.1	$4.6	$4.3	$20.3	1,598	NA					
Totals	$136.1	$38.0	$40.4	$16.5	$231.0	13,697	$76.1	$0.0	$2.7	$4.8	$83.6	5,988

Note: 1. Costs include costs for equivalent dual forcemains.

Table ES.14 Summary of Cost per Acre for Recommended Growth Infrastructure at Build-out

Description	Capital Costs per Effective Acre Developed							
	Trunk Sewer (Millions)	EQ Basin (Millions)	Force Main (Millions)	Pump Station (Millions)	Total (Millions)	Approx. Area Served (ACRE)	$/Acre	Population at Build-out (2.74 Units per Acre)
Basins 15[1]	$49.6	EQ tied to Basin 34	FM shared with Basin 34	PS shared with Basin 34		5178		22,034
Basins 34	$86.8	$22.5	$45.5	$10.5		7079		12,209
Basins 15/34 Subtotal:	$136.4	$22.5	$45.5	$10.5	$214.9	12257	$17,600	34,243
Basin 16	$23.6	-	$2.7	$1.4	$27.7	1075	$25,800	13,510
Basin 17[2]	$4.2	-	-	-	$4.2	1063	$3,110	1,388
Basin 18[3]	$6.0	-	-	-	$6.0	611	$4,300	16,689
Basins 19/22	$16.2	-	6.7	2.3	$25.2	1941	$13,000	9,980
Basin 23[3]	$8.7	-	2.7	4.8	$16.2	890	$4,300	2,684
Basin 25	$34.3	-	-	-	$34.3	2442	$14,100	2,735
Basin 26[3]	$2.5	-	-	-	$2.5	304	$4,300	25,925
Basins 27/28	$57.4	11.2	20.3	5.6	$94.5	5920	$16,000	34,598
Basin 29	$2.5	-	5.7	1.9	$10.1	187	$54,100	1,151
Basins 30/31	$11.0	4.3	3.1	2.4	$20.8	1491	$14,000	2,228
Basin 32	$5.2	-	8.3	1.9	$15.4	1288	$12,000	2,396
Basin 33 (Foundation Park)	$7.3	4.1	4.6	4.3	$20.3	1598	$12,800	42

Notes:

1. 1,200 acres has been removed from Basin 15 area shown in map since cost recovery has been previously assessed at $2,601,000 ($2,167.46/acre*1,200 acres). Maintained cost of 42 IN. and 12 IN. as shown on map.
2. Basin 17 cost recovery previously set at $3,110 per acre in 2015.
3. East Side cost recovery previously set at $4,297 per acre in 2004.

ES 4 Water Reclamation Facility Improvements

Based on the WRF process selection evaluation in Chapter 7, which includes factor weighting, alternative scoring and cost-benefit development, the preferred treatment alternative for this project is Alternative 1-1, 5-Stage Bardenpho Biological Nutrient Removal at WRF. This alternative is comprised of expansion of activated sludge to provide biological nutrient removal for phosphorus and nitrogen and further polishing with chemical phosphorous removal, final clarification, tertiary filtration and chlorine contact basin expansion.

The improvements summarized in Chapter 10 address treatment capacity upgrades for treatment through 2036, along with the noted high and medium priority reliability improvements.

Phase 1 process improvements generally include screenings, a primary clarifier influent diversion structure, increased activated sludge, filtration and chlorine contact capacity. The trickling filter train will continue to be used until nutrient removal regulations are in place. However, due to timing, a Phase 1a project needs to be constructed immediately including grit influent piping, diversion of peak flows directly from grit removal to the aeration basins and incorporating step-feed into the aeration basins. Also included in Phase 1a is rehabilitating the final clarifiers and existing filtration high priority items, and new biosolids dewatering, thermal drying and handling improvements.

In Phase 2, when fully constructed, the Alternative 1-1 biological nutrient removal and polishing scheme will provide treated effluent of a quality suitable to meet the expected ammonia, total nitrogen and total phosphorus design effluent criteria.

The long-term recommended improvements and ultimately the CIP envisions the capital improvements described herein. The recommended liquid process improvements will be necessary to meet the federally adopted ammonia criteria. At this point, Phase 1 ammonia removal and related solids handling improvements will need to be constructed by 2025 to meet expected design year growth. The implementation programming is designed to provide timely construction of the necessary improvements at the plant by integrating preliminary design for all projects required by 2025, also referred to as Phase 1 project improvements.

Included in the Phase 1 projects are the liquid and solids plant process improvements, reliability improvements, and fog facilities if assessments show fog is available.

Biosolids handling improvements are recommended in Chapter 10, as presented in Chapter 8. The biosolids handling improvements address sludge thickening, post-digestion storage, dewatering, thermal drying, and dewatered and dried sludge storage.

Anticipating that regulatory requirements will change in the future, the WRF improvements plan provides flexibility to incorporate the plan in phases and also includes provisions for future process changes. However, no costs are allocated in the long-term improvement program for potential future needs beyond the WRF Design Criteria stipulated in the following section.

ES 4.1 WRF – Design Criteria

The design criteria for the proposed WRF Improvements is based on flow and loading data from the existing WRF, while using the flow and loading assumptions for new growth which is fully described in Chapter 4. Projected flows are summarized in Table ES.15.

Table ES.15 WRF – Projected Flows

Area	2013 to 2015 Ave	2021	2026	2031	2036
	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*
Average Day	16.1	22.2	23.8	27.2	30.1
Maximum Month	23.7	31.1	34.0	38.7	42.7
Equalized Peak	35	35	50	57	57

Projected design year 2036 flows and loads are summarized in Table ES.16.

Table ES.16 WRF – Expand Existing WRF 2036 Design Year Flows and Loads

	Flow	BOD	TSS	NH3-N	TKN
	MGD	lb/d	lb/d	lb/d	lb/d
AADF	30.1	66,700	65,200	7,200	11,700
MMF	42.7	75,000	81,600	8,300	13,200
	MGD	mg/L	mg/L	mg/L	mg/L
AADF	30.1	265	259	29	46
MMF	42.7	210	229	23	37

AADF: Annual Average Day Flow
MMF: Maximum Month Flow

Prospective effluent limits are summarized in ES.17. The basis for the prospective effluent limits is presented in detail in Chapter 6. All prospective effluent limits should be thoroughly reviewed, when permits are issued, with action items listed in Chapter 6 in mind i.e. evaluate if incorporating river flow based and mass vs. concentration limits are beneficial to the WRF.

Table ES.17 WRF – Prospective Effluent Limits

	Ammonia (Permit #2 – Year 2026) Daily Max mg/l	BOD/TSS 30-day Average / Max. 7-Day mg/l	Dissolved Oxygen (D.O.) mg/l	E. Coli. Limit Colonies / 100 milliliters[3]	Total Nitrogen (TN) Permit #3 (Year 2030) Max. Month mg/l	Total Phosphorus (TP) Permit #3 (Year 2030) Max. Month mg/l
January - March	2.1	30/45	5.5	126	10	1
April - August	1.0	30/45	5.0	126	10	1
September - October	1.3	30/45	5.0	126	10	1
November - December	2.1	30/45	5.5	126	10	1

Notes:
1. pH limits are 6.5-9.0.
2. Total Residual Chlorine (mg/L) are not measurable (≤ 0.1).
3. Current Fecal Coliform limit is 200 Colonies / 100 milliliters.

ES 4.2 WRF – Regulatory Triggers

Table ES.18 identifies the anticipated regulatory activity, which were considered and identified in Chapter 6 Regulatory Planning. The regulatory timeline reflects the anticipated schedule for approval and implementation of nutrient standards.

Table ES.18 WRF - Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit	NA	Plan for anticipated more stringent ammonia standards. Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability.
		Schedule for construction –major projects will be dependent upon issuance of a new discharge permit and its compliance schedule.
		Proactively evaluate if incorporating river flow based and mass vs. concentration limits are beneficial to the WRF.
Permit #1 2022	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Phase 1a and Phase 1 Project to be constructed by 2021 and 2025.
Permit #2 2027	New Ammonia Standards	Assuming required improvements for ammonia removals complete.
		Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2029.
Permit #3 2032	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty.
		Track potential proposed changes in the nutrient standards.
Permit #4 2037	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

The above permitting schedule reflects discussions with SD DENR and progress in similar states.

ES 4.3 WRF – Reliability Improvements

A condition assessment of the WRF was conducted to determine the estimated remaining useful life of the facilities' components and was documented in Chapter 3 - Existing Wastewater System Facilities. The condition assessment included review of the following areas:

- Process equipment and operation
- Architectural condition
- Structural condition
- Mechanical condition
- Electrical condition

- Instrumentation condition

Based on the assessment, the WRF is in generally good condition; however, the WRF has facilities that are over 30 years old and have significant signs of age related deterioration. As part of the condition assessment, a schedule for replacement and/or renovation was developed. The drivers for the schedule are the estimated remaining useful life, reliability, and risk of failure for each item and coordination with future improvements.

It is prudent to continue to maintain and replace equipment as required, rather than schedule complete replacement if that equipment is going to be obsolete in the future plans. For example, it would not be prudent to invest in additional trickling filter intermediate clarifier capacity, as future nutrient standards will drive replacement of the trickling filters with activated sludge process capacity, as currently envisioned.

It is recommended that the estimated remaining useful life of items be reviewed annually and the replacement/renovation schedule revised accordingly.

Chapter 10 Appendix Table A.10.1 categorizes age and condition driven needs determined by onsite condition assessment and are reflected in Chapter 3 and described in detail in the associated appendices. Within the guidelines presented in that chapter, it also presents the timeline and incorporates an order of magnitude budget in terms of project costs for each.

Improvements for the existing aging facilities were identified from the WRF condition assessment and reliability review were ranked with a priority system based on the following rankings.

- o High Priority (0 – 5 Years) Capital Improvements: High priority items are recommended to be addressed immediately and completed within the next five years (2017 – 2021) as the CIP budget allows. These are improvements required to reliably continue to treat the flow to meet the current permit. These improvements address items such as safety, treatment and hydraulic capacity items, reliability, operations and energy minimization.
- o Medium Priority (5 – 10 Years) Capital Improvements: Medium priority items are to be completed by 2026. These are phased improvements required to reliably continue to treat the flow to meet the current permit. These improvements also address reliability, safety, treatment and hydraulic capacity items, reliability, operations and energy minimization. These items were allocated at least five more years of life.
- o Low Priority Plant Modifications to meet Other Needs: Low Priority improvements that are necessary to continue to meet the needs for the WRF to operate effectively and meet the effluent permit limits. These items have been given Low Priority designations due to the remaining life. Low priority items are planned for completion in 2027 – 2036. These items should be monitored during project planning, as it may be prudent to include various items in larger projects to take advantage of the economy of scale.

The high and medium priority items will be included in Phase 1 improvements, as both high and medium items need to be constructed by 2025.

Select high priority items including grit influent piping and primary clarifier influent diversion structure and piping will be included in the Phase 1a project to provide the required hydraulic capacity to pass the peak flow events. Also included in Phase 1a is rehabilitating the final clarifiers and existing filtration high priority items, and new biosolids dewatering/handling improvements.

ES 4.4 WRF - Recommended Improvements

This section presents the recommended facility improvements for the proposed WRF. The ultimate liquids treatment scheme is comprised of influent screenings, grit removal, primary clarifiers, nutrient removal using the 5-Stage Bardenpho process for nitrogen and phosphorus removal, final clarification, filtration, and chorine disinfection improvements.

The most notable technology-based changes are the long-term switch to Biological Nutrient Removal to meet regulations, the recommended change to the addition of FOG handling facilities to improve WRF's energy sustainability and, biosolids dewatering to improve operability and practicality of the sludge handling operation. All of the recommended improvements involve conventional, commonly used wastewater treatment technologies.

Note building numbers have been included with each itemized improvement as referenced from Figure ES.9.

For process residuals, onsite solids handling includes thickening, followed by anaerobic digestion. Following digestion, biosolids handling and disposal consists of dewatering via screw presses, followed by thermal drying for Class A sludge to be disposed of on the current land and a portion through possible sale for domestic use.

The site layout for the proposed WRF is presented in Figure ES.9 and the process flow diagram for the proposed WRF is presented in Figure ES.10.

Handling of the sidestream ammonia for Phase 1 and nutrients for Phase 2 are included in the Biowin model scenarios and the associated capital improvement costs are included as part of the selected treatment processes. The selected activated sludge process is sized for the anticipated recycle loads. Due to the small relative ammonia recycle loading, the benefits of sidestream treatment targeted to ammonia is limited for the selected treatment process. The current process selection equalizes the ammonia load and minimizes additional process components that would be required for the alternative patented sidestream ammonia removal processes.

The current plan recommends chemical feed for "tying up" the phosphorus as the most economical solution to address phosphorus removal, along with reducing struvite accumulation in anaerobic digesters. This also improves dewaterability of anaerobically digested biosolids and reduces high phosphorus recycle loading from solids handling (up to 50% influent load). However, the phosphorus recycle content and associated challenges with solids handling for a biological phosphorus removal process warrant further consideration during preliminary design. Phosphorus handling alternatives may be considered during predesign including processes that provide Phosphorus release (P-Release) from waste activated sludge (WAS).

The specific improvements are designed to provide adequate capacity for the projected 20-year nominal 2036 planning year average flow of 29.8 mgd, maximum month flow of 42.2 mgd and peak equalized flow of 57 mgd. The equalization volume included at the WRF assumes that a new 20 million gallon basin is constructed at the Chambers and Cliff site.

Note that costs have been rounded off and are in terms of 2016 project costs with the exception of the FOG and Microturbines projects, which are in 2013 dollars.

Figure ES.9 WRF - Proposed Site Layout

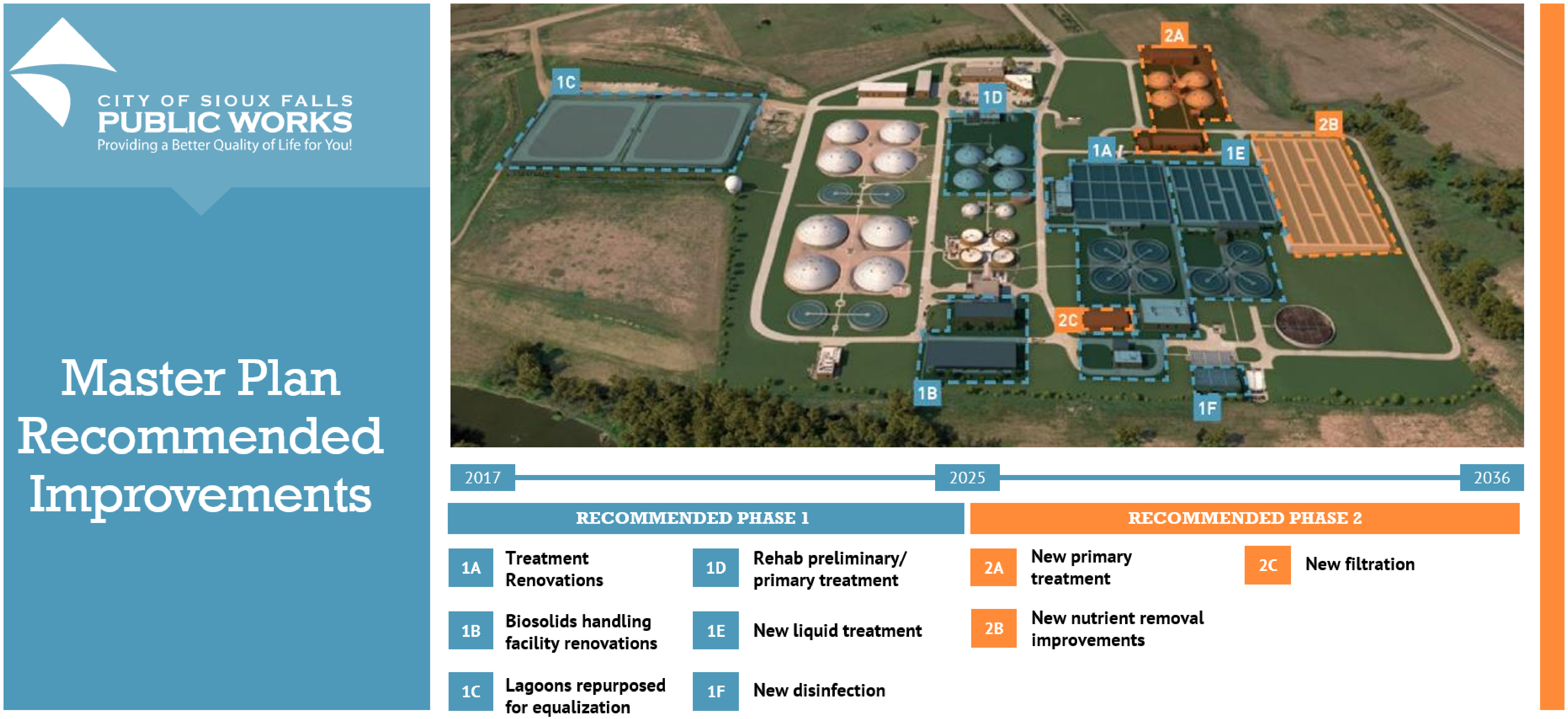
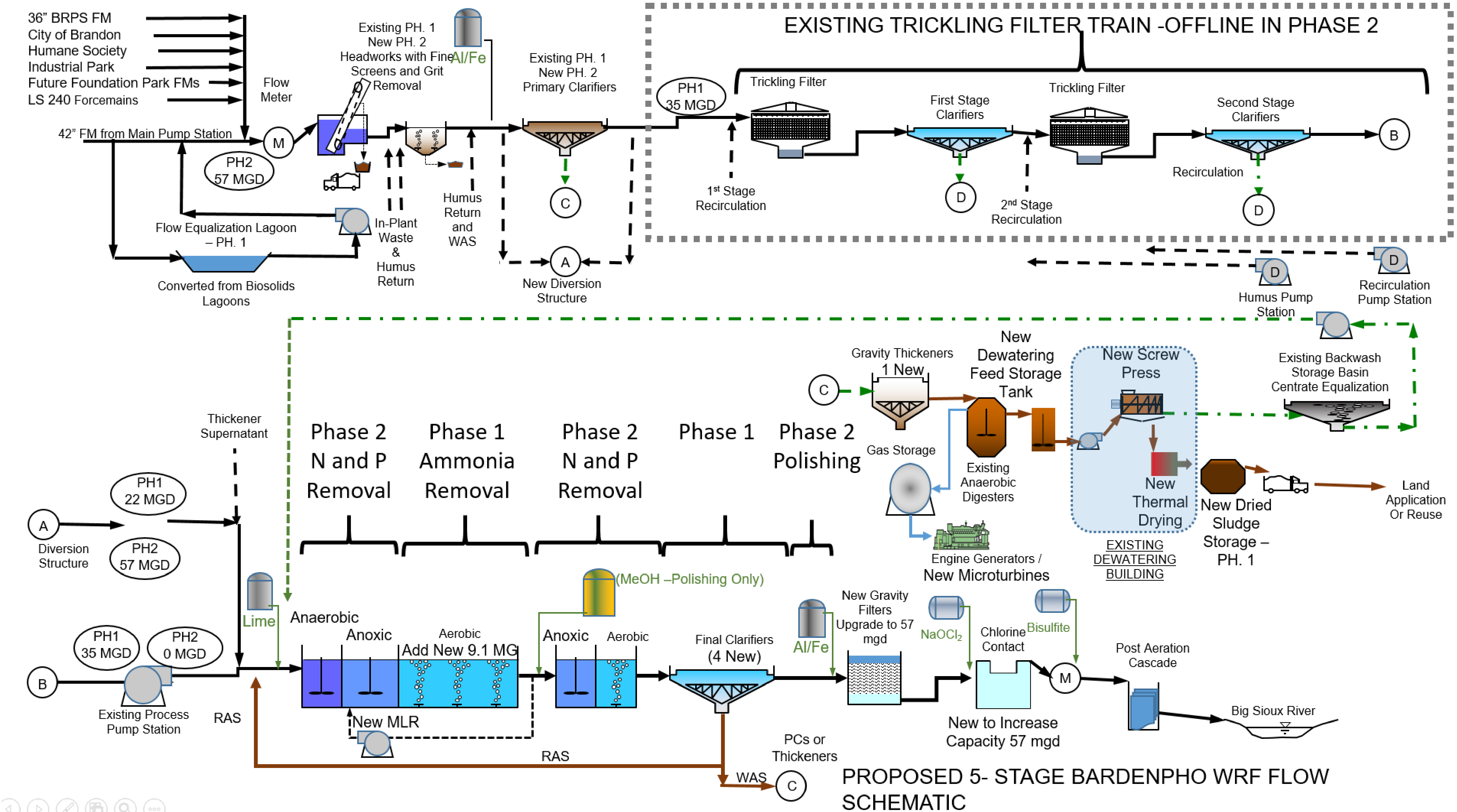


Figure ES.10 WRF - Proposed Process Flow Diagram



ES 4.5 WRF - Cost Estimates and Implementation Schedule

This section presents the WRF cost estimates and implementation schedule for construction of the recommended improvements.

ES 4.5.1 WRF – Capital Costs

The capital costs for the WRF are presented in two phases, which allows the Phase 2 nutrient removal project to be deferred and triggered by regulation.

The Phase 1 project includes liquid process improvements, solids handling improvements, and WRF high and medium priority reliability items. In addition, the initial Phase 1 project includes a Phase 1a initial aeration and hydraulics improvements project, which needs to be constructed immediately.

Refer to Figure ES.11 for a graphic of the associated timeline.

Table ES.19 provides a summary of the preliminary recommendations to upgrade the WRF to reliably treat the 2036 projected flows and loads. This table provides an overview of facility requirements, driving forces, and urgency/timing considerations.

Table ES.19 WRF - Summary of Recommendations for Design Year 2036

	Proposed Process Component		Driving Force for Improvement					Recommended Improvements
			Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	
Phase 1A - Improvements		Step Feed Improvement at Aeration Basins, Grit Influent Piping & PC Infl. Div. (1)	✓	✓	✓		✓	Construct piping and gates required to divert flow to second aeration basins during peak flows and loading to maintain D.O. Construct process gravity diversion structure from the grit effluent to the aeration basins to divert flow to secondary treatment train during peak flows. Grit Influent Piping Primary Clarifier Influent Diversion Final Clarifier Rehab Filter Building High Priority Items
Phase 1A - Improvements		Grit Influent Pipe Upsizing (1) (2)		✓				Increase grit influent pipe to be able to pass minimum of 60 mgd.
Phase 1A - Improvements		PC Influent Peak Diversion		✓				Construct pump station to function to divert peak PC influent or effluent flows.
Phase 1A - Improvements		Rehab Final Clarifiers					✓	Renovate the existing final clarifiers with Stamford Baffles™ and modern inboard weirs to provide for improved flow characteristics to limit short-circuiting.
Phase 1A - Improvements		Biosolids Dewatering/Handling Improvements		✓	✓	✓	✓	Construct a new mixed Dewatering Sludge Feed Tank (DSFT) with a minimum of 3 days of storage. Construct new polymer feed and an alum feed. Construct new dewatering units i.e. screw presses. Construct centrate transfer line to the existing backwash storage tank for aeration/equalization. Review sidestream impacts and construct lime feed as required based on final project phasing. Construct thermal drying with provisions to send dewatered sludge directly to storage. Construct dried cake aboveground pad/bunker storage for giveaway (half) and for contracted land application (half). Construct solids handling building standby generator and ATS.
		Phase 1 - Liquid Process Improvements	✓	✓	✓	✓	✓	
Phase 1 - Liquid Process Improvements	Preliminary	Screening Improvements		✓				Remove and replace screens complete with screenings dewatering to increase firm capacity to 57 mgd.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basin Upgrades (1)	✓		✓	✓	✓	Construct new fine bubble aeration system complete with new electrical and control system.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basin Splitter Box		✓				Construct new aeration basin influent splitter box for influent and RAS.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basins	✓	✓	✓		✓	Phase 1: Construct new aeration basins complete with fine bubble aeration. Renovate existing basins.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basin Blowers	✓	✓	✓		✓	Construct new blowers complete with new blower building.
Phase 1 - Liquid Process Improvements	Aeration Basins	Replace RAS and WAS Pumps	✓		✓	✓		Replace existing RAS and WAS pumps.
Phase 1 - Liquid Process Improvements	Aeration Basins	Final Clarifiers	✓	✓	✓			Construct final clarifiers - equivalent of 4 new clarifiers.
Phase 1 - Liquid Process Improvements	Tertiary	Filter Expansion – Shifted to Phase 2.	✓	✓	✓			Construct filter building expansion to add capacity to treat to 57 mgd.
Phase 1 - Liquid Process Improvements	Tertiary	Chlorine Contact Expansion (1) (2)	✓	✓	✓		✓	Construct chlorine contact basin expansion to add capacity to treat to 57 mgd.
Phase 1 - Liquid Process Improvements	Tertiary	Effluent Flow Meter Improvements		✓	✓		✓	Construct new flow metering to add capacity to measure flows to 57 mgd.

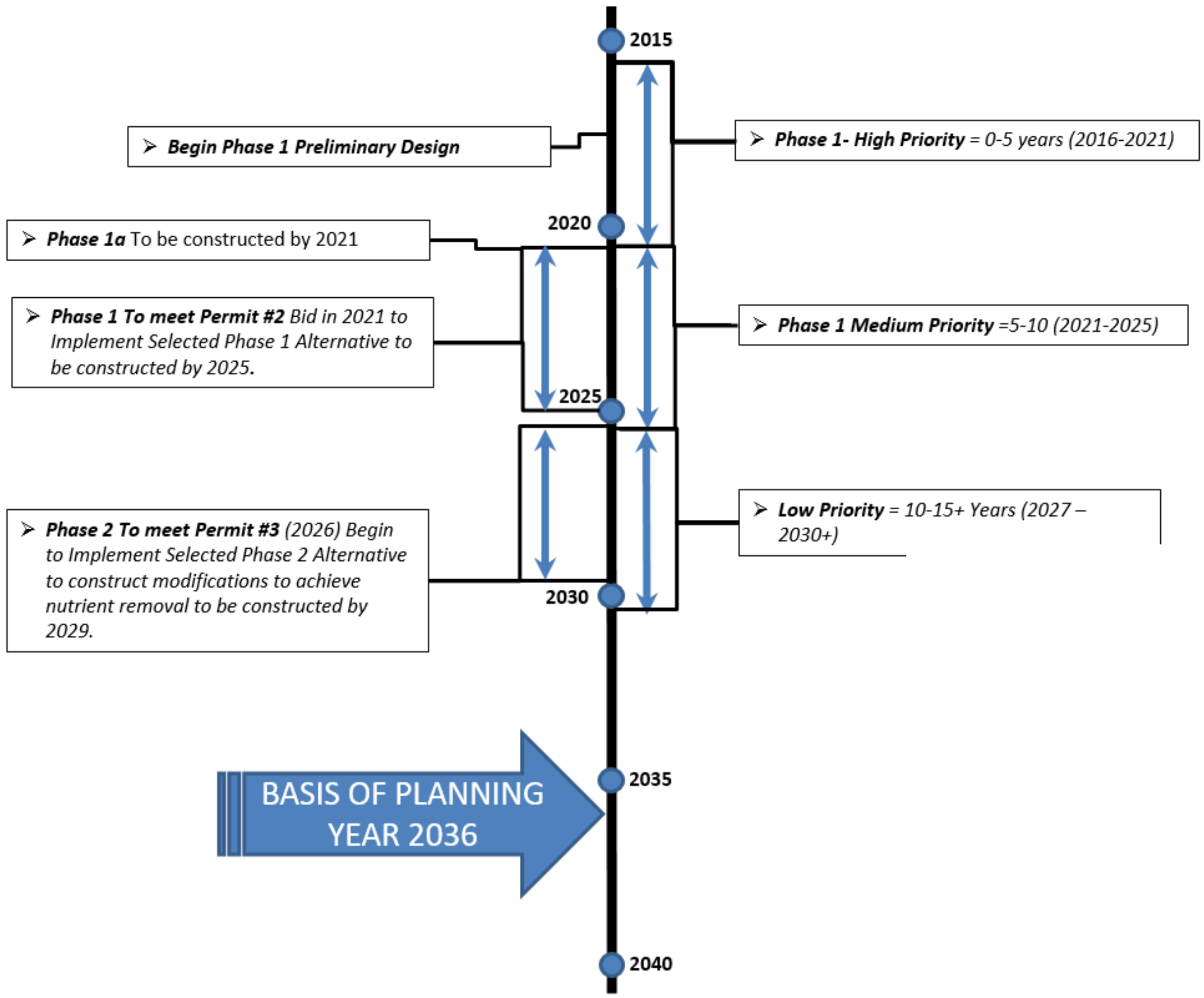
Table ES.19 WRF - Summary of Recommendations for Design Year 2036

	Proposed Process Component	Driving Force for Improvement					Recommended Improvements
		Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	
	Phase 1 - Solids Handling Improvements	✓	✓	✓	✓	✓	
Phase 1 - Solids Handling Improvements	New WAS Thickening	✓	✓	✓		✓	Construct WAS thickening final process to be determined with sludge dewatering evaluation update.
Phase 1 - Solids Handling Improvements	FOG Receiving – Shifted to Phase 2.					✓	Construct a Feedstock Receiving and Processing Station to receive and co-digest FOG in the short term and to receive and co-digest food/higher solid waste materials with additional improvements in the future when the associated waste collection program is developed. Action Items: Develop a food / higher solid waste collection program. If source(s) are available, develop an updated Basis of Design to include facilities for receiving and process food / higher solid waste.
Phase 1 - Solids Handling Improvements	Convert Biosolids Lagoons to Equalization Basins		✓			✓	Equalization improvements include converting the existing biosolids lagoons to equalization basins at the WRF. WRF improvements include the following: Construct tee and isolation valve off the 42-inch forcemain. Construct an automated valve to equalization basins. Construct a dry-pit style 7 mgd return pump station complete with valving and metering to 42-inch forcemain. Update gate controls at headworks structure. Update SCADA for coordinating Main Pump Station metering with headworks metering to provide a set diversion rate.
Phase 1 - Solids Handling Improvements	Energy Recovery / Microturbines – Shifted to Phase 2.					✓	Construct microturbines replacing engine generators for combined heat and power.
Phase 2 Improvements	WRF Phase 2 – Nutrient Project To Meet Permit #3 Total	✓		✓		✓	Construct folded aeration basins to allow anoxic recycle to be pumped over the wall complete with multiple trains, air piping and diffusers, mixers, internal recycle pumps, influent distribution and effluent launders. Construct a new anoxic recycle/RAS/WAS pump building. Construct anaerobic and anoxic basins as required within existing basins. Construct new alum feed system. Construct associated site work/demolition, site piping, and miscellaneous improvements.

Notes:

(1) High priority/immediate need.
(2) Hydraulic improvement.
(3) These costs assume that 48.3 MG of equalization basin capacity is in place.
(4) Miscellaneous Improvements include: architectural, structural, HVAC, electrical, SCADA, miscellaneous site structures and process related improvements identified during the condition assessment (only equipment cost associated with the alternatives are included and those with a replacement timeframe of ten years or less).

Figure ES.11 WRF - Recommended Improvements Timeline



The improvements have been compiled and presented herein in the form of a preliminary capital improvements plan included as Table ES.20 and footnoted accordingly.

Table ES.20 WRF - Capital Improvements Plan

Improvements Phase	Proposed Capital Improvements	Recommended Project Cost	
Phase 1a Improvements	Step Feed Improvement at Aeration Basins	$3,670,000	Immediate hydraulic and organic capacity need. 1. Phase 1a - Step Feed Exp. & PC Infl. Div. are immediate improvements required to extend plant capacity to allow Phase 1 to be constructed.
	Grit Influent Piping	$1,670,000	
	Primary Clarifier Influent Diversion	$1,900,000	
	Final Clarifier Rehab	$6,500,000	
	Filter Building High Priority Items	$1,000,000	
	Biosolids Dewatering/Handling Improvements	$18,100,000	
	Dewatering Building Rehab Items	$1,200,000	
	Phase 1a Subtotal	**$34,040,000**	
Phase 1 - WRF Improvements	Headworks	$14,600,000	Begin design in 2017 to meet 2025 construction date.
	Primary Clarifiers	$18,800,000	
	Aeration Basin Upgrades (1)	$4,000,000	
	Aeration Basin Splitter Box	$2,300,000	
	Aeration Basins	$38,600,000	
	Aeration Basin Blowers	$7,600,000	
	Replace RAS and WAS Pumps	$420,000	
	Final Clarifiers	$17,100,000	
	WRF - Filter Expansion	$7,100,000	
	Chlorine Contact Expansion (1) (2)	$3,200,000	
	Effluent Flow Meter Improvements	$420,000	
	Convert Biosolids Lagoons to Equalization Basins	$6,900,000	
	New Generator	$2,200,000	
	Site Piping	$2,700,000	
	WRF Phase 1 -New Thickening	$3,330,000	
	WRF – Microturbines	$4,150,000	
	WRF - FOG Receiving (Shifted from Phase 1)	$2,920,000	
	Phase 1 High Priority Items	*$15,094,600*	High Priority identified as immediate needs by condition assessment.
	Phase 1 Medium Priority Items	*$10,400,000*	Medium Priority identified as 5-10 year needs by condition assessment.
	Total Phase 1 Improvements Subtotal	**$161,900,000**	
	Total Phase 1a & Phase 1 Improvements Subtotal	**$195,900,000**	
Phase 2 - WRF Improvements	WRF - Phase 2 - Liquid Nutrient Improvements	$105,600,000	
Phase 1 – Collection Projects	Lift Stations High/Medium Condition Items	$3,310,000	
	Southeastern Drive	$1,400,000	
	Richmond Estates Trunk	$1,200,000	
	Pump Station 240 Forcemain	$36,000,000	
	Pump Station 240 Pump Upgrades	$2,800,000	
	Pump Station 240 Equalization	$2,900,000	
	Diamond Valley PS Upgrades	$250,000	
	Phase 1 – Collection Projects Subtotal	**$47,900,000**	

ES 4.5.2 Operational Driven Needs

Table ES.21 identifies recommended operational improvements. A digital intranet-based operations manual should be considered to facilitate continuous update and central access to SOP's and equipment manuals. Equipment Asset Management Software Updates (EAM), Computerized Maintenance Management Software (CMMS) should be developed to better manage renewal decisions. There are several short term alternatives, including implementation of a separate EAMs system such as AWWA's Plant Infrastructure Manager or HDR's AM Tools that are based on an MS Access database. However, the WRF should upgrade to a commercial version, as this would further assist with annual budgeting and implementation of the recommended high and medium priority improvements.

Table ES.21 Operations Improvements Summary – Monetary

Priority	Assessment Category	Opportunity	Opportunity Description	Years of Implementation	Cost
Medium	Operational Capabilities and Procedures	Operations Manuals	Development of a facility level O&M Manual is recommended. A digital intranet based manual should be considered to facilitate continuous update and central access to SOP's and equipment manuals.	2–5	$200,000
Medium	Maintenance Procedures	Equipment Asset Management Software Updates (EAM)	Consider developing a EAMs system to better manage renewal decisions. There are several short term alternatives to implement this initiative either by; enhancing the current CMMS system to include EAM features described earlier or implementing a separate EAMs system such as AWWA's Plant Infrastructure Manager or HDR's AM Tools that are based on an MS Access database.	2–5	$50,000
Medium	Maintenance Procedures	Computerized Maintenance Management Software (CMMS)	Consider the eventual replacement of the existing CMMS with a commercial version. Based on the updates made to the asset spreadsheet; the migration of the asset registry and historical data should be straightforward. Implementation is estimated to be $80,000 subject to final negotiations and changes to the scope of work. The licensing for a model includes an annual cost of $15-30,000 assuming 20 individual users.	5–10	$80,000
					$330,000

ES 4.5.3 WRF Project Schedule

A separated project phasing memorandum was developed and is included as a separate Technical Memorandum (TM). This TM is included as an attachment to the Executive Summary.

ES 4.5.4 WRF Consequences of Inaction

Failure to implement the recommended improvements in a timely manner could have significant adverse impacts on the City of Sioux Falls WRF, including:

- Non-compliance with discharge permit requirements.
- Non-compliance with City Treatment Capacity per Ordinance.
- Raw sewage spills, and associated public health impacts.
- Water quality impairment of the Big Sioux River.
- Inability to handle wastewater generated by the community.

These consequences would likely lead to regulatory enforcement actions and fines, and may result in a moratorium on construction within the City's service area

ES 4.6 Establish Guiding Regional Principles and Financial Policies

The City, with assistance from HDR, reviewed a number of guiding principles for regionalization and developed the general approach for establishing regional wastewater rates and system development charges. For reference, more detail is provided in Appendix 2.A – Regional Wastewater Executive Summary.

> ***"The foundation of successful regional systems is treating all parties (owners and regional customers) in a fair, equitable and transparent manner, particularly as it relates to the rate setting process."***

Financial policies were developed to provide the framework for the development of regional rate methodology and system development charges. In establishing a regional system, it is imperative that a rate-setting framework be established for all regional customers to understand the approach and methodology that will be used by the City to establish regional rates and system development charges on a fair and equitable basis. The foundation of successful regional systems is treating all parties (owners and regional customers) in a fair, equitable and transparent manner, particularly as it relates to the rate setting process.

Some of the more prominent principles and policies related to the establishment of a regional wastewater system are as follows:

- The City owns and operates the regional wastewater system. Local collection systems are owned and operated by the local entity.
- The regional system is defined as the City's wastewater treatment facilities and a portion of the City's interceptor/collection system needed to serve regional customers. Extensions

required to connect a regional customer(s) to the regional interceptor shall be paid for/funded by the local agency(s) that benefits from the extension.

- The City will use "generally accepted" rate setting methods to establish the regional rates and fees. A cost of service analysis will be used to equitably allocate the City's total wastewater system costs between the Regional Wastewater System and the City's retail customers. The City, as the owner of the Regional System, shall be entitled to earn a "fair" return on their investment to serve the regional customers.
- For purposes of the regional system, the City shall be defined as a regional customer, along with all other regional customers.
- System development charges (SDCs) shall be paid by all new regional customers connecting to the regional system and any customers expanding their existing capacity. All regional SDCs shall be used for expansion-related needs of the regional system.
- Local government shall retain responsibility for local rate setting. How regional rates and SDCs are passed through to local customers shall remain a local policy decision.

Given this basic framework of principles and financial policies, the regional wastewater rates and system development charges should be developed. The attached Appendix 2.A for the 2011 City of Sioux Falls – Regional Wastewater Feasibility Study further defines the methodology for a fair and equitable solution.

ES 5 Capital Improvements Phasing Documentation

ES 5.1 Project Background

The City is working to develop a preliminary WRF Capital Improvements Plan to begin implementing the WRF Master Plan recommendations.

The Master Plan was developed based on planning criteria established through workshops and regular progress meetings. The WRF portion of the Master Plan developed a project-phasing plan to address a 20-year planning period with anticipated regulatory trigger points. The City requested evaluation of alternative phasing considerations to better match capital spending with anticipated revenue.

ES 5.2 Summary

Figures ES.12 illustrates the preliminary site plan presenting major Phase 1 and 2 improvements.

This memorandum includes phasing analyses and discussion of the Phase 1a, Phase 1 and Phase 2 improvements and the project implementation schedules along with the associated cash flow requirements.

Phase 1a was developed as there are items which need to be completed by 2021 as follows:

- Phase 1a Step Feed Improvement at Aeration Basins
- Phase 1a Grit Influent Piping
- Phase 1a Primary Clarifier Influent Diversion (Hydraulics)
- Phase 1a Final Clarifier Rehabilitation
- Phase 1a Filter Building High Priority Items
- Phase 1a Biosolids Dewatering/Handling Improvements
- Phase 1a Dewatering Building Rehabilitation Items

Phase 1 includes improvements required by 2025 to address the following improvements categorized in the Master Plan:

- Return On Investment (ROI) and Operational
- Regulatory
- Capacity/Growth
- Age, Condition to Address Reliability

Phase 2 includes the improvements categorized as:

- Regulatory, to Provide Process Improvements for EPA Nutrient Limits
- Filter Expansion
- Identified ROI Items
  - Microturbines
  - FOG Receiving

The following sections present the development of this planning information.

Figure ES.12 WRF Master Plan Recommended Improvements

CITY OF SIOUX FALLS
PUBLIC WORKS
Providing a Better Quality of Life for You!

Master Plan Recommended Improvements

2017 — 2025 — 2036

RECOMMENDED PHASE 1

- 1A Treatment Renovations
- 1B Biosolids handling facility renovations
- 1C Lagoons repurposed for equalization
- 1D Rehab preliminary/ primary treatment
- 1E New liquid treatment
- 1F New disinfection

RECOMMENDED PHASE 2

- 2A New primary treatment
- 2B New nutrient removal improvements
- 2C New filtration

ES 5.3 WRF Phasing and Implementation Opportunities

Specific improvement items addressed for phasing and implementation include (Refer to Figure ES.12 for items referenced):

- 1A - Treatment renovations to existing activated sludge.
- 1B - Biosolids handling facility renovations.
- 1D - Rehabilitate preliminary (headworks) and primary treatment.
- 1E - New liquid treatment - activated sludge.
- 2A - New primary treatment – headworks and primary clarifiers.
- 2C - New Filtration
- Energy recovery and FOG

Each of these is discussed in the following paragraphs.

ES 5.4 Primary (Headworks) and Preliminary (Primary Clarifiers) Treatment Phasing and Implementation Options

Four options were reviewed to assist in determining the decision to build new or rehabilitate existing facilities as follows:

- Option 1 - Ph. 1 - Rehabilitate Existing Headworks and Primary Clarifiers (PCs) & Ph. 2 New Headworks and PCs
- Option 2 - Ph. 1 - New Headworks and Primary Clarifiers (PCs)
- Option 3 - Ph. 1 - New Headworks and Rehabilitate Existing PCs & Ph. 2 New PCs
- Option 4 - Ph. 1 - New Headworks, New 22 MGD PCs & Rehabilitate Existing PCs & Ph. 2 New 13 MGD PCs & Aeration Basins

Costs for each option are presented in Table ES.22.

ES 5.4.1 Option 1 – Rehab. Existing Headworks and PCs

Option 1 includes rehabilitating the existing headworks and PCs in Phase 1 with new headworks and PCs in Phase 2. Given the current hydraulic profile only primary clarifier influent flow can be diverted directly to the activated sludge aeration basins. Figure 2 presents the proposed flow schematic for Option 1.

It is important to note that there is a cost of rehabilitation of $8.42 million to defer the new facilities to Phase 2. This cost is for equipment and hydraulic upgrades required for the existing headworks and primary clarifiers as summarized below.

Summary of Costs for Preliminary and Primary Treatment

Phase 1a and Phase 1 improvements total $8.42 million as itemized below.

Phase 1a Grit Building (Headworks) Rehab. Influent Pipe Cost $1,670,000
Phase 1 - Grit Building (Headworks) High and Medium Priority Items.................. $1,250,000
Phase 1 - WRF Existing Screenings Rehabilitation Cost $2,100,000
Phase 1 - WRF Existing Primary Clarifiers Rehabilitation Cost $3,400,000

*Subtotal Headworks (Screenings and Grit) **$8,420,000***

Recommended improvements headworks and primary clarifier improvements which are deferred to Phase 2 are itemized as follows.

Deferred to Phase 2 - WRF New Screenings Improvements Cost $6,300,000
Deferred to Phase 2 - WRF New Grit Improvements Cost $8,300,000
Deferred to Phase 2 - New Primary Clarifiers with Domes Improvements Cost….$18,800,000

Subtotal New Headworks (Screenings and Grit) & New Primary Clarifiers*..........*$33,400,000

ES 5.4.2 Option 2 - New Headworks and PCs

Option 2 includes constructing new headworks and primary clarifier facilities at a higher elevation. This allows headworks and primary clarifier effluent to flow by gravity to the aeration basins.

This option has the highest up-front cost of $33.4 million but lowest overall Phase 1 and 2 cost. Primary clarifier effluent is fed directly to the aeration basins which is required for Phase 2.

ES 5.4.3 Option 3 - New Headworks and Rehab. Existing PCs

Option 3 includes new headworks and rehabilitating existing PCs in Phase 1 and deferring new PCs until Phase 2.

This option includes an $18.0 million investment in Phase 1 and $18.8 in Phase 2. The additional cost is for equipment upgrades to the existing primary clarifiers.

ES 5.4.4 Option 4 - New Headworks, New 22 MGD PCs & Rehab. Ex. PCs & Ph. 2 New 13 MGD PCs & Aeration Basins

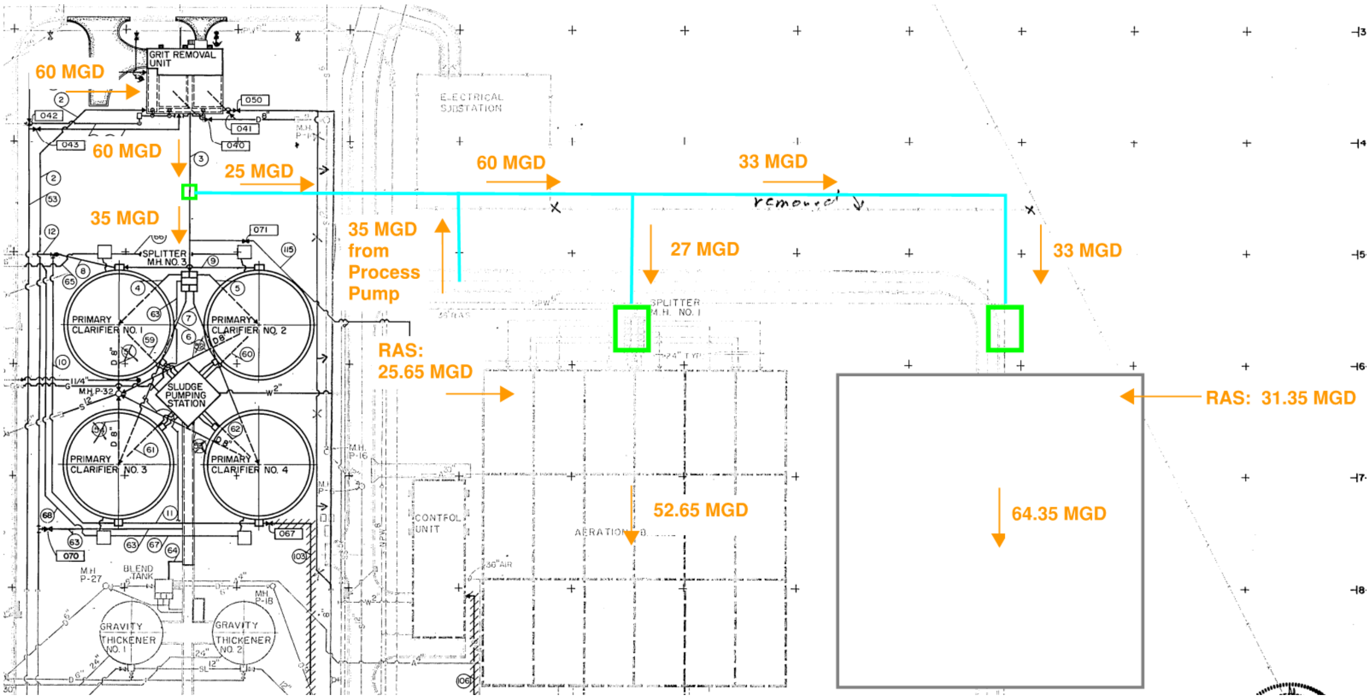
Option 4 includes new headworks, new 22 MGD PCs and rehabilitation of the existing PCs. In Phase 2, new 13 MGD PCs would be required to have a total capacity of 35 mgd.

This option includes a $27.9 million investment in Phase 1 and $9.6 million in Phase 2. Similarly, the additional cost is for equipment upgrades to the existing primary clarifiers.

Table ES.22 Primary and Preliminary Treatment Phasing Option Costs

	Phase 1	Phase 2	Phase 1 & 2
Option 1 - Ph. 1 - Rehab. Existing Headworks and Primary Clarifiers (PCs) with Ph. 2 - New Headworks and PCs **(Selected)**	$8,420,000	$33,400,000	$41,820,000
Option 2 - Ph. 1 - New Headworks and PCs	$33,400,000	$0	$33,400,000
Option 3 - Ph. 1 - New Headworks and Rehab. Existing PCs & Ph. 2 New PCs	$18,000,000	$18,800,000	$36,800,000
Option 4 - Ph. 1 - New Headworks, New 22 MGD PCs & Rehab. Ex. PCs & Ph. 2 New 13 MGD PCs	$27,900,000	$9,600,000	$37,500,000

Figure ES.13 Hydraulic Capacity with Diversion before Primary Clarifiers



ES 5.5 Preliminary and Primary Treatment Improvements Discussion and Recommendations

The recommended alternative in the Master Plan is Option 2. Option 2 includes constructing new headworks and primary clarifier facilities at a higher hydraulic profile elevation. The benefits of this recommended option include:

- Headworks and primary clarifier effluent flow by gravity to the aeration basins.
- Has the lowest total Phase 1 and Phase 2 cost.
- No need to upgrade the existing screening capacity (Capacity will be Exceeded in 2021 and Condition Related).
- No need to refurbish PCs (Original Equipment –Age and Condition Related).

ES 5.6 WRF Phasing Considering Anticipated Reserve

The City requested evaluation of alternative phasing considerations to better match capital spending with anticipated revenue. As a result, the selected alternative to reduce Phase 1 capital spending is Option 1. Option 1 includes rehabilitating the existing headworks and PCs. New headworks and PCs will be planned in Phase 2. Given the current hydraulic profile, only primary clarifier influent flow can be diverted directly to the activated sludge aeration basins.

ES 5.7 Preliminary and Primary Treatment - Impacts on Hydraulic Profile

If Option 1 is constructed in Phase 1, consideration of the Phase 2 headworks water surface profile needs to be taken into account. For planning and design of related pump stations, both Phase 1 (existing) and Phase 2 (Option 2) water surface elevations are presented. The location of the headworks should also be considered to optimize the ability for EQ screening and grit removal.

Table ES.23 Headworks Water Surface Elevation Summary

	Water Surface Elevation	Remarks
Phase 1 Existing Screening Channel	1363	
Phase 1 Parallel Force Main Influent Box/EQ Diversion Box	1365	60 mgd flow into WRF
Phase 2 Headworks Influent (Grit does divert to EQ)	1378	
Phase 2 Headworks Influent (Grit effluent does not divert to EQ)	1368	
Existing Lagoons	1362	Estimated elevation

Notes:

1. These elevations are provided for planning purposes only. They have been estimated to the nearest foot.
2. All elevations are NAVD 88 datum.

ES 5.8 Activated Sludge Phasing and Implementation Options

To provide options for the City to better match capital spending with anticipated revenue, options for phasing activated sludge capacity were reviewed and are presented in Table ES.24.

Table ES.24 Phased Cost and Activated Sludge Capacity

Increase in Average, MGD	Increase in Equalized Peak, MGD	Cost	Comments
9.1 mgd (30.1 mgd)	22 mgd (57 mgd)	$56 M	20 year Design Capacity
6 mgd (27 mgd)	14.5 mgd (50 mgd)	$38 M	**Selected** 10-15 Year Design Capacity
3 mgd (24 mgd)	7 mgd (42 mgd)	$20 M	5-10 Year Design Capacity

The 10-15 year design increase in average day capacity of 6 mgd revises the cost from $56 to $38 million. This is a reduced initial cost of $18 million for this selected phasing option.

Note that additional activated sludge capacity will be required in 10-15 years, depending on growth.

ES 5.9 Effluent Filtration Phasing and Implementation Options

Effluent filtration expansion to handle the projected 20-year peak flow was recommended as part of the Master Plan. The recommended Phasing option to minimize capital impact of Phase 1 improvements is to defer the filtration improvements to Phase 2. In this scenario, maximum month flows would continue to be filtered and flows exceeding the filtration capacity will be blended downstream.

Given the expected permit limits, the limits will be met under average, maximum month and peak flows through the plant with the existing filtration facilities.

Note however, the effluent filtration facilities will need to be expanded in Phase 2 to meet expected effluent nutrient limitations. Phase 2 filtration effluent filter media type needs to be evaluated to provide media which best accommodates solids capture for phosphorous removal. Current media has a very large pore size, allowing greater solids flow through.

The reduction in Phase 1 cost is a project cost of $7.1 million.

ES 5.10 Biosolids Handling Facility Phasing and Implementation Options

Biosolids handling facility improvements were reviewed and eliminated as a phasing option as new facilities are needed to be online by 2021 to meet solids handing capacity needs. Review sidestream impacts and construct lime feed as required based on final project phasing.

ES 5.11 Energy Recovery and FOG Phasing and Implementation Options

Energy recovery and FOG were being implemented as the FOG Study indicated a positive return on investment (ROI). To provide a means for the City to better match capital spending with anticipated revenue these will be deferred to a later date until funding is available.

ES 5.12 Pump Station 240, Equalization and Dual Forcemain

The PS 240, equalization and dual forcemain were reviewed in detail from a capacity and scheduling logistics standpoint as follows:

- The PS 240 equalization facility is needed by 2021 and preliminary design should be completed in 2018. Refer to Figure ES.15.
- The PS 240 dual forcemain preliminary design needs to be completed concurrently due the time required to finalize the alignment and acquire right-of-way. Refer to Figure ES.15.

ES 5.13 Summary of Facilities

The selected facilities implementation is as follows:

ES 5.13.1 Phase 1a – Constructed By 2021

- Step Feed Improvement at Aeration Basins
- Grit Influent Piping (Headworks)
- Primary Clarifier Influent Diversion (Hydraulics)
- Final Clarifier Rehabilitation
- Filter Building High Priority Items
- Biosolids Dewatering/Handling Improvements
- Dewatering Building Rehabilitation Items

ES 5.13.2 Phase 1 – Constructed by 2025

- Convert Biosolids Lagoons to Equalization Basins
  - (Completed as soon as Biosolids Lagoon is available for construction.)
- Rehabilitate Existing Preliminary Treatment (Headworks) – Per Phasing Discussion
- Rehabilitate Existing Primary Treatment (Primary Clarifiers) – Per Phasing Discussion
- Activated Sludge - @ 10-15 year design Capacity – Per Phasing Discussion
  - Aeration Basin Upgrades (1)
  - Aeration Basin Splitter Box
  - Aeration Basins
  - Aeration Basin Blowers
  - Replace RAS and WAS Pumps
  - New Final Clarifiers
- Chlorine Contact Expansion (1) (2)
- Effluent Flow Meter Improvements
- New Generator
- Site Piping
- Solids Processing
- New Thickening
- Medium and High Priority Items (Items identified as reliability risks due to age and condition)
- Phase 1 PS 240 EQ – Constructed by 2021
- The PS 240 dual forcemain preliminary design needs to be completed concurrently due the time required to finalize the right-of-way. Refer to Figure ES.15. To be constructed by 2022.

ES 5.13.3 Phase 2 – Constructed by 2029 as Determined by Regulation Implementation

- Process Improvements to Address Nutrients in Future Permit
- Activated Sludge Expansion – 30% Shifted to Phase 2 per phasing discussion
- Filter Expansion – Shifted to Phase 2 per phasing discussion
- Microturbines – Shifted to Phase 2 per phasing discussion
- FOG Receiving – Shifted to Phase 2 per phasing discussion

Table ES.25 Summary of Recommended Implementation Costs

Improvements Phase	Proposed Capital Improvements	Recommended Project Cost	Adjusted Phased Cost
Phase 1a Improvements	Step Feed Improvement at Aeration Basins	$3,670,000	$3,670,000
	Grit Influent Piping	$1,670,000	$1,670,000
	Primary Clarifier Influent Diversion	$1,900,000	$1,900,000
	Final Clarifier Rehab	$6,500,000	$6,500,000
	Filter Building High Priority Items	$1,000,000	$1,000,000
	Biosolids Dewatering/Handling Improvements	$18,100,000	$18,100,000
	Dewatering Building Rehab Items	$1,200,000	$1,200,000
	Phase 1a Subtotal	$34,040,000	$34,040,000
Phase 1 - WRF Improvements	Headworks	$14,600,000	$3,350,000
	Primary Clarifiers	$18,800,000	$3,410,000
	Aeration Basin Upgrades (1)	$4,000,000	$4,000,000
	Aeration Basin Splitter Box	$2,300,000	$2,300,000
	Aeration Basins	$38,600,000	$26,000,000
	Aeration Basin Blowers	$7,600,000	$7,600,000
	Replace RAS and WAS Pumps	$420,000	$420,000
	Final Clarifiers	$17,100,000	$12,000,000
	Effluent Filters	$7,100,000	Shifted to Ph. 2
	Chlorine Contact Expansion (1) (2)	$3,200,000	$3,200,000
	Effluent Flow Meter Improvements	$420,000	$420,000
	Convert Biosolids Lagoons to Equalization Basins	$6,900,000	$6,900,000
	New Generator	$2,200,000	$2,200,000
	Site Piping	$2,700,000	$2,700,000
	WRF Phase 1 -New Thickening	$3,330,000	$3,330,000
	WRF – Microturbines	$4,150,000	Shifted to Ph. 2
	WRF - FOG Receiving	$2,920,000	Shifted to Ph. 2
	Phase 1 High Priority Items	***$15,094,600***	***$15,094,600***
	Phase 1 Medium Priority Items	***$10,400,000***	***$10,400,000***
	Total Phase 1 Improvements Subtotal	**$161,900,000**	**$104,960,000**
Phase 1 and 1a- WRF Improvements	Total Phase 1a & Phase 1 Improvements Subtotal	$195,900,000	$137,400,000
Phase 2 - WRF Improvements	WRF - Phase 2 - Liquid Nutrient Improvements	$105,600,000	$105,600,000
	New Headworks (Shifted from Phase 1)		$14,600,000
	New Primary Clarifiers (Shifted from Phase 1)		$18,800,000
	New Aeration Basins (Shifted from Phase 1)		$12,600,000
	WRF - Filter Expansion (Shifted from Phase 1)		$7,100,000
	WRF – Microturbines (Shifted from Phase 1)		$4,150,000
	WRF - FOG Receiving (Shifted from Phase 1)		$2,920,000
	Phase 2 - WRF Improvements Subtotal	**$105,600,000**	**$165,800,000**

Table ES.25 Summary of Recommended Implementation Costs

Improvements Phase	Proposed Capital Improvements	Recommended Project Cost	Adjusted Phased Cost
Phase 1 – Collection Projects	Lift Stations High/Medium Condition Items	$3,310,000	$3,310,000
	Southeastern Drive	$1,400,000	$1,400,000
	Richmond Estates Trunk	$1,200,000	$1,200,000
	Pump Station 240 Forcemain	$36,000,000	$36,000,000
	Pump Station 240 Pump Upgrades	$2,800,000	$2,800,000
	Pump Station 240 Equalization	$2,900,000	$2,900,000
	Diamond Valley PS Upgrades	$250,000	$250,000
	Phase 1 – Collection Projects Subtotal	**$47,860,000**	**$47,860,000**

ES 5.14 Summary of Recommended Implementation Schedule

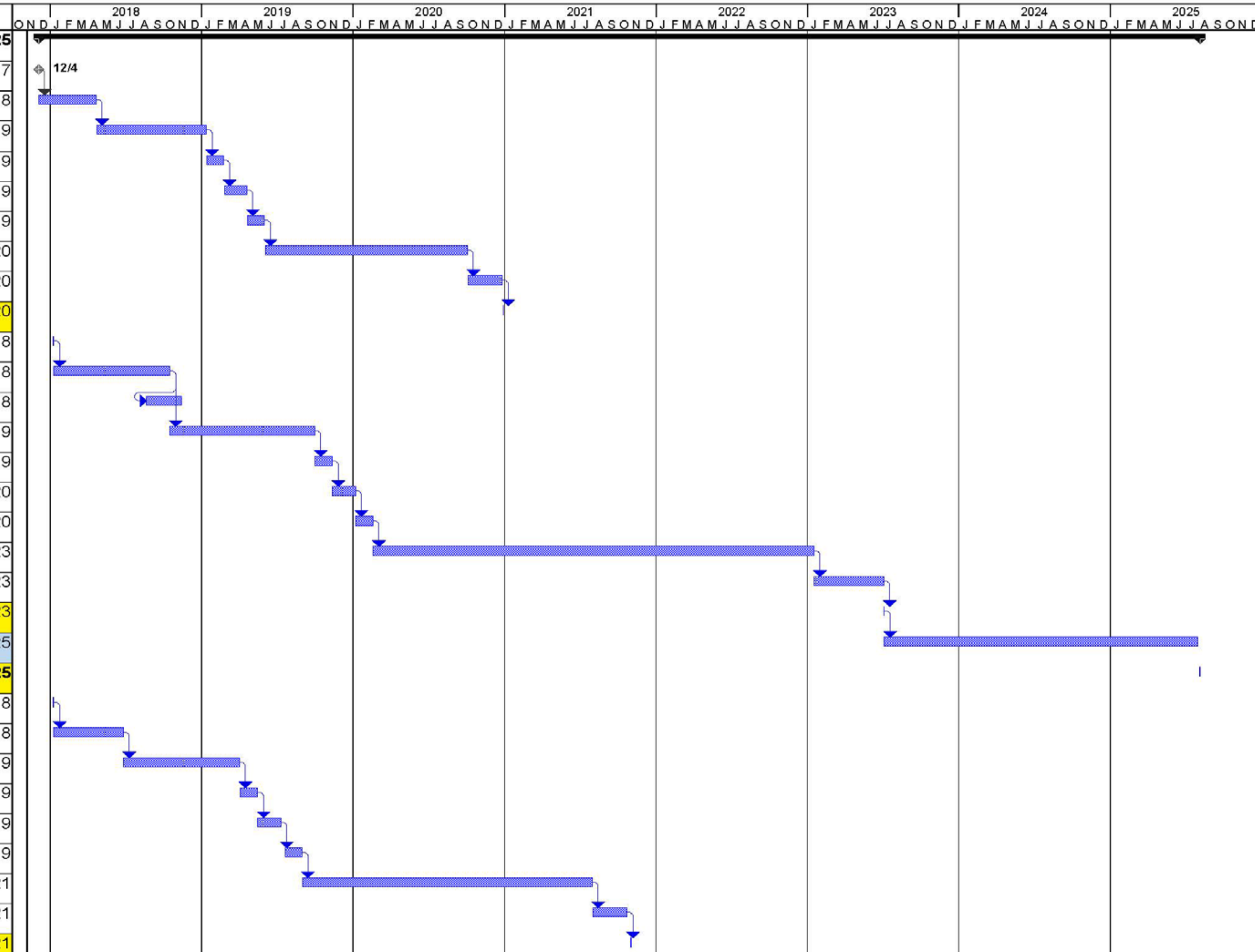
In accordance with the Master Plan, the vision is for the Phase 1a and Biosolids Handling coming online by the year 2021 and the Phase 1 projects reaching substantial completion in 2025. Refer to Figure ES.14.

The schedule shows preliminary design beginning in 2018 for all Phase 1 projects. As shown on the schedule, the design periods can be staggered to allow City staff ample opportunity for input and coordination. It is estimated that the WRF construction will take about three years, with the PS 240 equalization and forcemain constructed concurrently.

Figure ES.14 WRF Schedule

Sioux Falls WRF Master Plan Projections
Project Schedule

ID	Task Name	Start	Finish
1	**Water Reclamation Facility - Master Plan**	**Mon 12/4/17**	**Mon 8/4/25**
2	Notice to Proceed	Mon 12/4/17	Mon 12/4/17
3	Preliminary Design Phase 1A Improvements	Mon 12/4/17	Fri 4/20/18
4	Final Design	Mon 4/23/18	Fri 1/11/19
5	Bid Document Preparation/Review	Mon 1/14/19	Fri 2/22/19
6	Advertise	Mon 2/25/19	Fri 4/19/19
7	Contract Award	Mon 4/22/19	Fri 5/31/19
8	Construction Phase 1A Improvements	Mon 6/3/19	Fri 10/2/20
9	Startup and Training	Mon 10/5/20	Fri 12/25/20
10	**Phase 1A Improvements Project Completion**	Mon 12/28/20	Mon 12/28/20
11	Notice to Proceed For Remainder of Phase 1	Mon 1/8/18	Mon 1/8/18
12	Preliminary Design Remainder of Phase 1	Tue 1/9/18	Mon 10/15/18
13	Geotechnical	Tue 8/21/18	Mon 11/12/18
14	Final Design	Tue 10/16/18	Mon 9/30/19
15	Bid Document Preparation/Review	Tue 10/1/19	Mon 11/11/19
16	Advertise	Tue 11/12/19	Mon 1/6/20
17	Contract Award	Tue 1/7/20	Mon 2/17/20
18	Construct Phase 1 Improvements	Tue 2/18/20	Mon 1/16/23
19	Startup and Training	Tue 1/17/23	Mon 7/3/23
20	**Phase 1 Improvements Project Complete**	Tue 7/4/23	Tue 7/4/23
21	Project Phase 1 Float	Wed 7/5/23	Tue 7/29/25
22	**Phase I Improvements Needed**	**Mon 8/4/25**	**Mon 8/4/25**
23	Biosolids Phase 1 Notice to Proceed	Mon 1/8/18	Mon 1/8/18
24	Preliminary Design Biosolids Phase 1	Tue 1/9/18	Mon 6/25/18
25	Final Design	Tue 6/26/18	Mon 4/1/19
26	Bid Document Preparation/Review	Wed 4/3/19	Wed 5/15/19
27	Advertise	Thu 5/16/19	Wed 7/10/19
28	Contract Award	Mon 7/22/19	Fri 8/30/19
29	Construct Biosolids Phase 1	Mon 9/2/19	Fri 7/30/21
30	Startup and Training	Mon 8/2/21	Fri 10/22/21
31	**Biosolids Phase 1 Project Complete**	Mon 11/1/21	Mon 11/1/21



Project: WRF master plan scheduled w
Date: Mon 11/6/17

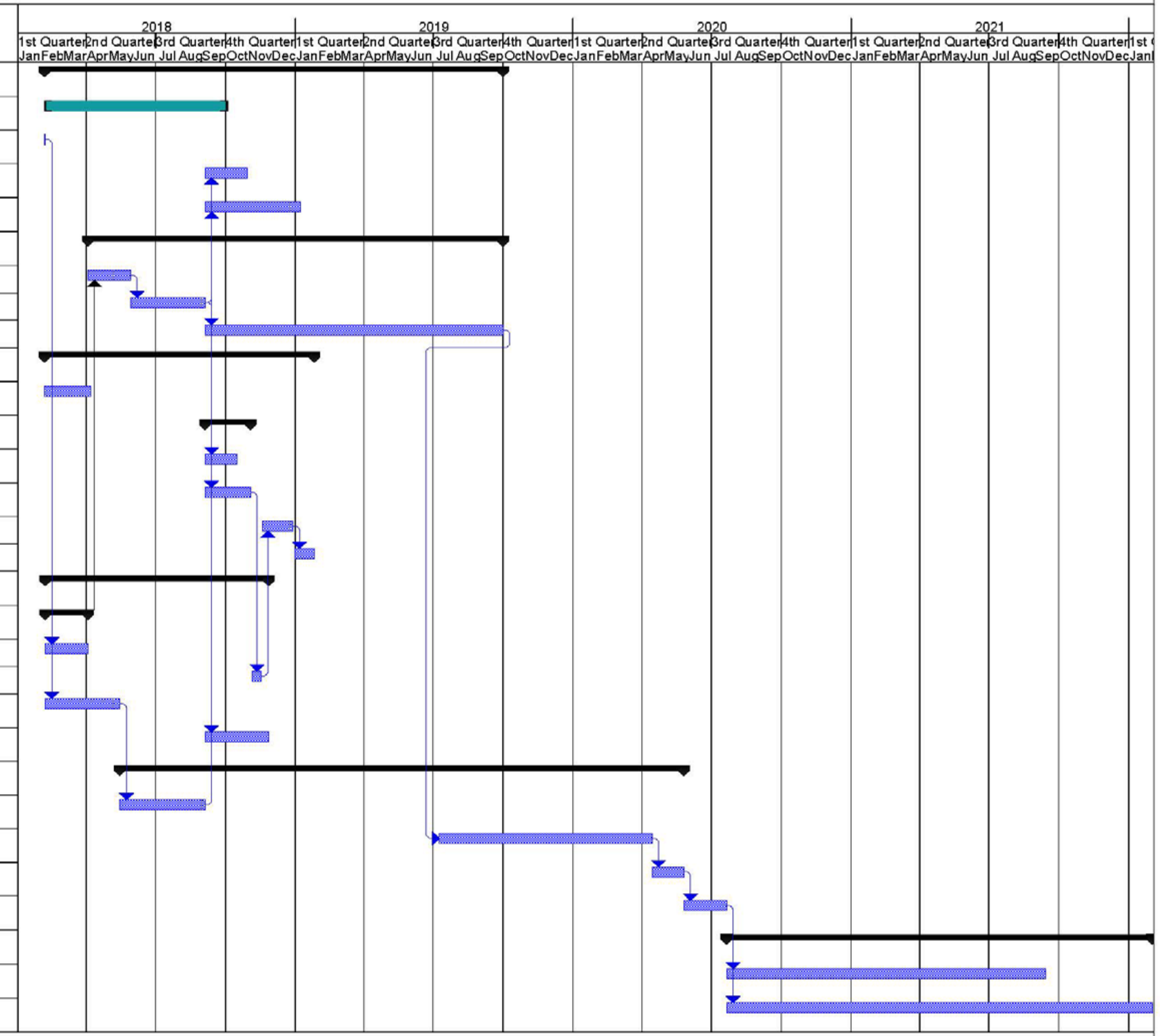
Task	Project Summary	Inactive Task	Duration-only	Finish-only
Split	External Tasks	Inactive Milestone	Manual Summary Rollup	Progress
Milestone	External Milestone	Inactive Summary	Manual Summary	Deadline
Summary	Inactive Task	Manual Task	Start-only	

Mon 11/6/17 10:31 AM Page 1

Figure ES.15 PS 240 Schedule

City of Sioux Falls, PS240 FM
Project Schedule

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Task 100 - Project Management**	431 days	Mon 2/5/18	Mon 9/30/19		
2	Task 110 - Management Plan/Initiation Meeting	173 days	Mon 2/5/18	Wed 10/3/18		
3	Notice to Proceed	1 day	Mon 2/5/18	Mon 2/5/18		
4	**Task 120 - Geotechical**	40 days	Tue 9/4/18	Mon 10/29/18	8	
5	**Task 130 - Permitting**	90 days	Tue 9/4/18	Mon 1/7/19	24	
6	**Land Acquisition**	390 days	Tue 4/3/18	Mon 9/30/19		
7	Easement Exhibit Preparation	40 days	Tue 4/3/18	Mon 5/28/18	18	
8	Access Agreements	70 days	Tue 5/29/18	Mon 9/3/18	7	
9	Easement Acquisition	280 days	Tue 9/4/18	Mon 9/30/19	8	
10	**TASK SERIES 200 – SRF Facility Planning**	255 days	Mon 2/5/18	Fri 1/25/19		
11	Task 210 – Alternatives Selection	45 days	Mon 2/5/18	Fri 4/6/18		
12	**Task 220 - Environmental Review**	44 days	Tue 9/4/18	Fri 11/2/18		
13	Task 221 - Wetlands Survey	30 days	Tue 9/4/18	Mon 10/15/18	8	
14	Task 222 - Archeology Survey	44 days	Tue 9/4/18	Fri 11/2/18	8	
15	Task 230 - Alternative Evaluation	30 days	Mon 11/19/18	Fri 12/28/18	20	
16	Task 240 - Facility Plan Submittal	20 days	Mon 12/31/18	Fri 1/25/19	15	
17	**TASK SERIES 300 – Predesign**	210 days	Tue 2/6/18	Mon 11/26/18		
18	**Task 310 – Alignment Selection**	40 days	Tue 2/6/18	Mon 4/2/18		
19	Task 311 - Alignment alternatives	40 days	Tue 2/6/18	Mon 4/2/18	3	
20	Task 315 - Alignment Recommendation	10 days	Mon 11/5/18	Fri 11/16/18	14	
21	Task 320 - Pump Station Predesign	70 days	Tue 2/6/18	Mon 5/14/18	3	
22	Task 340 - Final Survey	60 days	Tue 9/4/18	Mon 11/26/18	8	
23	**TASK SERIES 400 – DESIGN**	530 days	Tue 5/15/18	Mon 5/25/20		
24	Task 410 - 50% Design Drawings	80 days	Tue 5/15/18	Mon 9/3/18	21	
25	Task 420 - Final Design Drawings	200 days	Tue 7/9/19	Mon 4/13/20	9FS-60 days	
26	Task 430 - Final Document Submittal	30 days	Tue 4/14/20	Mon 5/25/20	25	
27	**Task 500 - Bidding Administration**	40 days	Tue 5/26/20	Mon 7/20/20	26	
28	**Task 600 Construction Phase**	400 days	Tue 7/21/20	Mon 1/31/22		
29	**Pump Station Construction**	300 days	Tue 7/21/20	Mon 9/13/21	27	
30	**Force Main Construction**	400 days	Tue 7/21/20	Mon 1/31/22	27	



Project: PS240 FM Project Schedule
Date: Wed 9/6/17

Task		Project Summary		Inactive Task		Duration-only		Finish-only	
Split		External Tasks		Inactive Milestone		Manual Summary Rollup		Progress	
Milestone		External Milestone		Inactive Summary		Manual Summary		Deadline	
Summary		Inactive Task		Manual Task		Start-only			

Wed 9/6/17 Page 1

Phasing TM APPENDIX

Cash-Flow Draw Summary

City of Sioux Falls
Capital Improvements Plan for Selected Projects
Annual Allocations Summary
Revised Date: 2/16/2018

Note: Engineering and adminstration fees set to 24% to match Master Plan Percentages -final fees to be adjusted based on timing and scope of final projects.

										Annual Breakdown								
		Design Time Period			Construction Time Period			Engineering Fees		Design and Construction		Construction Engineering						
Project	Const. Cost	Design Begin	Design End	Months	Const. Begin	Constr. End	Months	Design Fees	Const, Fees	2018	2019	2020	2021	2022	2023	2024	2025	Totals
WRF Phase 1a Liquid	$11,890,000	12/4/2017	4/22/2019	16.5	2/18/2020	7/3/2023	40.4	$1,430,000	$950,000	$1,040,000	$390,000	$220,000	$280,000	$280,000	$160,000			$2,370,000
WRF Phase 1a Biosolids	$15,570,000	1/9/2018	7/22/2019	18.3	9/2/2019	11/1/2021	25.9	$1,870,000	$1,250,000	$1,220,000	*$790,000*	$580,000	$530,000					$3,120,000
WRF Phase 1	$122,000,000	1/9/2018	1/7/2020	23.9	2/18/2020	8/4/2025	65.4	$14,640,000	$9,760,000	$7,360,000	$7,360,000	$1,490,000	$1,790,000	$1,790,000	$1,790,000	$1,790,000	$1,050,000	$24,420,000
Col. Pump Station Renovations	$2,670,000	1/9/2018	1/7/2020	23.9	2/18/2020	12/30/2022	34.3	$330,000	$210,000	$170,000	$150,000	$60,000	$70,000	$70,000				$520,000
Col. PS 240 EQ	$2,340,000	2/5/2018	4/16/2019	14.3	5/28/2019	11/9/2020	17.4	$290,000	$190,000	$220,000	*$130,000*	$130,000						$480,000
Col. PS 240 Forcemain and PS	$31,300,000	1/9/2018	1/7/2020	23.9	2/18/2020	12/30/2022	34.3	$3,760,000	$2,500,000	$1,890,000	$1,890,000	$730,000	$870,000	$870,000				$6,250,000
Col. Basin 15 Sewer	$15,500,000	1/9/2018	1/7/2020	23.9	2/18/2020	12/30/2022	34.3	$1,860,000	$1,240,000	$940,000	$940,000	$360,000	$430,000	$430,000				$3,100,000
Totals	$201,270,000							$24,180,000	$16,100,000	$12,840,000	$11,650,000	$3,570,000	$3,970,000	$3,440,000	$1,950,000	$1,790,000	$1,050,000	**$40,260,000**
City Legal, Admin., and Permitting	4.0%									$1,010,000	$1,010,000	$1,010,000	$1,010,000	$1,010,000	$1,010,000	$1,010,000	$1,010,000	**$8,080,000**
Design Fee	12.0%	Includes survey and geotechnical																
Construction Fee	8.0%	Includes survey, CA and Construction Inspection																
	24%	Per Master Plan Percentage																

										Annual Breakdown								
		Design Time Period			Construction Time Period			Engineering Fees		Construction Costs								
Project	Const. Cost	Design Begin	Design End	Months	Const. Begin	Constr. End	Months	Design Fees	Const, Fees	2018	2019	2020	2021	2022	2023	2024	2025	Totals
WRF Phase 1a Liquid	$11,890,000	12/4/2017	4/22/2019	16.5	2/18/2020	7/3/2023	40.4	$1,430,000	$950,000			$2,760,000	$6,480,000	$2,320,000	$320,000			$11,890,000
WRF Phase 1a Biosolids	$15,570,000	1/9/2018	7/22/2019	18.3	9/2/2019	11/1/2021	25.9	$1,870,000	$1,250,000		*$1,460,000*	$11,430,000	$2,690,000					$15,570,000
WRF Phase 1	$122,000,000	1/9/2018	1/7/2020	23.9	2/18/2020	8/4/2025	65.4	$14,640,000	$9,760,000			$12,680,000	$34,010,000	$42,500,000	$20,420,000	$11,120,000	$1,260,000	$122,000,000
Col. Pump Station Renovations	$2,670,000	1/9/2018	1/7/2020	23.9	2/18/2020	12/30/2022	34.3	$330,000	$210,000			$860,000	$1,470,000	$350,000				$2,670,000
Col. PS 240 EQ	$2,340,000	2/5/2018	4/16/2019	14.3	5/28/2019	11/9/2020	17.4	$290,000	$190,000		*$390,000*	$1,940,000						$2,340,000
Col. PS 240 Forcemain and PS	$31,300,000	1/9/2018	1/7/2020	23.9	2/18/2020	12/30/2022	34.3	$3,760,000	$2,500,000			$10,020,000	$17,210,000	$4,102,767				$31,300,000
Col. Basin 15 Sewer	$15,500,000	1/9/2018	1/7/2020	23.9	2/18/2020	12/30/2022	34.3	$1,860,000	$1,240,000		*$0*	$4,960,000	$8,520,000	$2,031,722				$15,500,000
Totals	$201,270,000							$24,180,000	$16,100,000	$0	$1,850,000	$44,650,000	$70,380,000	$51,304,489	$20,740,000	$11,120,000	$1,260,000	**$201,270,000**
					Annual Totals with Design and Construction and Fees					$13,850,000	$14,510,000	$49,230,000	$75,360,000	$55,754,489	$23,700,000	$13,920,000	$3,320,000	**$249,610,000**

Chapter 1 – Introduction

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD

February 2018

Table of Contents

Tables

Figures

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Chapter 1 Introduction

1.1 Project Background

1.1.1 WRF Facilities

The City of Sioux Falls WRF is located on the northeast side of Sioux Falls on Sycamore Avenue, south of the intersection of Sycamore Avenue and 60th Street. The WRF facility receives pumped flows from Pump Station 240 (including flow from Harrisburg), Brandon Road (Main) Pump Station (BRPS), the City of Brandon, the Humane Society, and flow from an adjacent industrial park. The WRF discharges treated water to the Big Sioux River.

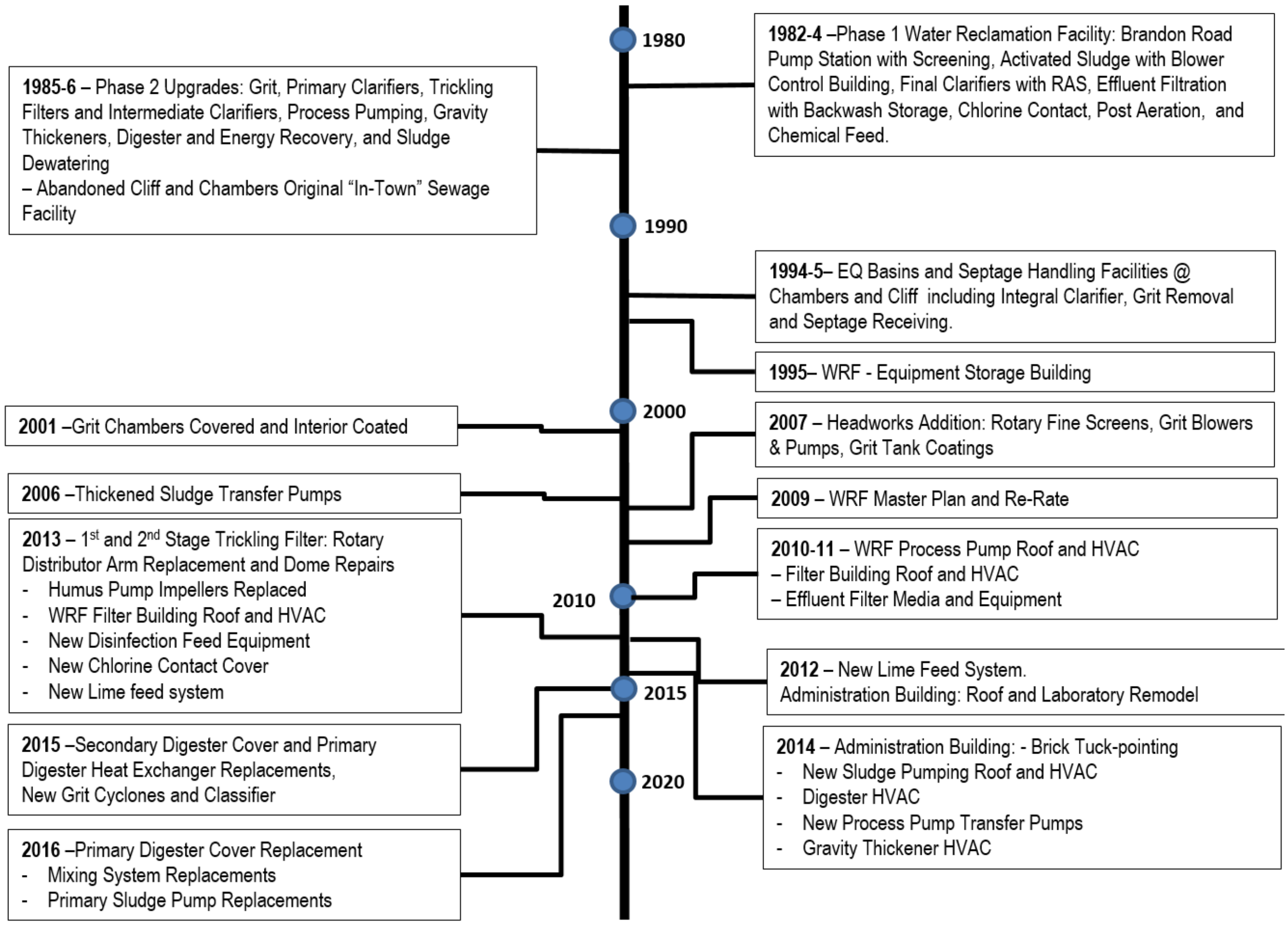
The original facility was constructed in phases beginning in 1980. The final phase was constructed in 1986. Several improvements have been made to the facility since the final phase was completed. The original facility was designed to accommodate an average day flow of 13.4 MGD and a peak instantaneous flow of 27 MGD. As part of the 2009 WRF master plan the re-rated capacity of the facility was increased to 21 MGD average day flow and 35 MGD peak equalized flow. Refer to Table 1.1 for associated rated loading capacities.

Table 1.1 Re-Rated Sioux Falls WRF Capacity - 2009

Parameter	Value
Average Daily Flow	21.0 mgd
Peak Hourly Flow (Equalized)	35.0 mgd
TBOD	51,240 lb/d
TSS	43,900 lb/d
TKN	9,440 lb/d

The history of the major WRF improvements is summarized in Figure 1.1.

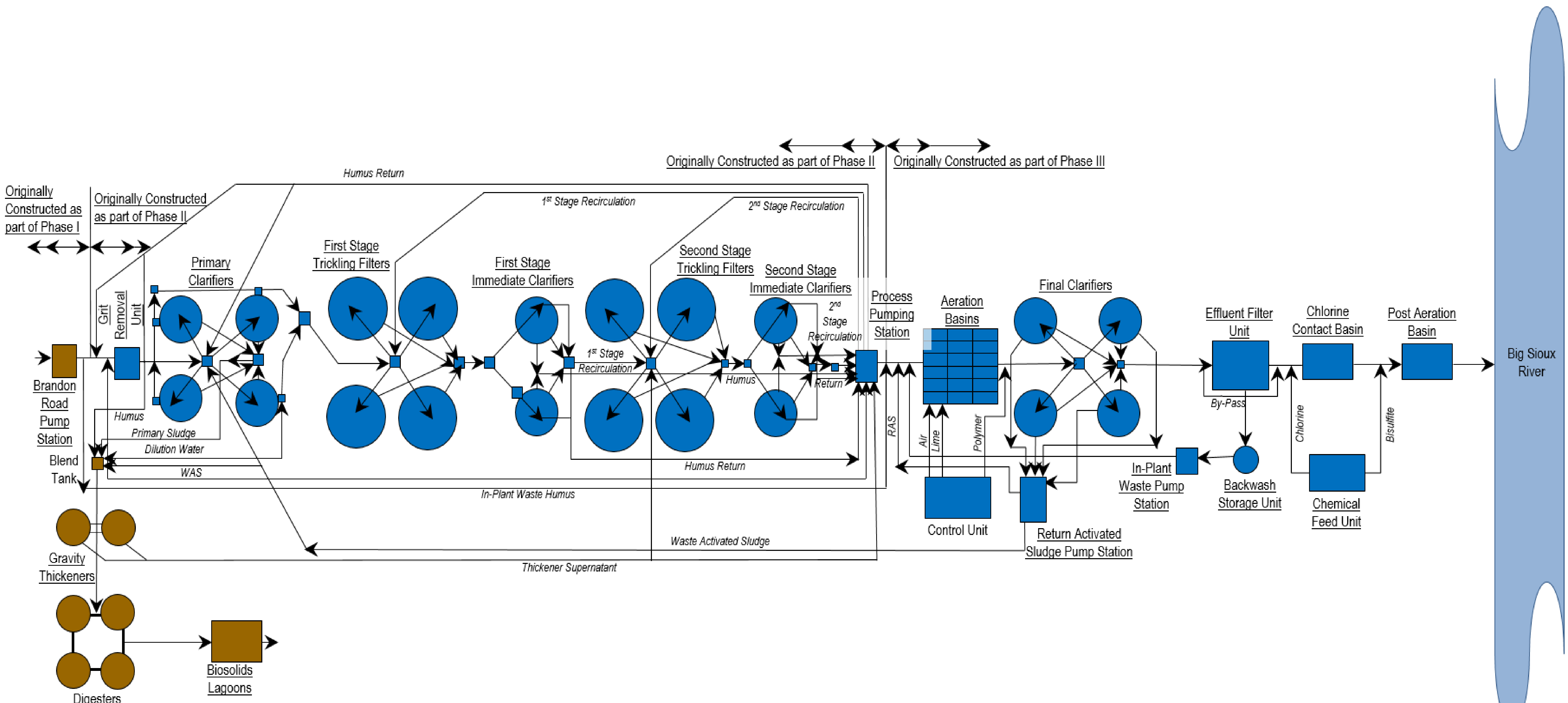
Figure 1.1 Water Reclamation Facility History of Major Improvements



The site layout in Figure 1.2 illustrates the general location of each component at the Water Reclamation Facility and the numbering system use to identify each component. The process flow diagram is illustrated in Figure 1.3, which presents a flow schematic for a visual of how the flows proceed through the WRF.

Figure 1.2 Water Reclamation Facility Process Components

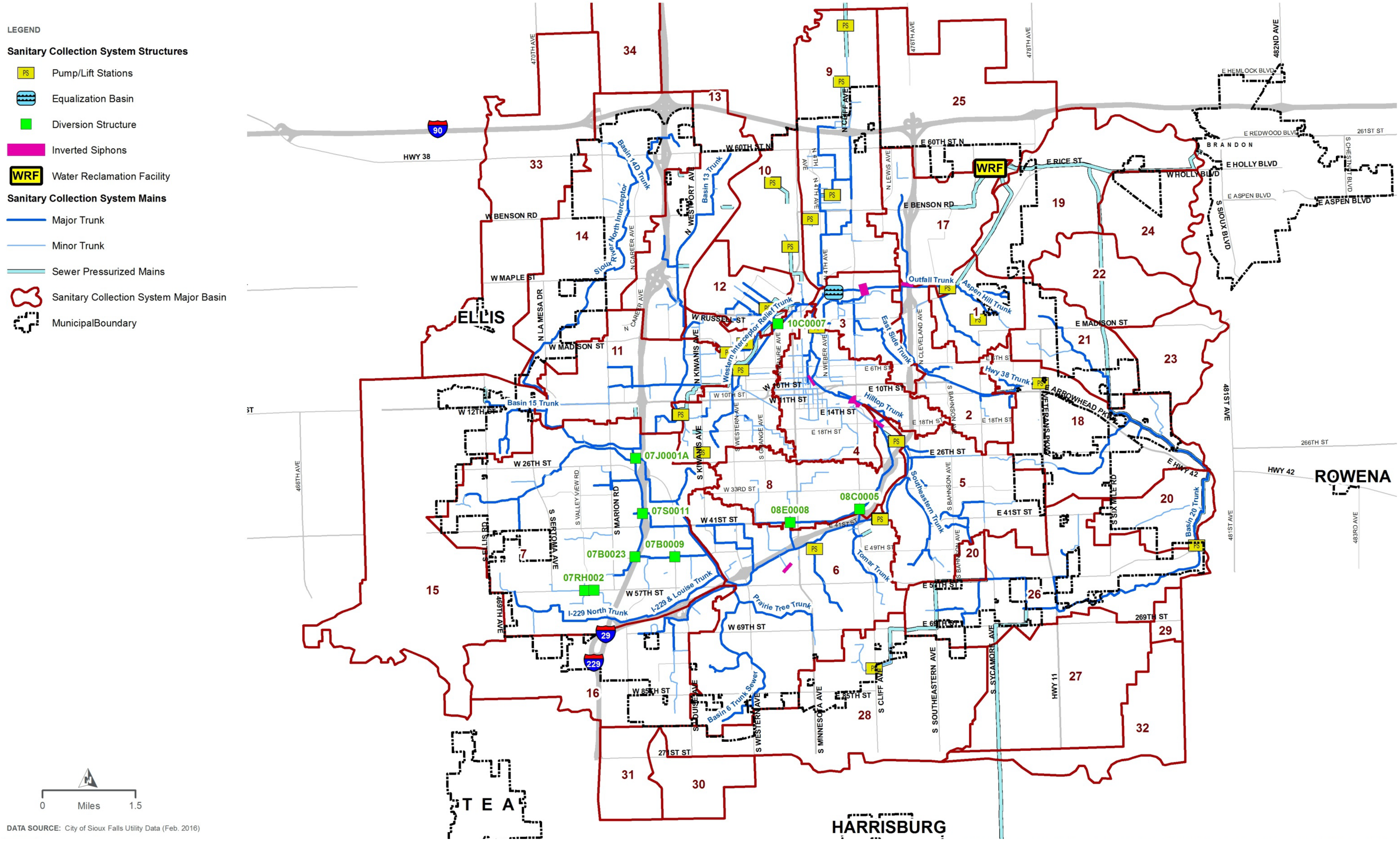
Figure 1.3 Water Reclamation Facility Existing Process Flow Schematic



1.1.2 Collection Facilities

The City's sanitary sewer collection system infrastructure serves a residential population of approximately 166,500 as of 2015. The City's collection system infrastructure consists of gravity mains, manholes, inverted siphons, lift stations and forcemains, flow equalization storage, and diversion structures. Figure 1.4 provides an overview of the existing collection system components discussed in the following sections. Chapter 3, Appendix 3-A provides a map of the existing system with more details.

Figure 1.4 Existing Collection System Overview



1.2 Project Purpose

The recommended capital improvements plan provides a long-term master planning tool for ultimate expansion of the collection system and the WRF, while identifying a phased construction program to meet reliability, hydraulic capacity and treatment requirements to address growth and regulations for the next 20 years. The plan will be refined as part of preliminary design efforts with project costs to match the further refined scope(s).

The master plan presents design concepts and budget information to serve as the basis for the preliminary design of subsequent projects. Overall, this master plan will provide direction for the preliminary design phase and, furthermore, it is the confirmation step in the overall project development cycle by defining and establishing how the project goals will be realized.

The master plan presents a review of the existing collection system and WRF (Water Reclamation Facility) capacities complete with a recommended capital improvements plan that reflects the timing for the following needs:

- Need to provide reliability and avert risk for failure for WRF and select lift stations.
- Need to increase existing and hydraulic capacity for growth for WRF, collection system and lift stations.
- Need to increase organic capacity for growth for WRF.
- Need to meet future growth and regulations at WRF.
- Need to improve WRF treatment operations.

Within the framework of this master plan, collection system analyses provides whole system optimization by solving the following pieces of the puzzle for the Utility of the Future:

- Collaboration with City Planning and regional customers to develop future service areas and populations.
- Calibrated collection system model with latest flow monitoring and further modelled growth impacts to hydraulic model.
- Sized and summarized system-wide collection system equalization/storage needs.
- Identified and provided long-term solutions for regionalization impacts i.e. gravity interceptors with satellite/regional water reclamation facilities or regional lift stations.
- Identified and prioritized major lift station infrastructure needs.

In combination with the results of the above, the Water Reclamation Facility (WRF) was optimized to treat the twenty-year and beyond flow and loading including:

- Projection of future flows and loadings.
- Complete plant-wide hydraulic model to identify and eliminate hydraulic limitations.
- Infrastructure impacts generated from pending nutrient removal/permitting requirements.

- Long-term disinfection expansion alternatives.
- Assigned timing recommendations for the improvements generated from the 2014 Biosolids Management Evaluation and 2013 Water Reclamation Facility FOG Receiving and Digester Complex Improvements Study.
- Provided long-term treatment solutions for biosolids handling, FOG and side-stream wastes through the review of innovative alternatives.

In summary, this Master Plan provides whole system optimization of the City's sanitary sewer collection system and Water Reclamation Facility(s) and identifies capital and operation and maintenance projects on a timeline fully vetted by the Planning Team for the WRF Utility of the Future.

1.3 Master Plan Organization and Summary

This Master Plan is organized into eleven Chapters. The first six Chapters provide the planning criteria and assumptions, document the existing treatment and collection systems, and document regulatory, agency and project considerations. Chapter 7 provides a detailed evaluation of proposed process treatment options, presents the evaluation of the alternatives, presents an economic and non-economic evaluation of each of the alternatives and selects an alternative for the treatment process at the WRF. Chapter 8 provides a thorough review of previous solids handling studies complete with updates based on both the newly developed planning criteria and the selected liquid process treatment alternative. Chapter 9 provides a detailed evaluation of the collection system and presents the hydraulic deficiencies along with recommended improvements, presents the evaluation of the collection system growth improvement alternatives, presents an economic and non-economic evaluation of each of the alternatives and selects an alternative for the long-term collection system arrangement for the City of Sioux Falls. Chapter 10 documents preliminary design components for the WRF and provides the costs for the selected improvements, a proposed project schedule and recommendations for further development of the project. Chapter 11 documents preliminary layout and sizing of the selected improvements for the collection system and provides the costs immediate needs, 2026 and 2036 needs, a proposed project schedule and recommendations for further development of the project.

The following sections provide a brief summary of each Chapter.

1.3.1 Chapter 2 – Population and Land Use Planning

Chapter 2 defines the future population, employment, and land use projections for both the City of Sioux Falls and Regional Communities which are used to establish the flow and loading characteristics. The resulting flows will be used to size the associated collection system and along with projected loadings define the impacts on the WRF. The background data utilized for projecting growth in Chapter 2 includes:

- Sioux Falls Land Use Data
- City of Sioux Falls GIS Utility Database
- Sioux Falls Long Range Traffic Model

- Shape Sioux Falls 2035 Comprehensive Plan (2009)Sioux Falls Wastewater Collection System Historical Flows and Monitoring Data
- Sioux Falls Water Reclamation Facility (WRF) Historical Flows
- Eastside Sanitary Sewer Siting Study
- Historical Water Meter Reading Data
- Historical Platting Area and Land Use Composition
- Developer Meetings
- FEMA 1% Annual Floodplain and USFWS National Wetland Inventory
- HDR Regionalization Study
- Banner Regionalization Study, 2016
- Brandon Comprehensive Wastewater Study, 2013
- Population projections from the 2008 WRF Master Plan
- Influent wastewater flow and loading characteristics

1.3.2 Chapter 3 – Existing Wastewater System Facilities

Chapter 3 presents a summary of the age and condition related needs to be addressed for reliability, recommended operational improvements and organic and hydraulic capacity related limitations. An attached appendix contains a Condition Assessment Technical Memorandum, which provides comprehensive descriptions for the recommended facility age and condition and operational improvements along with detailed cost breakdowns for the recommended solutions.

1.3.3 Chapter 4 – Wastewater Flows and Loads

Chapter 4 establishes the projected regional, industrial and domestic flow and loading characteristics for right-sizing the improvements at the WRF(s).

1.3.4 Chapter 5 – Collection System Model Development and Calibration

Chapter 5 summarizes the City of Sioux Falls' existing and future sanitary collection system model development. Spatially allocated future flows as well as model calibration are detailed in this chapter. Later Chapter 9, Collection System Analysis and Improvement Alternatives, and Chapter 11, Collection System Improvement Recommendations discuss model results under existing conditions as well future conditions modeling and capital improvement program (CIP) project recommendations based on Chapter 5 model calibration. The current model was updated to support the current master plan utilizing the following key information:

- Water meter-based base wastewater production (BWP),
- Dry-weather infiltration (DWI), and
- Rainfall derived infiltration and inflow (RDII) flow development, and resulting

- o Peak wet-weather flow

1.3.5 Chapter 6 – Regulatory Planning

Chapter 6 presents the regulatory assumptions and criteria used in planning the WRF improvements. It identifies and develops estimated discharge permit assumptions based on discussions with the SD DENR and discharge permitting in similar states. Specific planning emphasis is to address ammonia limits, which are expected to be implemented by 2026 and future nutrient discharge limits.

1.3.6 Chapter 7 – WRF Liquid Process Alternatives Evaluation

Chapter 7 reviews the baseline secondary treatment alternatives and screens alternatives from further consideration which have significantly higher initial costs and/or do not meet the non-monetary criteria developed by the planning team, i.e. acceptable process reliability. The selected alternative is identified via monetary and nonmonetary analyses for subsequent development in Chapter 10 for final costing and implementation. The following long-term expansion refined alternatives were selected for detailed analysis:

- Alternative 1-1 - 5 Stage Bardenpho Biological Nutrient Removal with Biological Phosphorus (BioP) removal with no carbon addition (Selected).
- Alternative 1-2 - 4 Stage Bardenpho Biological Nutrient Removal with ChemP and No Carbon (Base Alternative).
- Alternative 1-3 – Membrane Biological Reactor (MBR) with Chemical Phosphorus Removal (ChemP) and no Carbon.
- Alternative 2-2 – New East Side WRF Membrane Bioreactor, MBR and 4-Stage Modified Ludzack Ettinger (MLE) System at existing WRF.
    - o (Alternative 2-2 is a combination of Alternative 1-2 constructed at the existing water reclamation facility and a new East Side MBR).

Alternatives 1-1, 1-2 and 1-3 expand the existing WRF to handle 2036 design flows and loads. Alternative 2-2 is a combination of modifications of the existing WRF and a new East Side WRF for treatment of flows from the East Side Sanitary Sewer Basins. Chapter 7, Figure 7.8 presents locations of the existing WRF, potential East Side WRF and a general location for the omitted West Side WRF.

Chapter 7 also presents the capital costs, operational and maintenance costs, and life cycle costs for each alternative. The life cycle cost is then presented in an economic and a non-economic comparison for selecting the preferred alternative for the WRF. A matrix-type evaluation of noneconomic factors and typical benefit-cost evaluation are presented to aid in the selection.

Based on the alterative evaluation, the preferred alternative for this project is Alternative 1-1 - 5 Stage Bardenpho Biological Nutrient Removal with Biological Phosphorus (BioP) removal.

1.3.7 Chapter 8 – WRF Solids Handling Evaluation

Chapter 8 presents a review of previous solids handling study recommendations for upgrades or improvements to the existing solids handling system including thickening, solids digestion, dewatering, and drying facilities and provides recommendations. Two prior studies relevant to the Master Plan describing the recommended solids handling improvements for FOG and dewatering and drying are as follows:

- Water Reclamation Facility FOG Receiving and Digester Complex Improvements Study (FOG Study, December 2013)
- Biosolids Management Evaluation Study for Water Reclamation Facility (Biosolids Study, Updated June 2014)

The FOG Study section is an assessment of thickening through digestion, and the Biosolids Management Evaluation Study is an assessment of post-digestion facilities including dewatering and drying through ultimate disposal. The information presented includes the resulting master planning recommendations and associated costs.

The recommended biosolids handling plan is to dewater and thermally dry the solids thereby creating Class A biosolids, which will be compatible with public fertilizer use; any biosolids not used as fertilizer will be land applied. The remaining action items, which need to be reviewed as part of predesign for the dewatering facilities:

- Develop preliminary design basis, layout drawings and more detailed cost estimates for the following:
  - Alternative post-digestion biosolids storage mixing options
  - Biosolids lagoon transfer pumping
  - New dewatering equipment options
  - Dewatered sludge storage options
- Develop pilot testing protocol and pilot testing determine which equipment will be used. Additional investigation and pilot testing is recommended before a final decision is made on a solids dewatering alternative. Investigation and pilot testing would provide the following:
  - Potential for site visits to observe the alternatives evaluation in a full-scale operation at other facilities.
  - Reliability of the alternatives to consistently meet the sludge dewatering performance goals.
  - Determine the ability to operate the alternatives continuously on a 24-hour basis with minimal adjustments of the polymer and operator attention.

In addition, there are plans in place for acceptance of Fats, Oils and Grease (FOG) to provide for a sustainable WRF facility. The remaining FOG Study action items are as follows:

- Ensure that revisions to City ordinance, development of an education program, and enforcement infrastructure to keep FOG out of collection system are pursued. In addition, develop plans to encourage hauling to new FOG receiving facilities.

- Monitor competitors to determine whether the assumed tipping fee of $0.10 per gallon (escalated at 3 percent per year) is competitive.
- Need to continue to assess whether there are other high strength liquid waste streams that should be also be pursued.
- Affirm FOG Study assumptions that there will be reduced post digestion solids handling costs due to potentially lower solids production with co-digestion of FOG, and that the microturbines would have 95 percent generation uptime and cost $0.023 per kilowatt-hour to operate including the associated biofilter cost.
- Assuming that the City's intent is still to eventually receive and co-digest food/higher solid waste materials the Master Plan should do the following:
  - Develop a food / higher solid waste collection program.
  - If source(s) are available, develop an updated Basis of Design to include facilities for receiving and process food / higher solid waste.

1.3.8 Chapter 9 – Collection System Analysis and Improvements Alternatives

Chapter 9 presents a review of the City of Sioux Falls' (City) collection system capacity analysis for the existing system and the three planning years (2026, 2036, and 2066). In addition, the 100-year (2116 planning year) is also examined but not included for Capital Improvement Program (CIP) project recommendations. The capacity analysis is based on the City's collection system standards. The approach to achieving this goal is to evaluate the existing systems and prioritize the need for upgrades and/or replacement due to lack of capacity.

A summary is provided for the existing system deficiency improvements based on the three planning years (2026, 2036, and 2066) while recommended improvements were based on 2066 projected flows.

The future development expansion scenarios were also analyzed and presented with a preferred alternative developed for each planning year.

1.3.9 Chapter 10 – Summary of the WRF Plant of the Future

Chapter 10 further develops the selected alternatives identified in Chapter 7 and 8. Chapter 10 includes the following:

- The proposed design criteria are presented for the proposed WRF along with the prospective effluent limits into the Big Sioux River.
- The proposed site layout and plant schematic for the WRF are presented.

- When fully constructed, the Alternative 1-1 biological nutrient removal and polishing scheme will provide treated effluent of a quality suitable to meet the expected ammonia, total nitrogen and total phosphorus design effluent criteria.
- The long term recommended improvements and ultimately the capital improvements plan envisions the capital improvements described in Chapter 10. The implementation programming is designed to provide timely construction of the necessary improvements at the plant by integrating preliminary design for all projects required by 2025, also referred to as Phase 1 project improvements. The recommended liquid process improvements are those that will be necessary to meet the federally adopted ammonia criteria. At this point, Phase 1 ammonia removal and related solids handling improvements would need to be constructed by 2025 to meet expected growth.
- Included in the Phase 1 projects are the liquid and solids plant process improvements, and “reliability” improvements.
- FOG facilities will be added as FOG becomes available and is currently planned in Phase 2.
- The improvements address treatment capacity upgrades for treatment through 2036 along with the other noted high and medium priority reliability improvements. Phase 1 liquid improvements generally include screenings, primary clarifier improvements, increased activated sludge, filtration and chlorine contact capacity. The trickling filter train will continue to be used until nutrient removal regulations are in place. However, due to timing, a Phase 1a project needs to be constructed immediately including grit influent piping, diversion of peak flows directly from grit removal to the aeration basins and incorporating step-feed into the aeration basins.
- Biosolids handling improvements are recommended, as detailed in Chapter 8. The biosolids handling improvements address sludge thickening, post-digestion storage, dewatering, thermal drying and dewatered and dried sludge storage.
- The proposed Phase 1 and Phase 2 liquids treatment processes are presented in detail for existing and proposed improvements to aerated grit removal, primary clarifiers with decant recycle from a Unified fermentation and thickening (UFAT) of primary clarification residuals (improves nutrient removal performance), 5-stage Bardenpho with biological phosphorous removal, final clarification, filtration, chlorine disinfection.
- Biosolids Alternatives are presented for long-term thickening of solids produced at the WRF. One alternative includes processing the solids at the North WRF sufficient to meet Class A biosolids and the Class A biosolids will allow the City to consider other options for biosolids disposal.
- Chapter 10 presents the capital costs and staffing estimates for the proposed WRF improvements. The planning level capital cost for the Phase 1 WRF improvements is $190 million with Phase 2 costs totaling $101 million. These costs include both liquid and solids processing at the proposed WRF.

- The proposed implementation schedule for the WRF is also presented in Chapter 10. The schedule shows preliminary design beginning in August of 2018 with construction to be completed in 2025.

1.3.10 Chapter 11 – Summary of Collection System Improvements

Chapter 11 presents the recommended improvements to the City of Sioux Falls' (City) existing and future sanitary collection system. Recommendations are identified for the existing system or for future growth and grouped by type for sanitary sewer, pump station and forcemain, or equalization. Opinions of probable construction cost (OPCC) are identified for each improvement, and summarized into a Capital Improvements Plan (CIP). Further studies are also recommended to help further refine the extents and timing of recommended improvements.

Chapter 2 – Population and Land Use Planning

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Table of Contents

Tables

Figures

Appendices

Chapter 2 Population and Land Use Planning

2.1 Introduction

This chapter presents the evaluation of the anticipated land use planning and associated service population in the Study Area. The study area is discussed in Section 2.1.2.

This planning investigation examines the physical characteristics of the Study Area, population densities and potential growth, and existing land use and future zoning that will dictate future utility service requirements. To evaluate future capacity requirements, population and land use projections over a 20-year planning period are used to establish the magnitude and areas of future wastewater flows within the Study Area. Establishing appropriate wastewater service areas and identifying factors that affect growth and development provide a basis for projecting future populations and capacity requirements. The City's growth Tiers of 1-3, five (5-), 15-, and 25-year intervals are the primary basis for the Sioux Falls Wastewater Master Plan (Master Plan) planning period. Additionally, a review of longer-term growth for both the 50- and 100-year horizons is also considered in this master planning effort.

Evaluating future facility and distribution/collection system requirements is dependent on many considerations including, but not limited to, the following:

- Service area considerations and topography
- Population growth and density
- Visiting population and employment impact
- Land use and zoning
- Environmental constraints
- Magnitude and type of commercial and industrial activity in the area to be served
- Potential new development and timing
- Potential regional contributors and their associated flows and timing schedule
- Condition and capacity of the existing systems

These considerations are addressed herein and used for developing the future capacity requirements for the Sioux Falls wastewater collection system and treatment facilities. Development of flow projections and the comparisons of existing capacity capabilities versus future capacity requirements for each system are provided as a basis for evaluation in the subsequent chapters of this report. The chapters that follow include:

- Existing Wastewater System Facilities (Chapter 3)
- Wastewater Flows and Loads (Chapter 4)
- Collection System Model Development and Calibration (Chapter 5)
- Regulatory Planning (Chapter 6)
- WRF Liquid Process Alternatives Evaluation (Chapter 7)
- WRF Solids Handling Evaluation (Chapter 8)

- Collection System Analysis and Improvements Alternatives (Chapter 9)
- WRF Plant of the Future (Chapter 10)
- Summary of Collection System Improvements (Chapter 11)

2.1.1 Resources

Several resources were used in the Master Plan planning development. These included:

- Sioux Falls Land Use Data
- City of Sioux Falls GIS Utility Database
- Sioux Falls Long Range Traffic Model
- Shape Sioux Falls 2035 Comprehensive Plan (2009)Sioux Falls Wastewater Collection System Historical Flows and Monitoring Data
- Sioux Falls Water Reclamation Facility (WRF) Historical Flows
- Eastside Sanitary Sewer Siting Study
- Historical Water Meter Reading Data
- Historical Platting Area and Land Use Composition
- Developer Meetings
- FEMA 1% Annual Floodplain and USFWS National Wetland Inventory
- HDR Regionalization Study
- Banner Regionalization Study, 2016
- Brandon Comprehensive Wastewater Study, 2013

The following gives a brief description of how each resource listed above was utilized in projecting wastewater flows and determining future growth areas.

- Sioux Falls City's Planning Office land use data for the area designated as the Metropolitan Planning Organization (MPO) boundaries. This area is divided into traffic analysis zones (TAZs) which has land use and employment data from which projections were derived.
- The 2040 Long Range Transportation Plan and Traffic Model developed Traffic Analysis Zones (TAZs), which contained current (2013) and projected (2040) population and employment data by zone. Population and employment data within the zones were transferred to the parcel level by spreading population over residential land uses and employment over non-residential land uses within each zone using GIS. Population and employment of the parcels were then summed by basin to support basis-specific analysis of projected flows. TAZ data was also used to determine population and employment growth within the regional communities.

- The Shape Sioux Falls 2035 Comprehensive Plan was used in combination with the TAZ data to project when growth in an area would occur and the projected land use in those areas.
- Sioux Falls Wastewater Collection System Historical Flows and Monitoring Data were used as a reference in establishing per capita wastewater flows. The data provides insight into wastewater discharges by type of land use, collection system age, location, etc. The data included individual interceptor, trunk and basin monitoring, as well as flows at the major lift stations.
- Sioux Falls Water Reclamation Facility (WRF) Historical Flows were used to cross check predictions for current conditions based with actual flow data collected at the WRF.
- The Eastside Sanitary Sewer Siting Study projected wastewater flows for determining treatment and pumping flows for the eastside development, projecting flows by basin. This data was used as another source of information for the flow projection, comparing projections made with the additional references in this master planning analysis.
- The Historical Water Meter Reading Data was used to verify assumptions made in projecting wastewater flows from existing areas. This water meter data under dry weather flows (winter months) can approximate the wastewater flow under most conditions. There are exceptions to this, such as when there is an industry that provide their own water source yet discharge into the sanitary sewer, consumes water in the product, or treats its own wastewater for direct discharge, such as John Morrell.
- Historical Platting Area by Land Use was used in areas that were outside of the Shape projection period to estimate how many acres would be developed, how much of that is developable and the land use distribution that could be anticipated.
- FEMA 1% Annual Floodplain and the USFWS National Wetland Inventory were used to identify environmental constraints that may inhibit future growth in certain areas.
- Banner Preliminary Engineering Study -Wastewater Regionalization -Tea, Harrisburg and Worthing, SD; May 2016.

2.1.2 Study Area Boundary

The Study Area boundary is developed to establish the limits of the area considered in the Master Plan for the 20-year planning period of the Water Reclamation Facility and 50- 100- years for the collection system for the City of Sioux Falls and its regional customers. Refer to Figure 2.1.

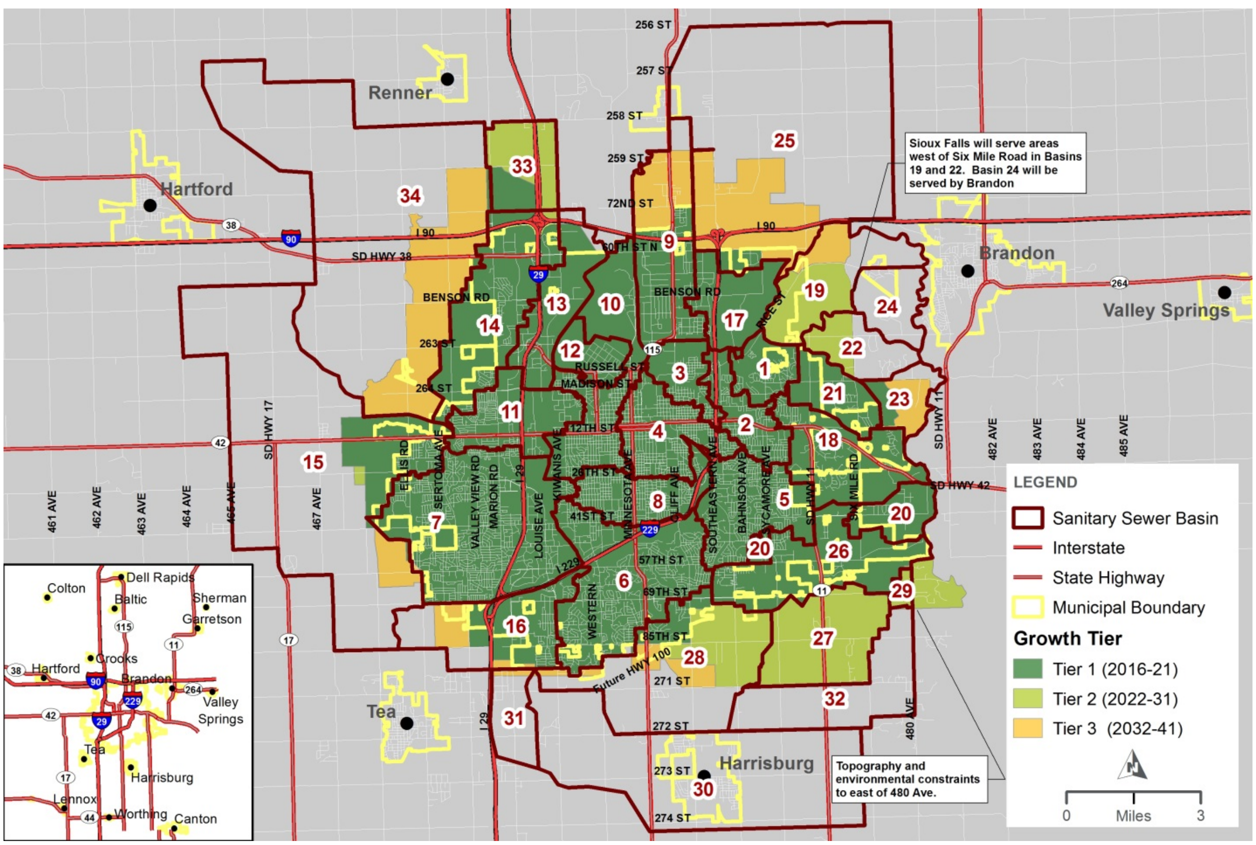
It should be noted that this long-range master plan considers various regional population and land use projections that may or may not need wastewater service by Sioux Falls. Given the speculative nature of the pace of growth and the need for City services, the Master Plan purposefully builds its capital program on approved or adopted City planning information, using outside City growth factors as potential longer range service area needs. Proceeding in this manner, the Master Plan attempts to plan for known conditions, and preserve service availability for areas outside the City's boundary wherever possible.

The wastewater service boundaries in Minnehaha and Lincoln counties were evaluated based upon the current and future land use, the population and employment data contained in the Traffic Analysis Zones (TAZs), and other potential regional communities that may likely connect to the City's regional wastewater collection/treatment systems. Currently the communities of Harrisburg and Brandon as well as the Renner and Prairie Meadows Sanitary Districts are a part of the regional system, delivering at least a portion of their wastewater to Sioux Falls.

2.1.3 Service Areas

Wastewater flow is determined by the population served and the land use of the area to be served. Base wastewater flows are adjusted using peaking and infiltration and inflow (I/I) factors to establish design criteria for treatment capacity and collection systems. Within the Study Area, the Wastewater Service Boundary establishes the area currently being served by the wastewater collection system as well as the area identified as likely to be connected to the sewer system. Figure 2.1 shows the established Wastewater Service Boundary for Sioux Falls as established by current growth tiers, which is approximately 91,000 acres for all basins (existing and within future identified service boundary). A breakdown of the existing wastewater service area by service basin or community is shown in Figure 2.1.

Figure 2.1 Study Area Boundaries - Growth Tiers



Flows were listed at 2013 as year 2013 was the base year for the transportation study. Note that some areas such as Basin 31 have or will likely soon be developing and are not included in Tiers shown in the Shape Sioux Falls 2035 document. Discrepancies such as this are expected with a planning document which forecasts the anticipated growth and actual conditions will be reflected and used in forecasting of the next version of the Shape document.

Table 2.1 Existing Wastewater Service Areas

Service Basin	Total Area[1] (acres)	Average Daily Flow (2013), MGD
Sioux Falls	48,704	16.17
Harrisburg	1,577	0.49
Brandon	3,326	0.71
Total	53,607	17.37

Source: [1] Sioux Falls Municipal Boundary GIS Dataset

2.1.4 Future (Sioux Falls and Regional Customers)

The Future Wastewater Service Area includes the growth areas projected in the Shape Sioux Falls 2035 plan and additional potential growth areas in the next 100 years as projected by the Sioux Falls Planning Department. The Future Wastewater Service Area includes 34 major sanitary sewer basins as shown on Figure 2.1. In addition, the Future Wastewater Service Area includes projected flows and loadings from existing regional customers (Brandon, Harrisburg, Renner Sanitary District, and Prairie Meadows Sanitary District) and potential additional communities (Tea, Hartford, Wall Lake Sanitary District, Lennox, Crooks, Baltic, Garretson, Valley Springs, Corson, Rowena, Canton, and Worthing). Information provided by those communities' engineers and/or population/employment data from the TAZs was utilized to project flows and loads that are expected when a regional community ties into either the WRF or Sioux Falls' collection system.

The shape Sioux Falls plan projected growth in three tiers:

- Tier 1: 0-5 years out (through 2021),
- Tier 2: 6-15 years out (through 2031)
- Tier 3: 16-25 years out (through 2041)

Since this evaluation must consider the impact to long-life infrastructure such as sewer interceptors and trunk lines, discussions with the City's Planning Department led to the development of two additional tiers. These include:

- Tier 4: 26-50 years out (through 2066)
- Tier 5: 51-100 years out (through 2116)

The intent of developing Tiers 4 and 5 was to provide a means to spatially allocate growth to an appropriate extent and expand basins as needed to assist the decision-making processes of corridor planning for sewers, pump stations and major treatment facilities. City Planning will develop future tiers as part of the "Shape Sioux Falls" in the customary planning periods of 25 years or less.

2.1.5 Planning Periods

To support the integration of a long-range 100-year planning horizon, the following specific planning intervals are used for developing growth, land use and wastewater flow projections and developing recommended improvements:

1. 10-year near-term (2016-2026)
2. 20-year mid-term (2027-2036)
3. 50-year long-term (2037-2066)
4. 100-year long-range term (2067-2116)

These planning periods and projected growth were selected in coordination with City Planning and WRF collection and treatment facility staff recommendations for both near-term improvements and long-term service expansion requirements. These planning periods are briefly summarized herein as follows.

10-Year Interval (Near-Term)

The near-term analyses provide recommendations for improvements to address limitations in the existing system and for expanding facilities to serve near-term new development areas. For the 10-year time frame, recommended improvements are prioritized, and construction phasing and timeline are developed. Recommended improvements are summarized in a 10-year capital improvement plan (CIP) along with estimated capital costs.

20-Year Interval (Mid-Term)

The mid-term analyses provide an interim benchmark between near-term facility improvements and long-term needs and goals. These analyses provide a basis for the timing of phased improvements and provide a measure of how soon major improvements may be required after the near-term period. Recommended improvements are prioritized and capital improvement cost estimates are provided for general planning purposes.

50-Year Interval (Long-Term)

The 50-year analyses are primarily provided as a basis for evaluating how long-term growth may impact the Sioux Falls regional wastewater system facilities. While population projections and future development cannot be accurately quantified for this 50-year horizon, these projections will help identify additional potential system shortfalls. The 50-year analyses provide a basis for evaluating long-term wastewater collection and treatment requirements. The long-term plan provides a foundation for phasing of improvements and helps avoid installing near- and mid-term improvements that may not account for long-term needs. This approach is designed to provide a backdrop to CIP planning to assure no-regret capital improvement spending. Estimated construction costs or detailed CIPs will not be developed for the 50-year planning period.

100-Year Interval (Long-Range)

The long range, 100-year analysis looks at potential growth in the extended term and its potential impact on long-term assets such as interceptor sewers and trunk lines and the impact the long range outlook may have on the existing WRF and potential other treatment facilities.

2.2 City and Regional Planning Considerations

The Study Area is located within Minnehaha and Lincoln Counties in the State of South Dakota and is positioned in the southeast corner of the state. The City of Sioux Falls is generally located at the intersection of Interstate 90 and Interstate 29, which allows convenient access for commuters to employment opportunities and attracts visitors and business to the area.

2.2.1 Physical Characterization

The physical characteristics of the area to be served, such as topography, floodplains, wetlands, and geographical location greatly influence the type of land use and in turn the population density as well as commercial and industrial activity within the area. Shape Sioux Falls 2035 notes environmental considerations that may prevent development in areas that are environmentally unsuitable for building or septic systems, and protect floodplains, major drainage ways, steep slopes, or other natural areas from incompatible development, which may result in environmental problems.

Figure 2.2 depicts many of the Study Area's physical/environmental characteristics discussed in the following sections.

2.2.2 Geology and Soils

The geology of the Study Area is comprised primarily of loess, loamy and sandy eolian material, loamy glacial till or silty material over loamy glacial till. Most undeveloped areas are used for cultivated cropland while steeper areas are used for pastureland and rangeland. These soils may be found in the level to flat to gently undulating terrain that exists across much of the Study Area. Geologic constraints are present to the east of Sioux Falls towards Rowena where quartzite outcropping occurs and makes development a challenge due to increased costs required for blasting rock and constructing in the high bedrock areas.

2.2.3 Topography

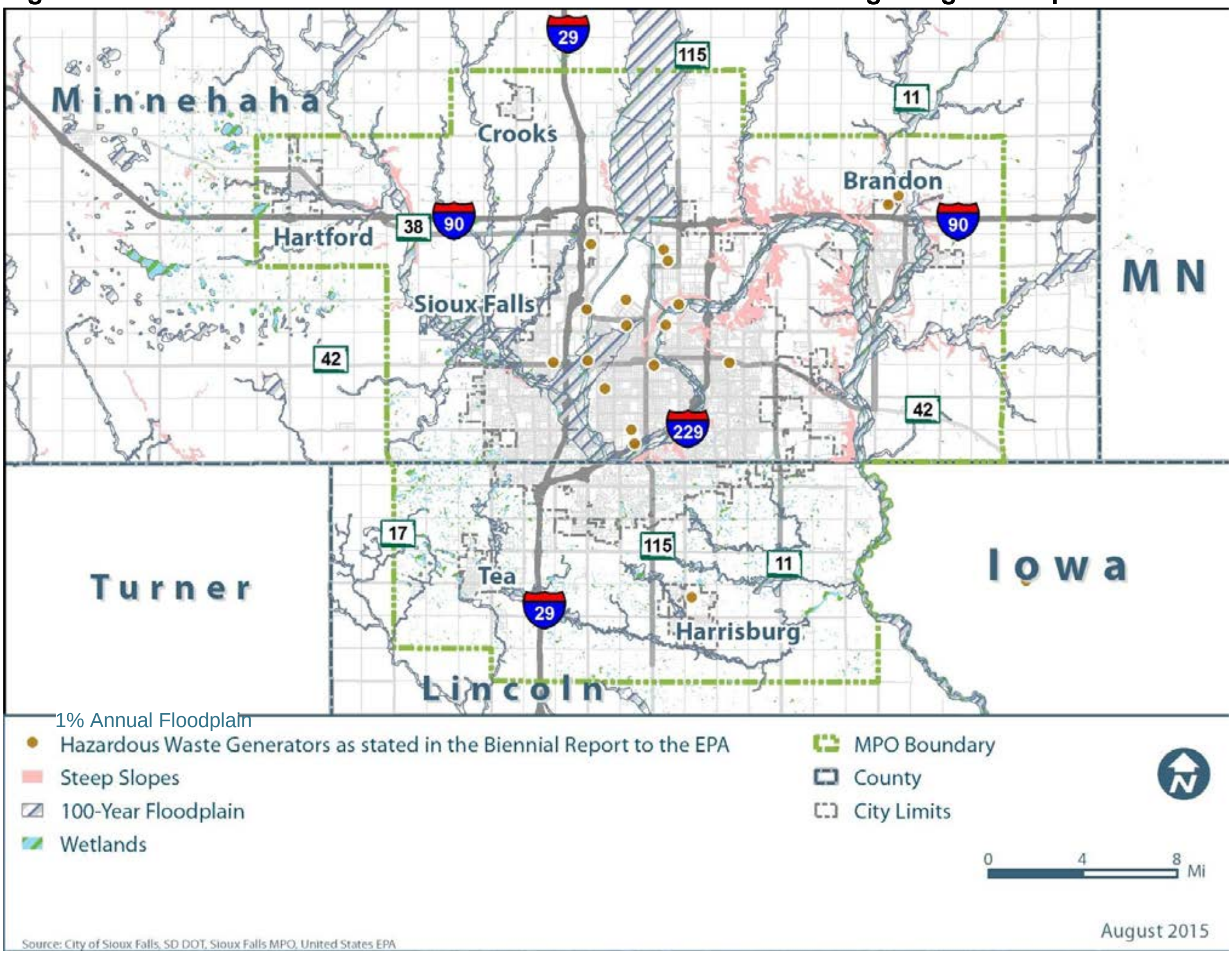
In general, the topography is typical of the prairie pothole region with poorly defined drainage networks, specifically in south Sioux Falls. Northwest to northeast of Sioux Falls, the topographic relief allows for better-defined drainage ways and fewer wetlands. Topography along the Big Sioux River contains river break formations where the topography shifts rather dramatically in comparison to the surrounding landscape. The river breaks are located along the river segment along Rice Street, to the west of Brandon, and continues south along the river to Canton.

2.2.4 Surface Water, Flood Plains and Wetlands

The primary water features within the Study Area include the Big Sioux River and Skunk Creek, a main tributary to the Big Sioux River. Both of these water features contain Federal Emergency Management Agency (FEMA) mapped 1% annual floodplains, which complicate growth. FEMA also recently reevaluated the 1% annual floodplain boundaries to the southeast of Sioux Falls and expanded the 1% annual floodplain. Wetland density is also very high on the south side of Sioux Falls. The southeast portion of Sioux Falls contains the Spring Creek watershed. This watershed has received much attention in recent years due to flooding, a problem that is exacerbated by urban growth in the upper portions of the watershed.

Wetlands are protected by Section 404 of the Clean Water Act. Work typically associated with water and wastewater systems and conducted in wetlands will require coordination with Federal and/or state water quality agencies and the issuance of a permit by the U.S. Army Corps of Engineers (Corps). Wetlands are sensitive environmental areas that serve many beneficial functions including ground water recharge, flood control, filtering of surface water runoff, and providing essential wildlife habitat. Onsite storm water detention and wetland mitigation will be critical components of further development within this watershed, specifically when wetland impacts occur and a Corps 404 permit is required.

Figure 2.2 Environmental Constraints Identified Within the 2040 Long-Range Transportation Plan



2.2.5 Groundwater

Shallow aquifers are the largest source for drinking water supplies to Sioux Falls and the regional communities, primarily the Big Sioux and Skunk Creek Aquifers. To protect these vital shallow aquifer resources as a public water supply, wellhead protection zoning ordinances have been established for the counties within the study area.

2.3 Existing Conditions

2.3.1 Population

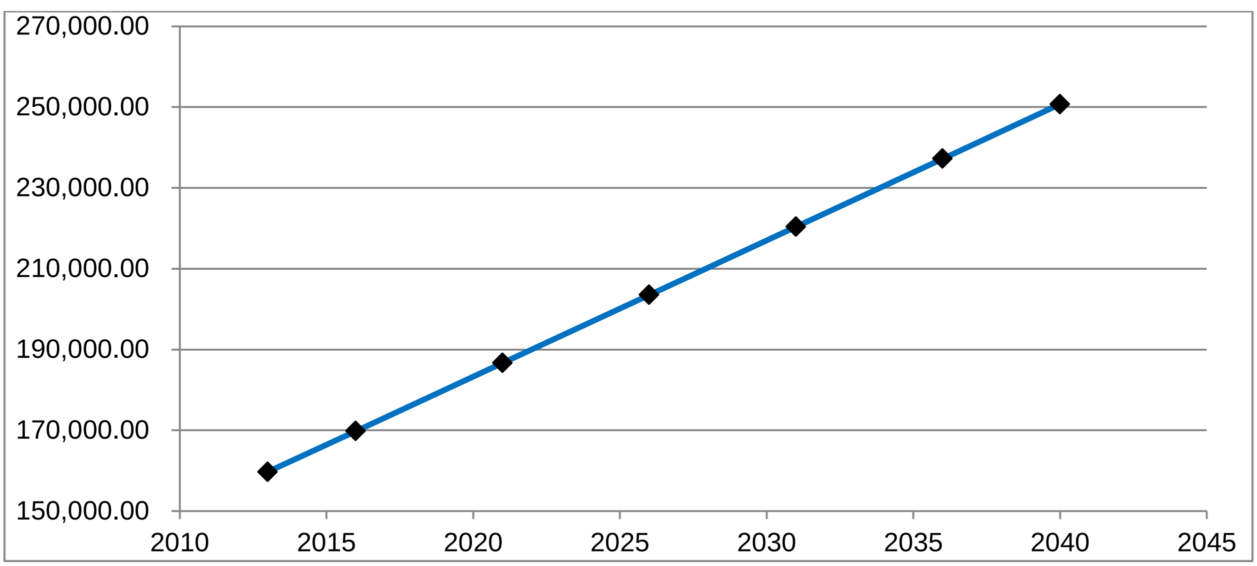
Population trends within the Study Area provide a basis for estimating future population growth and its impact on the wastewater conveyance and treatment facilities. The historical growth and population summary and the population projections analysis performed for the Study Area account for populations within the City of Sioux Falls and its existing customers (Brandon, Harrisburg, Renner Sanitary District and Prairie Meadows Sanitary District) and other potential regional customers (Tea, Hartford, Wall Lake Sanitary District, Lennox, Crooks, Baltic, Garretson, Valley Springs, Corson, Rowena, Canton, and Worthing).

Sioux Falls

As discussed with the City's Planning Department, the majority of growth is anticipated to occur to the south and east of the area currently served. In-fill and redevelopment of existing areas within the City limits also provide areas for future development.

Sioux Falls' recent population growth has consistently been positive, ranging from a low of 1.01% in 2011, to a high of 3.15% in 2000. Population projections to the year 2040 were obtained from the TAZ data and correlate with the values being used by the City Planning Department. These values, developed by the City Planning Department, are based on historical growth and trends, and utilize a straight-line projection, shown in Figure 2.3. This straight-line projection was continued for the longer-term population projections required for this evaluation. Utilizing the TAZs and basin boundaries in GIS, the population and employment by basin through 2116 was estimated and is further discussed in Section 2.5.

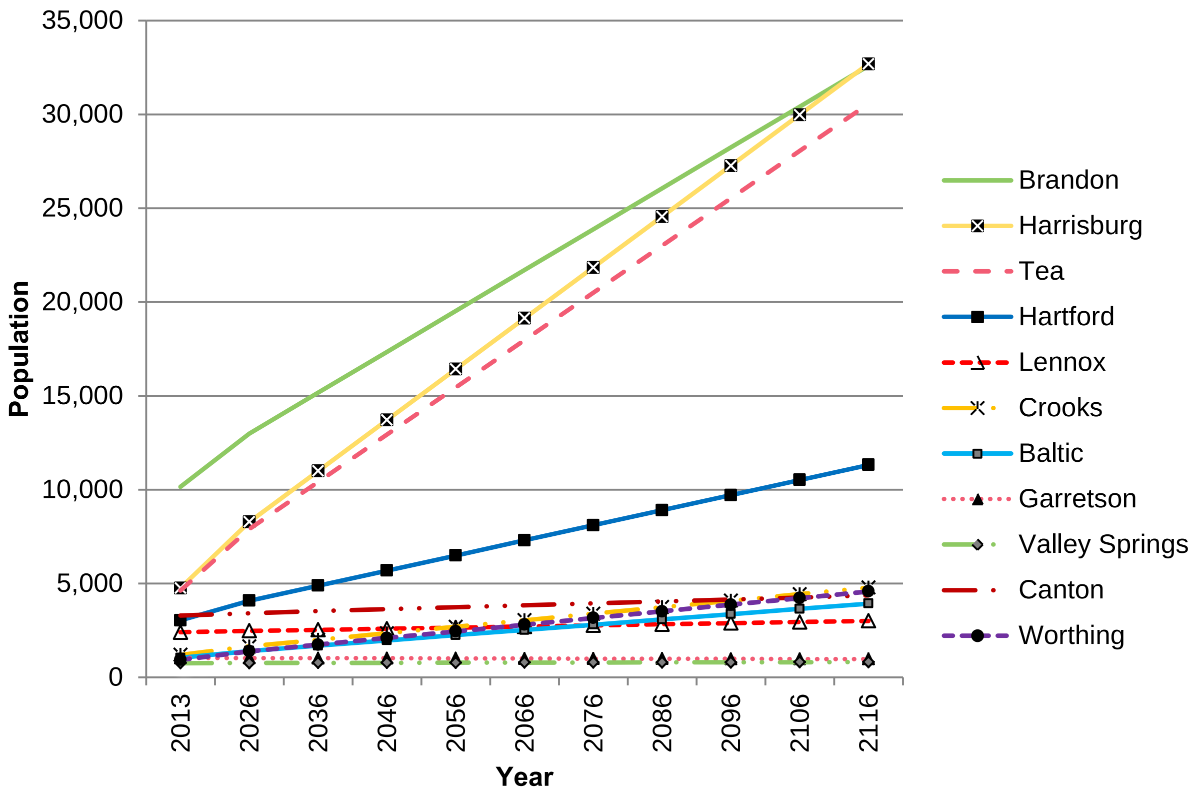
Figure 2.3 Sioux Falls Population Projections



Regional Customers

In addition to the projected City of Sioux Falls population, two regional communities, Harrisburg and Brandon, and two sanitary districts, Renner and Prairie Meadows, have partnered with Sioux Falls to treat and dispose of at least a portion of their local wastewater. There are also other regional communities that are considering or could consider regional participation, including Tea, Hartford, Wall Lake Sanitary District, Lennox, Crooks, Baltic, Garretson, Valley Springs, Corson, Rowena, Canton, and Worthing. The population projections for these regional communities and others were determined from the TAZs that contained notable population growth between 2013 and 2040 and are shown in Figure 2.4. This data was used to estimate flows to add to the Sioux Falls values. The sanitary districts and Rowena were not accounted for separately, as they are accounted for in the future Sioux Falls or adjacent community's contributing area projections.

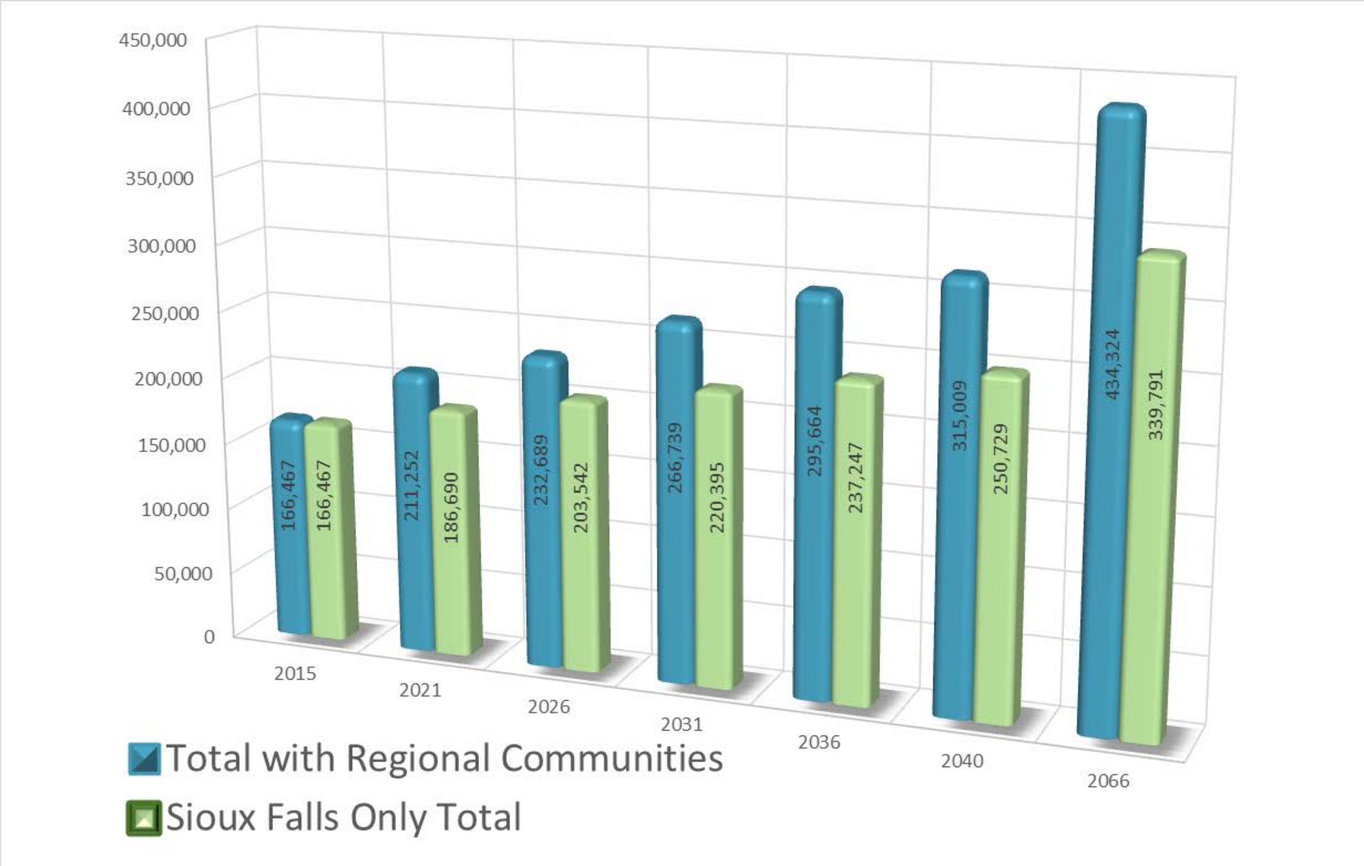
Figure 2.4 Projected Regional Community Growth



Total Customers

A graphic of the projected total potential wastewater system population including the City of Sioux Falls (Figure 2.3) and the potential regional communities (Figure 2.4) is presented in Figure 2.5.

Figure 2.5 Projected Sioux Falls and Regional Community Growth



2.3.2 Land Use

Land use in and around the City of Sioux Falls over the past 15 to 20 years has steadily changed from predominately agricultural to residential, commercial and industrial general land use types. The purpose of this section is to document the existing land uses and estimate future land uses as an element of population and wastewater flow projections.

Figure 2.6 provides a map of current land use for the Study Area based on available Sioux Falls parcel GIS data that contains land use information. Approximately one third of the City of Sioux Falls currently consists of residential land use. The makeup of the developed lands within the Study Area is shown graphically in Figure 2.7 and a summary is provided in Table 2.2. These land areas provide a reference point for comparing current and future conditions. Table 2.2 is based on the Sioux Falls GIS database for current platted parcels.

Figure 2.6 Sioux Falls Existing Land Use Map

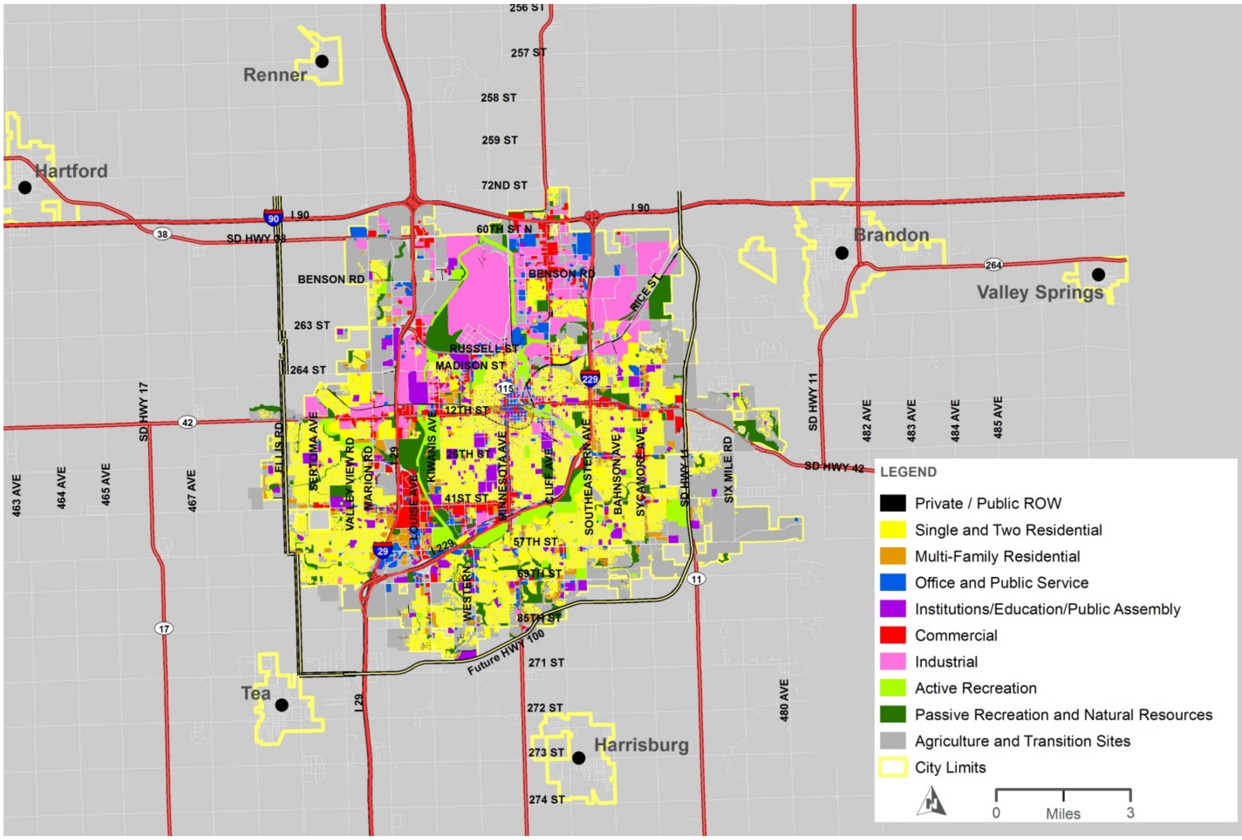


Figure 2.7 Sioux Falls Existing Land Use Makeup

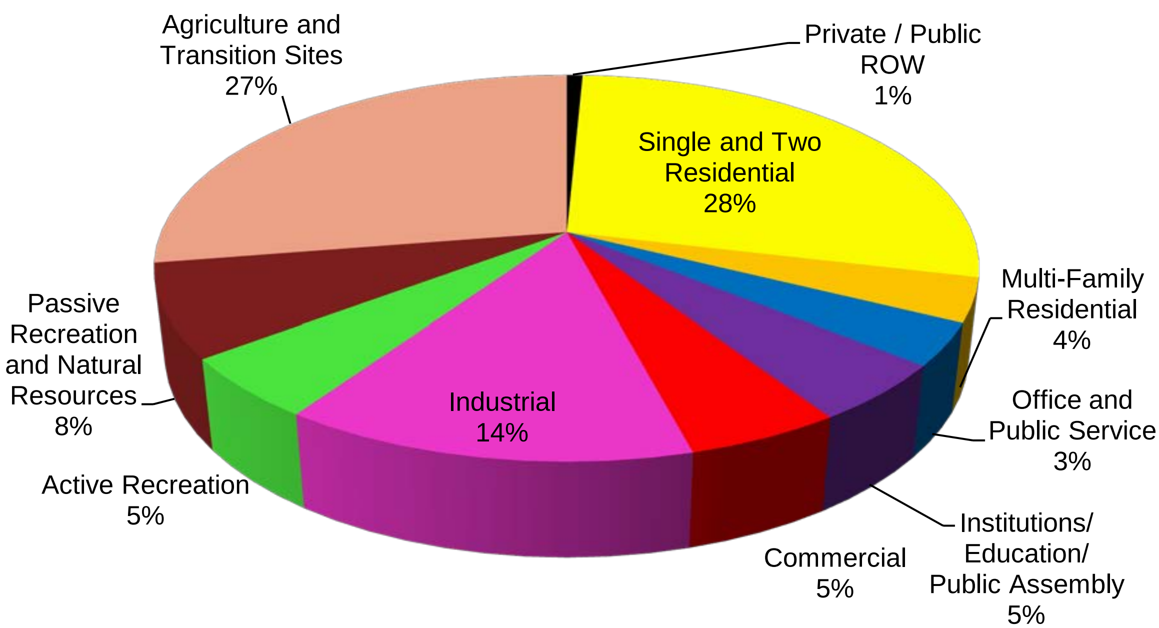


Table 2.2 Sioux Falls Existing Land Use Summary

Land Use Activity	Developed Area (acres)	Percent of Total Area
Private/Public ROW	299	0.7%
Single and Two Residential	11,323	28.0%
Multi-Family Residential	1,472	3.6%
Office and Public Service	1,418	3.5%
Institutions/Education/Public Assembly	1,980	4.9%
Commercial	2,076	5.1%
Industrial	5,526	13.7%
Active Recreation	2,082	5.1%
Passive Recreation and Natural Resources	3,141	7.8%
Agriculture and Transition Sites	11,142	27.5%
Total	**40,459**	**100.0%**

Source: City of Sioux Falls Planning and GIS Department land use database for parcels.

2.4 Future Basis of Planning

An evaluation of the impacts of potential development on wastewater service requirements was completed based on recent development planning documents, known development plans, land use and zoning information, undeveloped land, platting history, and unit densities. The evaluation provides general information about where and when development might be expected in the Study Area. From this information, concept-level locations and sizing for wastewater service facilities can be evaluated.

2.4.1 Shape Sioux Falls 2035

The Shape Sioux Falls 2035 Comprehensive Plan was used to establish appropriate duty factors for projecting growth, including housing unit densities for single and multi-family homes, median household size, and 28-year platting averages (see Table 2.3). For example, 90% of every undeveloped 640 acres becomes developed into either residential, park, industrial, commercial, or office/institutional land use while 10% consists of roads, sidewalks, etc. Of the 90% of land that becomes developed, 49% becomes single-family homes, 9% multifamily, 9% parks, etc. These duty factors were used to portion undeveloped land into land use activities and apply population and employment densities. As such, this information provides an appropriate basis of planning for the future conversion of undesignated land.

2.4.2 Long Range Transportation Plan

The 2040 Long-Range Transportation Plan was designed to guide the region's transportation planning. The cooperative effort involved staff, officials, and residents from the Cities of Brandon, Crooks, Harrisburg, Hartford, Sioux Falls, Tea; Federal Highway Administration (FHWA); Lincoln

County; Minnehaha County; the South Dakota Department of Transportation (SDDOT); and the South Eastern Council of Governments (SECOG). This plan contains growth areas for many of the regional communities including Crooks, Harrisburg, Harford, and Tea. TAZ were also revised during this effort using input from the surrounding communities to include population and employment numbers spatially throughout the region based on individual community facility and master plans.

2.4.3 Growth Areas

Major growth areas were evaluated and categorized by grouping sewer basins into major geographical basins in order to view the spatial allocation of projected growth on a larger scale. This information is critical when planning for future wastewater capital investments. Table 2.4 provides a tabular listing of the sewer basins assigned per Geographical Basin. The compilation of these basins is shown graphically on Figure 2.8.

Table 2.3 Duty Factors Used for Projecting Future Growth

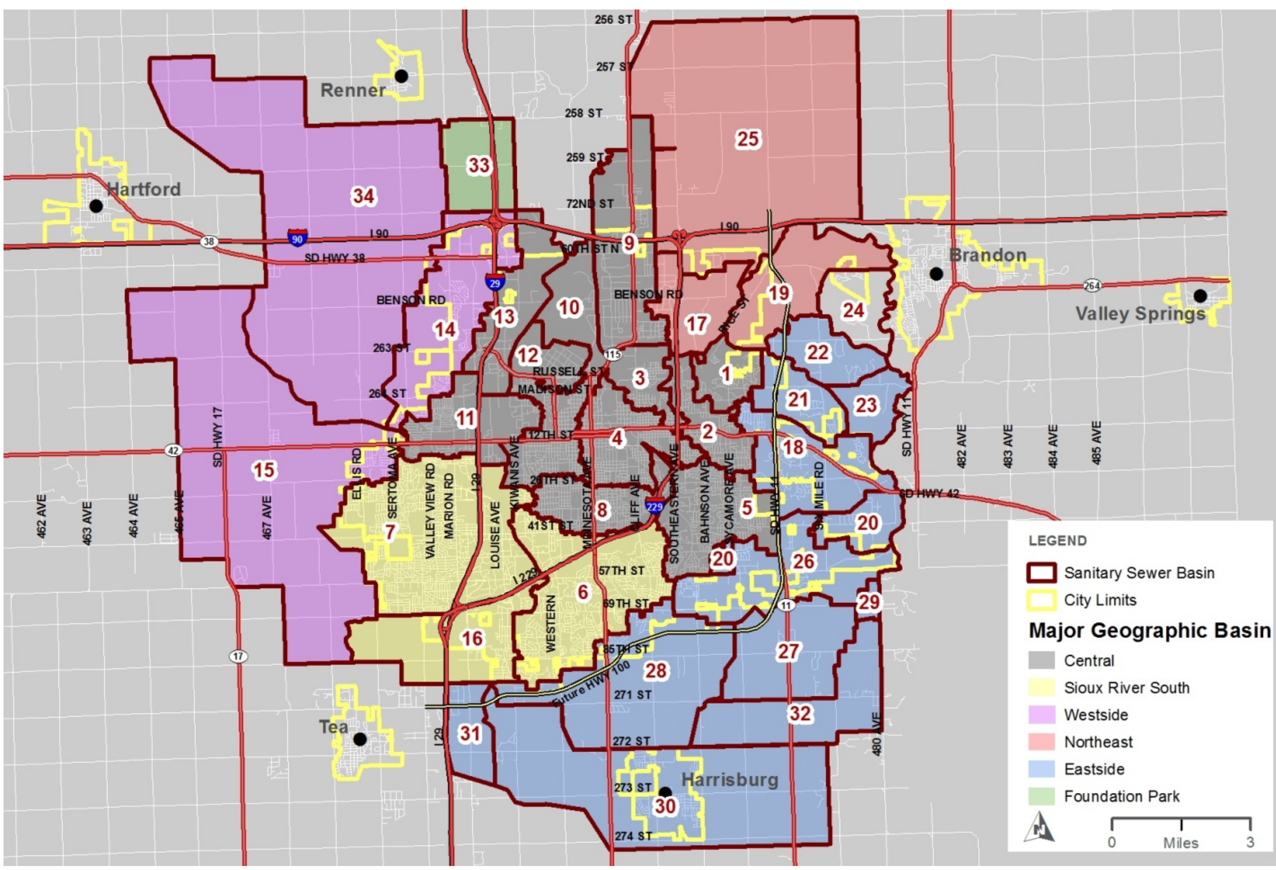
Category	Duty/Scale Factor
Platting[b]	
Developed Land / 640-ac Section[a]	90%
Single Family	49%
Multi Family	9%
Public / Semi-Public	9%
Industrial	17%
Commercial	9%
Office / Institutional	7%
Residential Build Out	
Single Family Units/Acre [a]	2.74
Multi-Family Units/Acre [a]	16.00
Median Household Size (Persons/Unit)	2.40
Employment Build Out [c]	
Industrial Employment / Acre	9.93
Retail Employment / Acre	29.04
Office Employment / Acre	33.51
Institutional Employment / Acre	26.14

Source: Table Source/Notes
[a] per 2015 platting fees
[b] per Exhibit 2.E of Shape Sioux Falls 2035
[c] per Sioux Falls Zoning Ordinance parking calculations (modified to maintain employment type composition and employment : population ratio)

Table 2.4 Major Geographical Basins with Study Area

Major Geographical Basin	Major Basins
Central	1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13
Sioux River South	6, 7, 16
Westside	14, 15, 34
Northeast	17, 19, 25
Eastside	20, 21, 22, 23, 26, 27, 28, 29, 30, 31, 32
Foundation Park	33

Figure 2.8 Sioux Falls Major Geographical Basins



2.5 Future Population, Employment, and Land Use Projections

2.5.1 Population and Employment

Population and employment projections provide the basis for developing plans for future utilities to serve growth and for analyzing impacts to the existing conveyance and treatment facilities. The population and employment projections are based on population and employment data within the TAZs for 2013 and 2040. The growth rate between 2013 and 2040 was used to project population and employment out to 100 years, suggesting a continuation of projected growth values over the long-term planning period.

Spatial Allocation of Population and Employment

As previously discussed, TAZ information was used to provide the spatial allocation of population and employment for existing conditions and the year 2040. Since TAZs do not correlate with sewer drainage basin boundaries, population and employment within the basins was derived through a multi-step GIS spatial overlay process, designed to spread population and employment within the TAZ to the appropriate land uses. This process was necessary to avoid spreading large population and employment amounts across basin boundaries where TAZ fall within multiple basins, a common occurrence.

Within each TAZ, the population was distributed among residential land uses at varying densities for single family and multi-family residential areas utilizing the duty factors and scale factors previously shown in Table 2.3. Similarly, employment was distributed among non-residential employment oriented land uses. In the cases where no residential land use was identified within a TAZ and population was present, then the population was distributed among non-residential land uses and vice versa for employment. Once this exercise was complete, population and employment density could be applied to the land use features within the Sioux Falls GIS land use datasets. The land use dataset were then intersected or overlaid with the sewer basins so that the TAZ based population and employment information could be assigned to the appropriate sewer basins.

After completing this exercise for both the 2013 and 2040 TAZ data, the population and employment growth rate by basin was established and linear growth was applied until a build out threshold was reached within the respective Tier. Population and employment build out was determined within the basins using the duty factors and scale factors shown in Table 2.5. Table 2.5 shows the percent build out threshold/duty factors that were used for the growth tiers for the 50- and 100-year population and employment projections.

It should be noted that some basins within central Sioux Falls currently exceed the 90% population build out and/or 50% employment build out threshold of Tier 1. These basins, indicated as “Central” Major Geographic Basin in Table 2.6, are not projected to grow, and may even decrease over time based on the 2013-2040 TAZ data. The basins in central Sioux Falls that have yet to attain this build out threshold were identified as “Central – Growing.”

This TAZ-based growth projection strategy integrated basin specific growth rates while aligning with the projected city of Sioux Falls linear growth rate over the next 100 years. The extent of non-developed land added to Sioux Falls in Tiers 4 and 5 was determined by calculating the area necessary to fit the projected population and employment under the parameters set by the long-term and long-range percent build out duty factors.

Sioux Falls

This study provided population and employment projections for 2026, 2036, 2066, and 2116 at various scales including major basins, major geographic basins (i.e. major growth areas) and the City as a whole and is presented in Table 2.6 and Table 2.7. This population and employment data has been compiled by the major geographic basins and shown in Figure 2.9. A larger format version of this figure has also been included in the map pocket following. These projections were converted into the planning periods for this project using linear interpolation until previously discussed growth threshold / duty factors have been attained.

Table 2.5 Percent Build Out Duty Factors for Long-Term and Long Range Planning

2066	% Build Out
Population (2066)	
Tier 1	90%
Tier 2	90%
Tier 3	45%
Tier 4	25%
Tier 5	0%
Employment (2066)	
Tier 1	50%
Tier 2	40%
Tier 3	16%
Tier 4	0%
Tier 5	0%
Population (2116)	
Tier 1	90%
Tier 2	90%
Tier 3	90%
Tier 4	75%
Tier 5	50%
Employment (2116)	
Tier 1	50%
Tier 2	50%
Tier 3	50%
Tier 4	50%
Tier 5	28%
Source: City of Sioux Falls, Planning Department 2016	

Table 2.6 100-year Population Projection within Sioux Falls

Basin	Major Geographic Basin	Population Projection			
		2026	2036	2066	2116
1	Central - growing	3,358	3,633	4,854	4,854
2	Central	8,893	8,722	8,654	8,654
3	Central	4,952	4,956	4,958	4,958
4	Central	15,652	15,484	15,417	15,417
5	Central	17,316	17,624	17,747	17,747
6	SRS	18,727	19,227	22,399	22,473
7	SRS	38,400	39,419	41,957	42,013
8	Central	10,332	10,057	9,948	9,948
9	Central - growing	3,302	3,890	5,907	9,038
10	Central	11,968	11,751	11,663	11,663
11	Central - growing	7,448	7,737	14,543	14,543
12	Central	942	920	911	911
13	Central - growing	264	329	819	819
14	Westside	7,352	10,043	17,697	17,704
15	Westside	6,342	8,887	22,034	59,932
16	SRS	8,264	11,380	13,510	17,338
17	Northeast	439	421	1,388	1,388
18	Eastside	6,300	9,333	16,689	16,689
19	Northeast	1,163	2,057	6,455	7,348
20	Eastside	3,107	4,246	5,334	5,334
21	Eastside	3,537	5,730	9,412	9,412
22	Eastside	1,697	3,003	3,525	3,525
23	Eastside	818	1,446	2,684	3,946
25	Northeast	1,080	1,907	2,735	39,198
26	Eastside	11,031	16,987	25,925	25,925
27	Eastside	3,405	6,025	16,656	16,737
28	Eastside	5,734	8,992	17,942	27,390
29	Eastside	378	669	1,151	1,151
30	Eastside	-	-	1,157	17,984
31	Eastside	-	-	1,071	4,165
32	Eastside	4	6	2,396	12,219
33	Foundation Park	20	36	42	42
34	Westside	1,317	2,330	12,209	55,528
Total		**203,542**	**237,247**	**339,791**	**505,997**

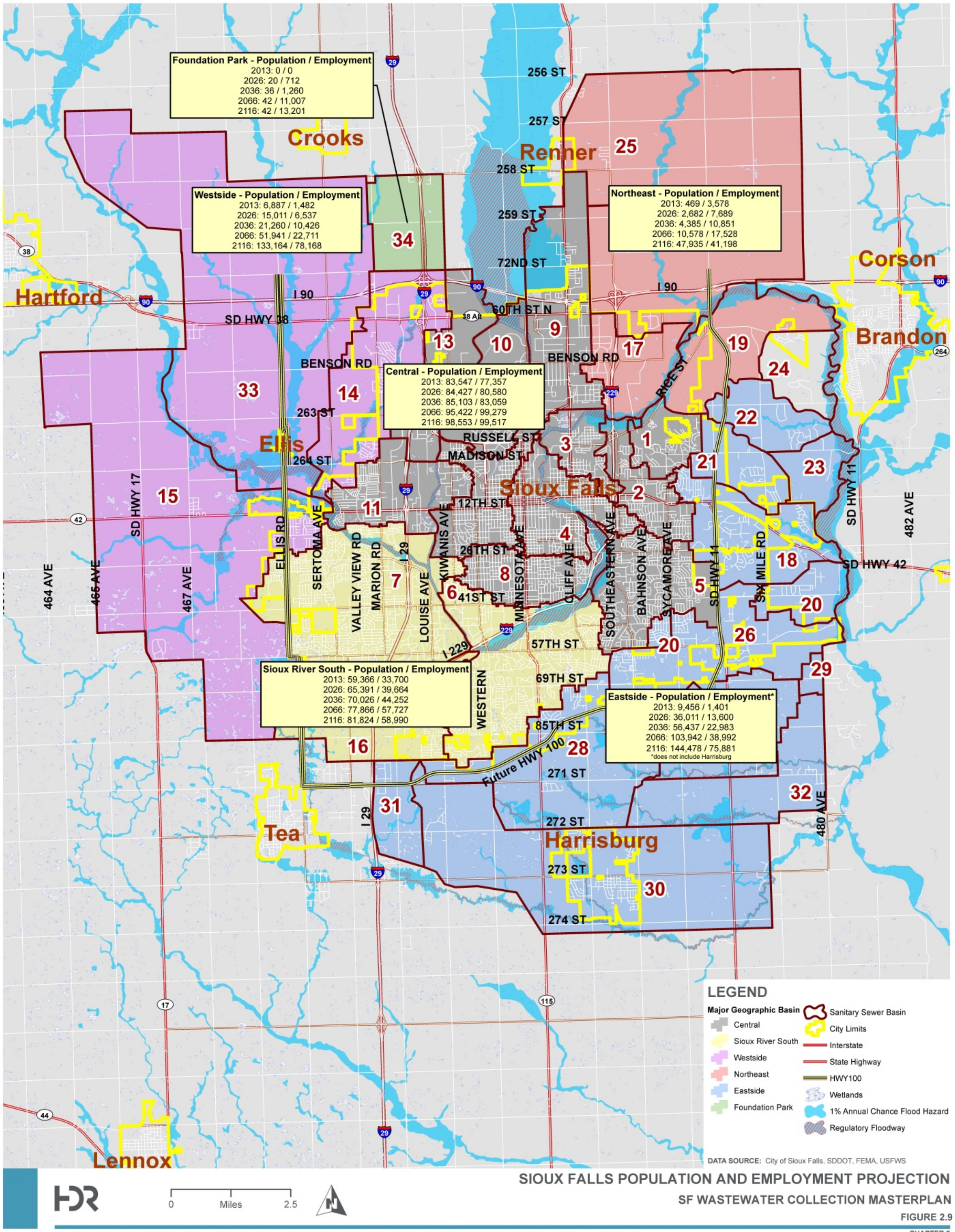
Source: Table is based 2040 Long Range Transportation Plan and Traffic Model developed Traffic Analysis Zones with Sewer Basin Boundaries.

Table 2.7 100-year Employment Projection within Sioux Falls

Basin	Major Geographic Basin	Employment Projection			
		2026	2036	2066	2116
1	Central - growing	868	878	3,065	3,066
2	Central	2,868	2,828	2,813	2,813
3	Central	4,344	4,369	4,380	4,380
4	Central	22,350	22,601	22,701	22,701
5	Central	3,702	3,856	3,917	3,917
6	Sioux River South	12,473	12,864	16,044	16,066
7	Sioux River South	21,072	21,943	26,110	26,110
8	Central	6,439	6,351	6,315	6,315
9	Central - growing	12,779	13,130	16,366	16,602
10	Central	11,878	11,738	11,682	11,682
11	Central - growing	5,728	6,264	11,724	11,724
12	Central	4,558	4,514	4,496	4,496
13	Central - growing	5,066	6,530	11,820	11,820
14	Westside	4,762	7,399	16,469	16,628
15	Westside	1,211	2,029	3,791	30,375
16	Sioux River South	6,120	9,445	15,573	16,814
17	Northeast	4,374	5,111	9,553	9,560
18	Eastside	3,294	5,049	9,954	9,954
19	Northeast	1,349	2,386	3,778	5,029
20	Eastside	189	334	843	843
21	Eastside	898	1,523	2,593	2,593
22	Eastside	1,065	1,885	2,871	3,344
23	Eastside	10	17	45	45
25	Northeast	1,966	3,354	4,198	26,609
26	Eastside	3,123	5,403	9,112	9,114
27	Eastside	1,549	2,741	4,465	5,384
28	Eastside	3,459	6,011	9,087	17,995
29	Eastside	11	20	23	23
30	Eastside	-	-	-	15,030
31	Eastside	-	-	-	5,029
32	Eastside	0	0	-	6,527
33	Foundation Park	712	1,260	11,007	13,201
34	Westside	564	998	2,452	31,165
Total		**148,782**	**172,832**	**247,244**	**366,955**

Source: Table is based 2040 Long Range Transportation Plan and Traffic Model developed Traffic Analysis Zones with Sewer Basin Boundaries.

Figure 2.9 Sioux Falls Population and Employment Projections

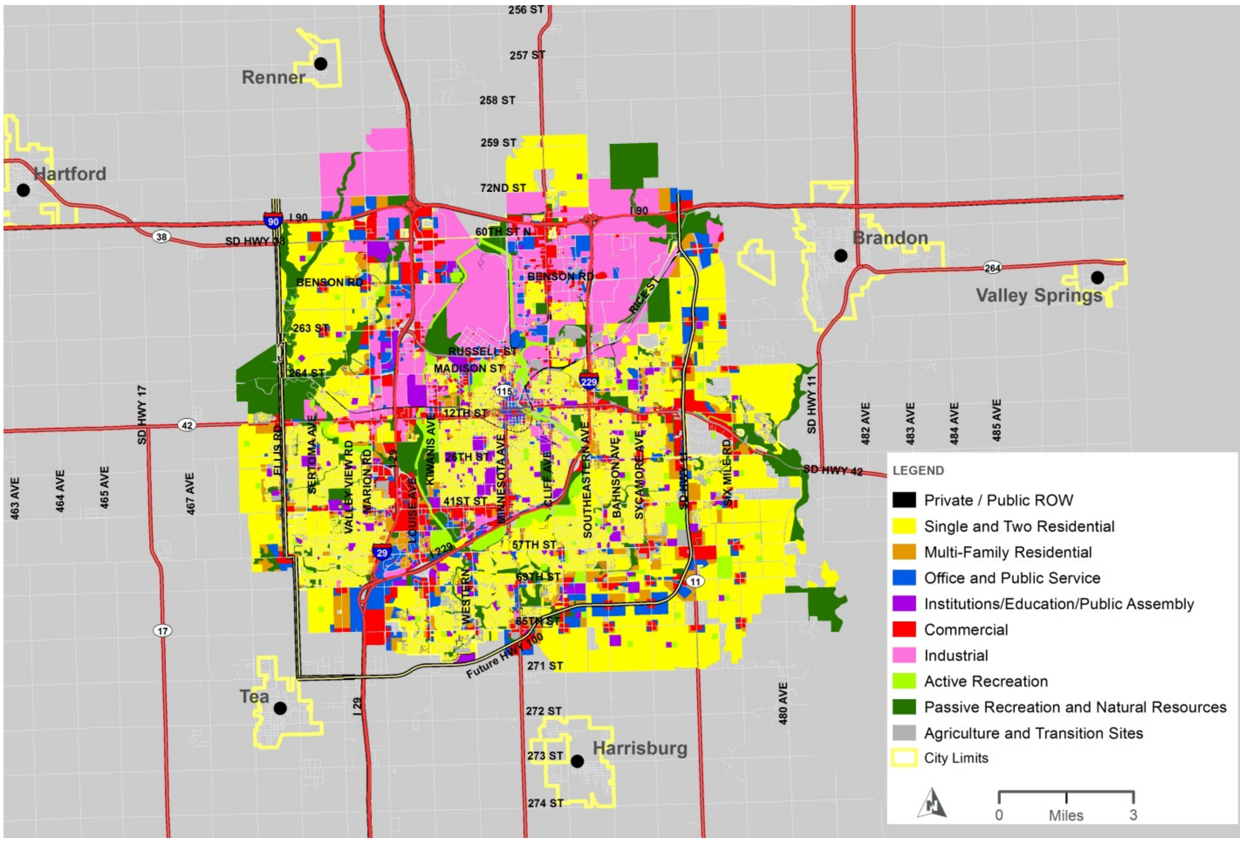


2.5.2 Land Use

Sioux Falls

The future land use composition is similar to the current land use composition although the majority of agricultural land has been converted to other urban land uses. Land use composition is expected to remain relatively stable well into the future. Residential areas with hubs of commercial land uses are the primary growth areas in south Sioux Falls, whereas growth in industrial land use is primarily occurring in north Sioux Falls. The future land use GIS dataset is currently contained within Tier 3. A summary of this future land use composition is shown spatially and graphically on Figure 2.10.

Figure 2.10 Sioux Falls Future Land Use Map - Tier 3



The contribution of each land use type for Sioux Falls as a whole is summarized in Figure 2.11 and Table 2.8. No new detailed future land use data was created or assigned to specific areas as part of this study for the 50- and 100-year projections, but rather an estimate of undeveloped land beyond the extents of the current future land use dataset was established based on the land required to fit the projected population of Sioux Falls.

Figure 2.11 Sioux Falls Future Land Use Makeup - Tier 3

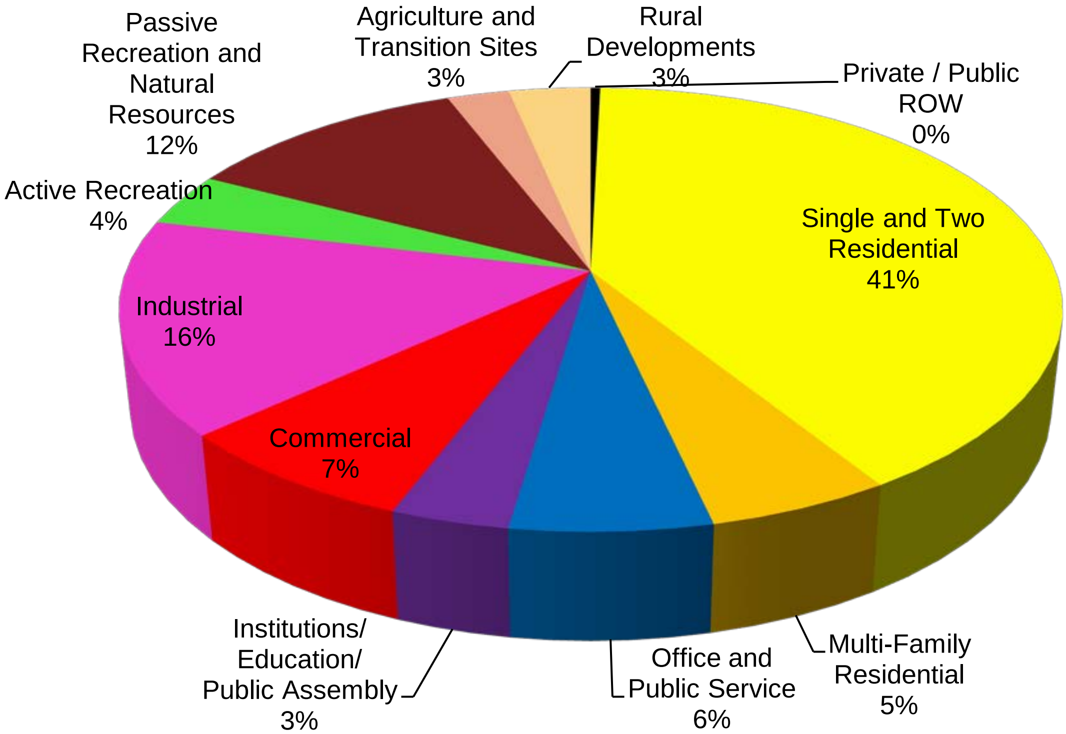


Table 2.8 Sioux Falls Future Land Use Summary - Tier 3

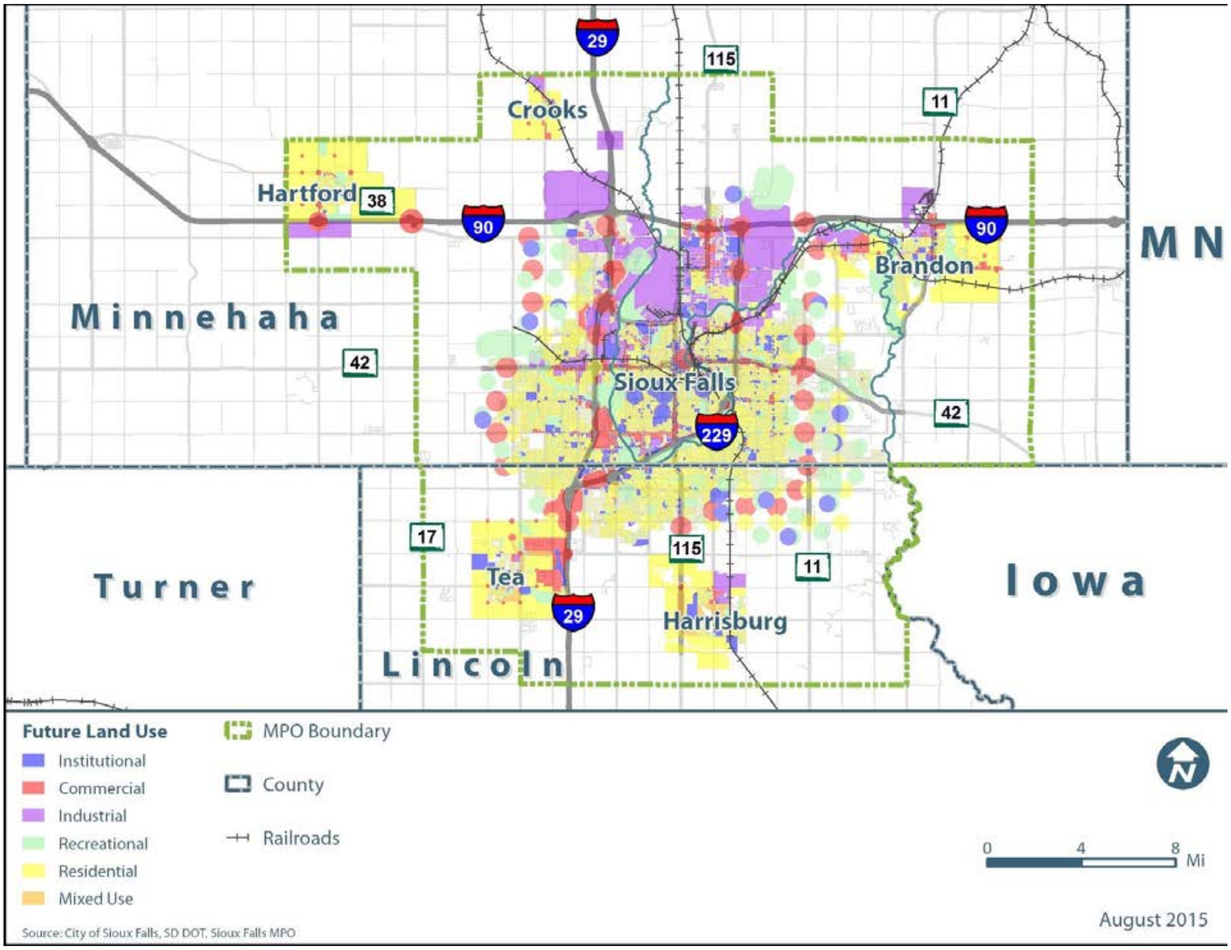
Land Use Activity	Area (acres)	Percent of Total Area
Private/Public ROW	258	0.4%
Single and Two Residential	27,100	40.7%
Multi-Family Residential	3,591	5.4%
Office and Public Service	3,918	5.9%
Institutions/Education/Public Assembly	2,305	3.5%
Commercial	4,925	7.4%
Industrial	10,377	15.6%
Active Recreation	2,579	3.9%
Passive Recreation and Natural Resources	7,666	11.5%
Agriculture and Transition Sites	1,675	2.5%
Rural Developments	2,208	3.3%
Total	**66,602**	**100.0%**

Source: City of Sioux Falls Planning and GIS Department future land use and parcel land use database.

Regional Customers

Future land use for potential regional customers was gathered during the 2040 Long-Range Transportation Plan. Figure 2.12 identifies various employment nodes and other future land uses within Sioux Falls and the surrounding region.

Figure 2.12 Future Land Use for Regional Communities



2.6 Establish Guiding Regional Principles and Financial Policies

The City, with assistance from HDR, reviewed a number of guiding principles for regionalization and used them to develop the general approach for establishing regional wastewater rates and system development charges. For reference, the Executive Summary and Fact Sheets 1 through 4 for the 2011 City of Sioux Falls – Regional Wastewater Feasibility Study are provided in Appendix 2.A.

Financial policies were developed to provide the framework for the development of regional rate methodology and system development charges. In establishing a regional system, it is imperative that a rate-setting framework be established in order for all regional customers to understand the approach and methodology that will be used by the City to establish regional rates and system development charges on a fair and equitable basis. The foundation of successful regional systems is treating all parties (owners and regional customers) in a fair, equitable and transparent manner, particularly as it relates to the rate setting process.

"The foundation of successful regional systems is treating all parties (owners and regional customers) in a fair, equitable and transparent manner, particularly as it relates to the rate setting process."

Some of the more important and prominent principles and policies related to the establishment of a regional wastewater system are as follows:

- The City owns and operates the regional wastewater system. Local collection systems are owned and operated by the local entity.
- The regional system is defined as the City's wastewater treatment facilities and a portion of the City's interceptor/collection system needed to serve regional customers. Extensions required to connect a regional customer(s) to the regional interceptor shall be paid for/funded by the local agency(s) that benefits from the extension.
- The City will use "generally accepted" rate setting methods to establish the regional rates and fees. A cost of service analysis will be used to equitably allocate the City's total wastewater system costs between the Regional Wastewater System and the City's retail customers. The City, as the owner of the Regional System, shall be entitled to earn a "fair" return on their investment to serve the regional customers.
- For purposes of the regional system, the City shall be defined as a regional customer, along with all other regional customers.
- System development charges (SDCs) shall be paid by all new regional customers connecting to the regional system and any customers expanding their existing capacity. All regional SDCs shall be used for expansion-related needs of the regional system.
- Local government shall retain responsibility for local rate setting. How regional rates and SDCs are passed through to local customers shall remain a local policy decision.

Given this basic framework of principles and financial policies, the regional wastewater rates and system development charges should be developed. The attached Appendix 2.A for the 2011 City of Sioux Falls – Regional Wastewater Feasibility Study further defines the methodology for a fair and equitable solution.

2.7 Abbreviations

CIP	Capital Improvement Plan
Corps	U.S. Army Corps of Engineers
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GPM	Gallons per Minute

MGD	Million Gallons per Day
MPO	Metropolitan Planning
SECOG	South Eastern Council of Governments
SDDOT	South Dakota Department of Transportation
TAZ	Traffic Analysis Zone
USFWS	United States Fish and Wildlife Service
WRF	Water Reclamation Facility

2.8 References

- Sioux Falls Parcel and Land Use Data
- Shape Sioux Falls 2035 Comprehensive Plan (2009)
- Sioux Falls Long Range Traffic Model
- Sioux Falls Wastewater Collection System Historical Flows and Monitoring Data
- Sioux Falls Wastewater Water Reclamation System (WRF) Historical Flows
- City of Sioux Falls Membrane Bioreactor (MBR) Eastside Sanitary Sewer System (ESSS) Satellite WRF Siting Study, November 2011
- Historical Water Meter Reading Data
- FEMA 1% Annual Floodplain
- USFWS National Wetland Inventory
- 2011 City of Sioux Falls – Regional Wastewater Feasibility Study

Chapter 3 - Existing Wastewater System Facilities

Wastewater Treatment and Collection System Master Plan

Sioux Falls, SD

February 2018

Table of Contents

Tables

Figures

Appendices

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Chapter 3 Existing Wastewater System Facilities

3.1 Introduction

The objective of this chapter is to summarize the City of Sioux Falls' (City) existing collection and treatment facilities and physical condition of select collection system pump stations and forcemains along with the Water Reclamation Facility (WRF) treatment facilities. The approach to achieving this goal was to evaluate the existing systems and prioritize the need for upgrades and/or replacement due to lack of capacity or age and condition.

A Technical Memorandum (TM) is located in Section 3-B of the appendix to allow the City and staff to be informed at a high level of detail of the condition assessment for the collection system pump stations and forcemain along with the WRF facilities. The summary and recommendations from this TM form the basis of the condition assessment portions of this chapter.

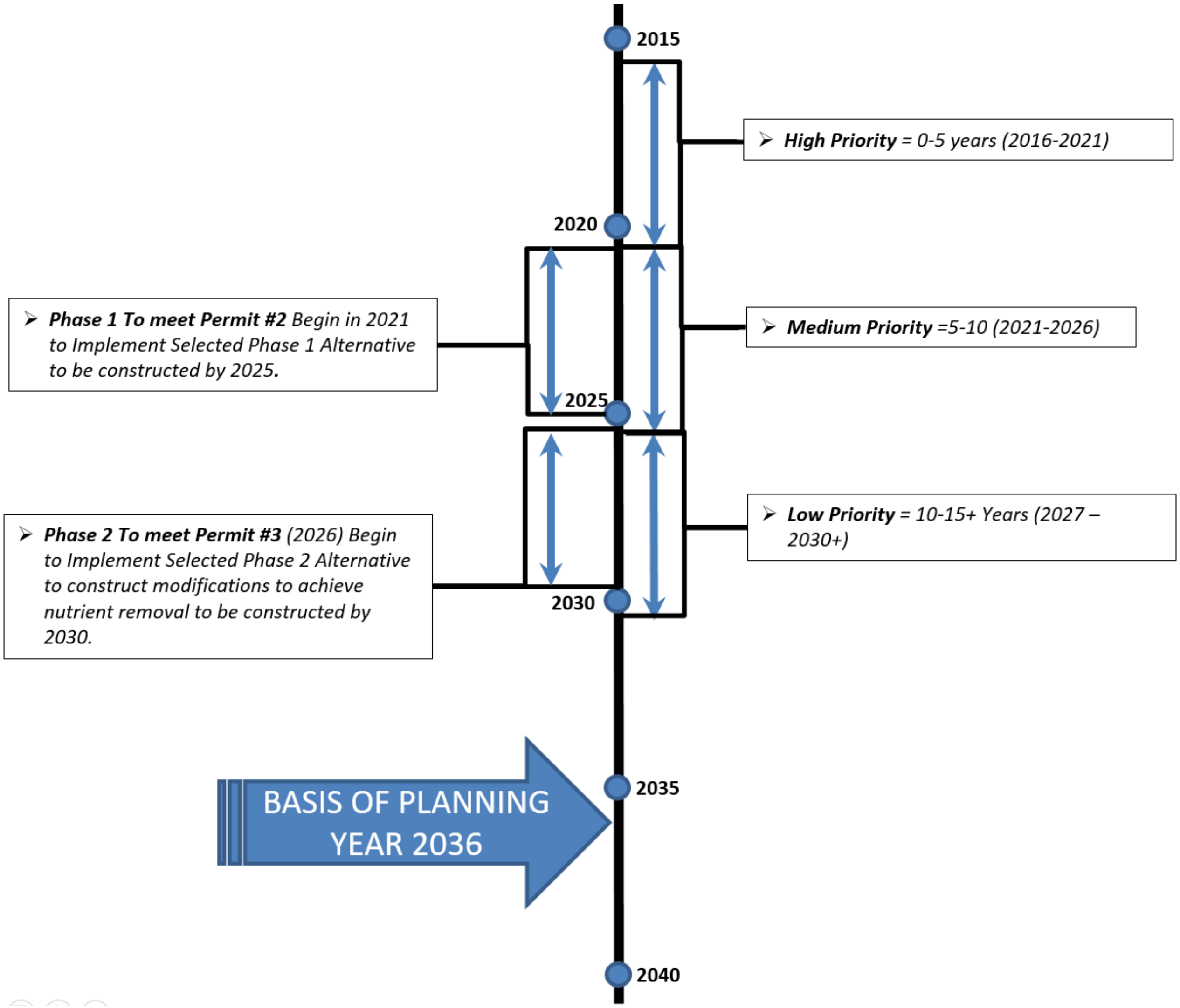
3.2 Priority for Condition-Driven Improvements

Numeric values associated with each asset condition have been developed in order to provide a complete picture of the value, condition, risk and impact of its loss or failure. Considerations such as run-to-fail operations, need for redundancy, risk tolerance, worker safety, etc. all needed to be recognized in their proper priority.

Priority for condition-driven improvements has been rated as High, Medium and Low. **Those assets with a High rating should be addressed immediately**. Assets rated as Medium can continue operating, but should be upgraded and/or replaced within the next 5 – 10 years. The Low priority rated assets are assumed to be operational for the next 10 – 20 years.

The costs for the recommended improvements that coincided with Phase 1 improvements were include as part of the larger project. Refer to Figure 3.1 for a timeline depiction of how the condition assessment corresponds to the bigger picture phased treatment improvements.

Figure 3.1 Priority for Condition-Driven Improvements

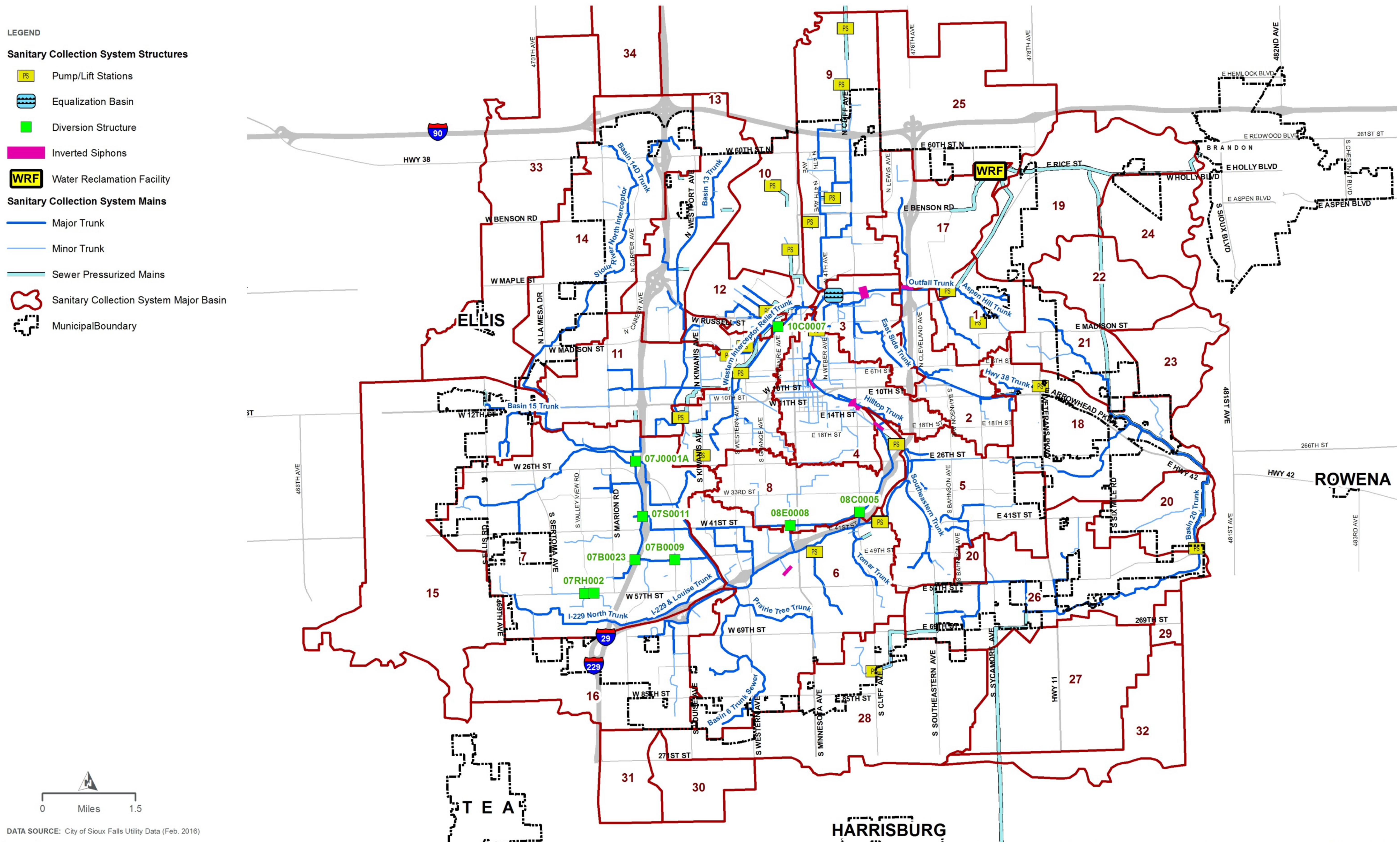


3.3 Existing Collection System

The City's sanitary sewer collection system infrastructure serves a residential population of approximately 166,500 as of 2015. The City's collection system infrastructure consists of gravity mains, manholes, inverted siphons, lift stations and forcemains, flow equalization storage, and diversion structures. The City provided their latest GIS information on February 6, 2016 which this existing system inventory is primarily based on; in addition, select as-built drawings, pump curves and test data, and other existing information were provided to inform the facility inventory and summary of the existing collection system for hydraulic modeling and evaluation purposes.

Figure 3.2 provides an overview of the existing collection system components discussed in the following sections. Appendix 3-A provides a map of the existing system with more details.

Figure 3.2 Existing Collection System Overview



3.3.1 Sanitary Sewer Basins

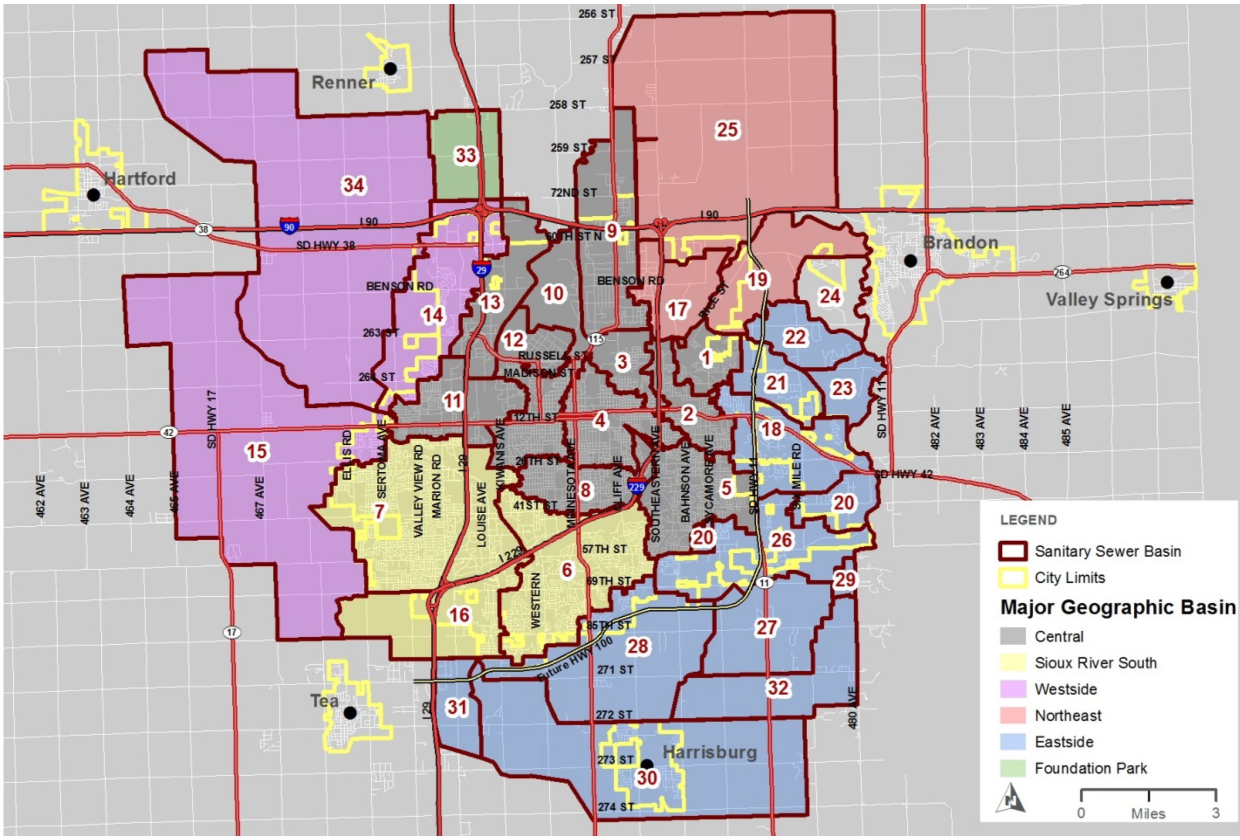
Sanitary sewer basins define areas within the service area from which flows can be collected and conveyed by gravity to the WRF. In some cases a group of basins then need to be served by lift stations to convey the flow into another gravity basin or directly to the WRF. Previously, the 1990 Wastewater Collection System Facilities Plan identified 13 major drainage basins within the existing sanitary sewer system. In the 2002 Sanitary Sewer Collection System Facilities Plan an additional 16 basins were added for a total of 29 basins to accommodate from recent and projected future growth areas.

For this Master Plan, the City provided sanitary sewer basins, or pipe-sheds, as part of their GIS data. There are 226 sub-basins in 34 major basins that total 144 square miles. An additional 5 sanitary sewer basins are added around the periphery of the City since the last collection system planning study to allow for additional growth area. The number of sub-basins increased from 184 in the 2002 plan to 226 during this Master Plan. These basins do not include the outlying municipalities of Renner or the Cities of Tea, Harrisburg, Crooks, or Hartford or a large portion of the City of Brandon. The major sewer basins used during this Master Plan are depicted in Figure 3.3.

The topography covered by these sanitary sewer basins covers more than 300 feet in elevation changes between the highest areas served and the existing WRF. The highest area of the system is generally located on the west side of the City. There are several areas lower such as the entire eastside system that needs to be pumped to the WRF due to the ridge that travels around the City on the east (Great Bear Ski Area). The steepest slopes are along the embankments surrounding the Big Sioux River.

Of these basins, 166 sub-basins in 25 major basins that total of 89 square miles contain existing sanitary collection system infrastructure. The remaining major basins and sub-basins are representative of future growth potential for the collection system to support City or surrounding municipality growth and development. The extents of the basins cover the 100-year planning boundary and consistent of a mixture of gravity and lift station served areas. Where gravity service is possible, most of the basins were extended to their gravity boundaries to maximize the servable area in the future without providing lift stations.

Figure 3.3 Sioux Falls Major Sanitary Sewer Basins



3.3.2 Sewer Mains

The City's 2016 GIS database contained 16,050 sanitary collection gravity mains (excluding future mains, services and stub-outs), 12,000 of which contain pipe inverts and 15,900 contain diameter information. Of these gravity mains, 11,440 are standard mains, 1,100 are minor trunk mains, 2,030 are trunk mains, and 1,470 are private mains. Table 3.1 lists the major and minor trunk sewers in the City's collection system as identified in the 2016 GIS. Appendix 3.A contains a color coded map detailing the extents of the trunk sewers. There are ten major interceptors within the collection system as follows:

- Outfall Trunk
- Central Main Interceptor
- Northeast Trunk Interceptor
- Sioux River North Interceptor
- Sioux River South Interceptor
- South Side Interceptor
- South Sioux Interceptor
- Western Interceptor
- Western Interceptor Relief Trunk
- Westside Relief Interceptor

These major interceptors are shown in bold text in Table 3.1 and are also shown in Figure 3.2.

The existing system consists of a total of 846 miles ranging from 6 through 66 inches in diameter. Several locations were surveyed as part of the Master Plan either to confirm discrepancies in pipe diameter or slope or fill data gaps in the trunk system. The surveyed attributes were updated in the Master Plan GIS database and in the hydraulic model as discussed in Chapter 5. Table 3.2 lists the total length of gravity sewer mains by diameter and material as of the February 2016 GIS database provided by the City.

Table 3.1 Trunk Sewers within the City of Sioux Fall's Existing Collection System

Trunk Sewer Name	Pipe Diameter Range	Length of Sewer Pipe (ft)	Trunk Sewer Name	Pipe Diameter Range	Length of Sewer Pipe (ft)
Aspen Hill Trunk	8-in — 15-in	10,080	**Northeast Trunk Interceptor**	**8-in — 24-in**	**19,910**
Aspen Hill Trunk Extension	8-in	400	Old Northeast Trunk	10-in — 12-in	1,860
Aspen Trunk	12-in — 15-in	570	Orchard Heights Trunk	8-in	1,600
Basin 13 Trunk	8-in — 42-in	32,530	**Outfall Trunk**	**8-in — 66-in**	**19,260**
Basin 14D Trunk	8-in — 10-in	5,550	Pam Road Trunk	10-in — 21-in	7,310
Basin 15 Trunk	8-in — 18-in	11,760	Prairie Tree Trunk	8-in — 21-in	16,730
Basin 20 Trunk	8-in — 42-in	15,820	Richmond Estates Trunk	8-in — 10-in	6,590
Basin 6 Trunk Sewer	15-in — 18-in	7,250	**Sioux River North Interceptor**	**8-in — 42-in**	**69,450**
Bypass on Western Interceptor	10-in — 24-in	6,140	**Sioux River South Interceptor Trunk**	**24-in — 54-in**	**21,050**
Central Main Interceptor	**10-in — 60-in**	**41,100**	Sioux River South Interceptor Trunk Extension	12-in — 24-in	17,640
Columbia Heights Trunk	10-in — 12-in	5,410	Sioux River South Trunk	8-in — 36-in	28,240
Diamond Field Estates Trunk	8-in — 24-in	10,890	**South Side Interceptor**	**18-in — 24-in**	**9,400**
East Side Trunk	8-in — 24-in	28,360	**South Sioux Interceptor**	**10-in — 54-in**	**11,770**
Golden Valley Trunk	8-in — 12-in	3,970	South Sioux Interceptor Trunk	8-in — 15-in	15,900
Hayward Sewer Dist. Trunk	8-in — 24-in	16,230	Southeastern Trunk	8-in — 24-in	12,430
Hayward Trunk	10-in — 24-in	3,770	Southwest Sanitary Sewer District	10-in — 18-in	9,920
Hilltop Heights Trunk	10-in — 12-in	2,080	Southwest Trunk	8-in — 24-in	15,380
Hilltop Trunk	10-in — 15-in	4,450	Sunny view Acres Trunk	10-in — 12-in	2,450
Holiday Estates Trunk Sewer	8-in — 10-in	2,940	Tomar Heights Trunk	10-in — 12-in	1,800
Hwy 38 Trunk	8-in — 15-in	9,810	Tomar Trunk	8-in — 12-in	5,670
I-229 & Louise Trunk	18-in — 24-in	4,220	**Western Interceptor Relief Trunk**	**8-in — 36-in**	**27,580**
I-229 North Trunk	12-in — 18-in	11,450	Western Interceptor Relief Trunk Sewer Extension	12-in — 24-in	4,160
I-229 Trunk	12-in — 15-in	3,750	**Western Interceptor Trunk**	**10-in — 36-in**	**7,800**
Lincoln Hills Trunk	10-in	3,290	**Westside Relief Interceptor**	**18-in — 30-in**	**6,270**
Lower Riverside Trunk Sewer	10-in — 36-in	17,170	Whispering Woods Trunk Sewer	10-in — 21-in	11,050
Morningside Trunk	8-in — 18-in	17,420	Unnamed Trunk Sewers		301,250

Source: City of Sioux Falls GIS Geodatabase, February, 2016
Note: Interceptor Sewers are in Bold

Table 3.2 Gravity Sewer Mains by Material and Diameter

Diameter	Cast Iron Pipe Unlined (CIPU)	Cobblestone	Ductile Iron Pipe (DIP)	High Density Polyethylene (HDPE)	HOBAS (Centrifugally Cast Glass Fiber Reinforced (GRP)	Polyvinyl Chloride Pipe (PVC)	Reinforced Concrete Pipe (RCP)	Steel	Truss Black (ABS)	Truss White (PVC)	Vitrified Clay Pipe (VCP)	VCP Lined	Unlabeled	Total Length (ft)
varies						2,357				562	2,187		23,323	**28,430**
4”			83			361					90		127	**661**
6”	878		294	610		20,069				7,414	41,179		34,225	**104,669**
8”	10,775		2,827	325		1,518,984	15	303	38,056	350,030	1,230,541	1,040	168,508	**3,321,404**
10”	4,242		668	314		99,059			4,251	15,004	96,290		8,120	**227,951**
12”	1,339		1,700	821		75,031			3,572	10,250	55,232		7,525	**155,470**
15”	210		603	556		41,675	313			6,762	53,350		8,488	**111,956**
16”	277		618			81								**976**
18”	126		407			54,340	834			450	36,398		6,763	**99,318**
20”	122										3,209			**3,331**
21”			164			54,583	500			95	9,176		7,227	**71,745**
24”	328		1,424	1,032		50,302	9,229				27,739		2,295	**92,349**
30”			2,414		5,101	18,066					477		516	**26,575**
32”		27			829		180							**1,036**
36”		1,166	3,892		1,429	9,067	17,609				622		364	**34,148**
38”		479												**479**
40”		1,078				405	671							**2,154**
42”			395		4,900	6,617	494							**12,405**

Table 3.2 Gravity Sewer Mains by Material and Diameter

Diameter	Cast Iron Pipe Unlined (CIPU)	Cobblestone	Ductile Iron Pipe (DIP)	High Density Polyethylene (HDPE)	HOBAS (Centrifugally Cast Glass Fiber Reinforced (GRP)	Polyvinyl Chloride Pipe (PVC)	Reinforced Concrete Pipe (RCP)	Steel	Truss Black (ABS)	Truss White (PVC)	Vitrified Clay Pipe (VCP)	VCP Lined	Unlabeled	Total Length (ft)
48”					495	604	1,739						119	**2,956**
54”					23,199									**23,199**
60”			793		13,067								102	**13,962**
66”				401			10,232							**10,633**
Total	**18,297**	**2,750**	**16,283**	**4,058**	**49,020**	**1,951,601**	**41,816**	**303**	**45,879**	**390,567**	**1,556,491**	**1,040**	**267,701**	**4,345,807**

Source: City of Sioux Falls GIS Geodatabase, February, 2016

The upstream and downstream manhole identifiers are combined for unique sewer main identifiers in hydraulic model conduit elements to maintain integration with the City's GIS system.

3.3.3 Sewer Manholes

The City's 2016 GIS database contained 15,686 sanitary collection manholes (excluding those associated with future mains, services and stub-outs). Most manholes are identified using a seven-character string (e.g. 07S0011). The first two characters of the string identify the major basin number (e.g. 07) while the third character designates the sub-basin within the major basin (e.g. S). The remaining four characters are the unique manhole number within the major and sub-basin. Some manhole identifiers are up to eight characters due to sub-basins that have been added since the original sub-basin numbering. These unique identifiers are used in the hydraulic model junction elements to maintain integration with the City's GIS system.

Of the 15,686 manholes in the GIS, 1,277 were missing invert, diameter, and rim elevation. The process to fill in the missing data gaps for hydraulic modeling is provided in Chapter 5.

The City has flow monitors for measuring sewer flows throughout the service area that they install in manholes. Chapter 5, Collection System Model Development and Calibration, has additional information about the flow monitors and where they were installed in the system for the Master Plan.

3.3.4 Diversion Structures

There are numerous apex manholes and inter-basin flow splits within the City's collection system; however, there are eight major diversions in the trunk mains that direct substantial volumes of flow to other basins. These diversion structures are listed in Table 3.3 and shown on Figure 3.2.

Other locations where the flow splits into two downstream sewers, such as apex manholes in the local collection system, are included in the GIS and model but were not surveyed or otherwise studied in-depth. The manhole identifiers for the diversion structures are used in the hydraulic model to represent the junction elements and maintain integration with the City's GIS system.

Table 3.3 Diversion Structures within the City of Sioux Fall's Existing Collection System

Location	Upstream Manhole	Elevations	Notes
Western Interceptor Relief Trunk to the Bypass on the Western Interceptor; Intersection of West Bailey St and North Summit Ave	10C0007	• Rim Elev. = 1422.5 • Invert In (24" SW) = 1413.28 • Invert Out (24" NE) = 1313.14 • Overflow Weir (NW) = 1414.08 • Overflow Invert Out (18" NW) = 1412.23	The flow from 10C0007 typically continues northeast through the Western Interceptor Relief Trunk, but can overflow to the northwest into the Bypass on the Western Interceptor via and overflow weir to end up at pump station 203.

Table 3.3 Diversion Structures within the City of Sioux Fall's Existing Collection System

Location	Upstream Manhole	Elevations	Notes
Intersection of the Sioux River South Trunk and Westside Relief Interceptor; west of I-29 and north of West 26th St.	07J0001A	• Rim Elev. = 1414.21 • Invert In (30" S) = 1399.64 • Invert In (24" W) = 1399.76 • Invert Out (30" N) = 1399.64 • Overflow Invert Out (24" E) = 1400.71	The flow from 07J0001A typically flows north to the Sioux River North Interceptor, but can flow east to sub-basin 07F through the Sioux River South Trunk as overflow.
Intersection of the Southwest Trunk and Westside Relief Interceptor; west of I-29 along West 37th St.	07S0011	• Rim Elev. = 1414.14 • Invert In (21" W) = 1405.94 • Invert Out (30" N) = 1405.04 • Overflow Invert Out (21" E) = 1407.04 (plugged)	The flow from 07S0011 typically flows north through the Westside Relief Interceptor, but can flow east to sub-basin 07F through the Southwest Trunk as overflow. The flow to the east is currently (2016) plugged.
Fork in the Southwest Sanitary Sewer District Trunk; west of I-29 and north of West 49th St.	07B0023	• Rim Elev. = 1441.11 • Invert In (12" SW) = 1427.81 • Invert Out (12" E) = 1427.91 (plugged) • Overflow Weir = 1428.47 • Overflow Invert Out (12" NE) = 1427.26	The flow from 07B0023 typically goes east to end up in the Sioux River South Trunk, but can flow north to sub-basin 07H through the Southwest Sanitary Sewer District Trunk as overflow. Sometime after 2010 a plug was installed that keeps the flow from going east under the I-29 to the Sioux River South Trunk and sends all of the flow to the north through the Southwest Sanitary Sewer District Trunk. There is a weir in the manhole that is 1.2 feet above the manhole invert for the outlet to the northeast, meaning that water is allowed to back up against this weir with the east outlet plugged.
Intersection of the and Pam Road Trunk and South Side Interceptor; Intersection of South Cliff Ave and East Pam Road (near Lincoln HS)	08C0005	• Rim Elev. = 1405.67 • Invert In (20" SW) = 1399.57 • Invert In (12" NW) = 1400.37 • Invert Out (20" NE) = 1399.57 • Invert Overflow Out (12" SE) = 1399.67; pipe flows over bench for main trunk line to get to SE overflow pipe.	The main trunk sewer flows from southwest (Pam Road Trunk) to northeast (South Side Interceptor), but the flow can divert over a bench southeast back into the Pam Road Trunk and flow into sub-basin 06AB. The overflow reaches the Tuthill lift station.

Table 3.3 Diversion Structures within the City of Sioux Fall's Existing Collection System

Location	Upstream Manhole	Elevations	Notes
Intersection of West 41st St and South Duluth Ave.	08E0008	• Rim Elev. = 1415.66 • Invert In (21" W) = 1407.54 • Invert In (15" N) = 1407.28 • Invert Out (24" S) = 1404.18 • Invert Out (21" E – overflow) = 1407.38	The main trunk sewer flows south into the Sioux River South Interceptor with a 21" DIP/PVC overflow pipe to the east into the Pam Road Trunk that runs from the intersection of 41st and Duluth to the intersection of 41st and Spring and is designed to only be used when MH 08E0008 is surcharged approx. 3 feet. Due to storm sewer conflicts through the intersection, there is a siphon in the 21" pipe. The west pipe is also a 21" PVC pipe. The designed functioning outlet pipe is a 24" PVC generally @ 0.5% all the way south across I-229 to the Sioux River South Interceptor
Intersection of West 57th Street and South Holbrook Avenue	07RH005	• Rim Elev. = 1494.81 • Invert In (8 or 10" W) = 1483.51 • Invert In (8 or 10" S) = 1484.51 • Invert Out (10" E) = 1483.36 • Invert Overflow out (10" N) = 1484.41	Flow typically goes east to the I-229 North Trunk but can overflow to the north to the Sioux River North Interceptor Sewer Trunk.
Intersection of West 57th Street and South Drexel Drive	07RH002	• Rim Elev. = 1490.38 • Invert In (8" W) = 1474.68 • Invert Out (10" E) = verify • Invert Out (8" N) = 1474.68 (plugged)	Flow typically goes east to the I-229 North Trunk, but can overflow to the north to the Southwest Sanitary Sewer District Trunk. Currently (2016) the pipe to the north is plugged.
Intersection of the Sioux River South Trunk and Southwest Trunk; Intersection of South Louise Ave and West 49th St.	07B0009	• Rim Elev. = 1409.94 • Invert In (16" S) = verify • Invert Out (15" NE) = 1403.18 • Overflow Invert Out (15" N) = 1404.01 (plugged)	Flow typically goes east through the Sioux River South Trunk, but can overflow to the north to Southwest Trunk. Currently (2016) the pipe to the north is plugged.

Sources: City of Sioux Falls GIS Geodatabase, February, 2016; City of Sioux Falls Workshop, June, 2016; email correspondence; as-built plans

3.3.5 Inverted Siphons

There are seven (7) known inverted siphons in the City's collection system and they are summarized in Table 3.4 with their location, upstream and downstream manholes and their general configuration and pipe diameters. The data for these was obtained from as-builts' and the City's GIS database. All of these siphons are contained in the hydraulic model. The Basin 17 Siphon underneath the Big Sioux River west of I-229 is being considered for elimination during this plan through a gravity rerouting of the upstream sewers to the east.

Table 3.4 Inverted Siphons within the City of Sioux Fall's Existing Collection System

Name	Location	Upstream Manhole	Downstream Manhole	Configuration	Length
Outfall Trunk siphon	Outfall trunk sewer underneath the Big Sioux River east of Cliff Ave at Lien Park	03A0005	03A0004	3 Parallel Inverted Siphons: • 1x22-inch diameter • 1x27-inch diameter • 1x32-inch diameter • 1x36-inch diameter (new)	~690 ft
Beadle Park siphon	Minor trunk sewer underneath the Big Sioux River west of Cliff Ave at Beadle Park	04G0001	04H0005	1 Inverted Siphon: • 8-inch diameter	~250 ft
Phillips Avenue Siphon	Sewer main underneath the Big Sioux River northeast of the N Phillips Ave./E 9th St intersection	04JA001	04J0001	1 Inverted Siphon: • 12-inch diameter	~230 ft
Cherry Rock Siphon	South Side Interceptor underneath the Big Sioux River at Cherry Rock Ave northeast of E River Blvd	08A0004	08A0003	1 Inverted Siphon: • 11.75-inch diameter	~265 ft
Duluth Ave/41st St Overflow Siphon	Overflow trunk at W 41st St east of S Duluth Ave	08E0008	08E0006	1 Inverted Siphon: • 21-inch diameter	~25 ft
Basin 17 Siphon	Basin 17 trunk underneath the Big Sioux River West of I-229	17A0001A	02A0007A	2 Parallel Inverted Siphons: • 2x8-inch diameter	~310 ft

Sources: City of Sioux Falls GIS Geodatabase, February, 2016; *Sanitary Sewer Collection System Facilities Plan* (Black & Veatch, 2002)

3.3.6 Lift Stations and Forcemains

Table 3.5 contains a list of the inventoried lift stations for which data is available. The flow rating, the manufacture's actual approximated flow, and pump flow testing data from 2013 and 2009 were gathered from the City (Table 3.7). The firm capacities of the lift stations summarized is based on the pump flow testing or original pump curve information using the most current data available with one pump out of service. Lift station operation curves from the previous modeling efforts were compared to this data and adjusted as necessary. Pump operation curves were extracted from the *Sanitary Sewer Collection System Facilities Plan* (Black & Veatch, 2002) model and adjusted based on the information reflected in Table 3.7. There are several lift stations which have permanent SCADA facilities for confirming flows within the hydraulic model which is discussed in more depth in Chapter 5. The lift station identification numbers in Table 3.5 are used with a suffix of .1, 0.2, etc. for each pump element in the hydraulic model.

Table 3.5 Lift/Pump Stations within the City of Sioux Fall's Existing Collection System

Pump ID	Alternative ID	Location	Number of Pumps	Public/Private	Status
LS #200	Brandon Rd. (Main) Pumping Station	3300 E. Rice St.	4	City-owned	Modeled
LS #201	2nd & Brookings	1000 Blk. N. 2nd	2	City-owned	Modeled
LS #202	Air Terminal	South End of Costello Terminal	2	Airport-owned	Modeled
LS #203	Cherokee and "C"	Cherokee and C Ave.	3	City-owned	Modeled
LS #204	Modern Press	806 N. West Ave.	2	City-owned	Modeled
LS #205	6th & Hawthorne	6th & Hawthorne, 300 Blk. N.	2	City-owned	Modeled
LS #206	Burnside	1800 Burnside	2	City-owned	Modeled
LS #213	23rd & Kiwanis	1421 S. Kiwanis	2	City-owned	Modeled
LS #215	Sioux River North	3301 W. 12th St.	4	City-owned	Modeled
LS #218	Tuthill Park Lift Station	3500 S. Blauvelt	4	City-owned	Modeled
LS #220	Rock Island, Riverside Park	1260 S. Blauvelt	2	City-owned	Modeled
LS #221	Sycamore & Vail	1116 N. Sycamore	2	City-owned	Modeled
LS #224	50th Street North	716 E 50th St N. RJ	2	City-owned	Modeled
LS #225	40th Street North	210 E. 40th Street North	2	City-owned	Modeled
LS #226	Fire Training Center	Airport	2	Private	Not Modeled
LS #227	Rainbow Stables	201 Powderhouse Rd.	2	City-owned	Modeled
LS #230	Humane Society	3720 E Benson Rd	2	Private	Not Modeled
LS #239	Diamond Valley	7301 S Cliff Ave.	2	*City-owned*	Modeled
LS #240	ESSS Lift Station	9400 E 57th St.	3	City-owned	Modeled
LS #241	*Park 8*	At WRF 4500 N. Sycamore	2	*City-owned*	Not Modeled
LS #242	National Guard North	701 W National Guard Dr. PF	2	Private	Not Modeled
Sources: City of Sioux Falls GIS Geodatabase, February, 2016; City Lift Station table					

Table 3.6 Abandoned Lift/Pump Stations within the City of Sioux Fall's Existing Collection System

Pump ID	Alternative ID	Location	Number of Pumps	Public/Private	Status
LS #207	Ramada Inn	2902 W. Russell	2	City-owned	Abandoned
LS #208	Rice & Kiwanis	1400 N. Kiwanis	2	City-owned	Abandoned
LS #209	9th & Kiwanis	101 N. Kiwanis	3	City-owned	Abandoned
LS #216	Summerhill South	4813 S. Sycamore	-	City-owned	Abandoned
LS #217	26th & Dubuque	5211 E. 26th St.	2	City-owned	Abandoned
LS #219	Haley & Bailey	1231 N. Haley Ave.	2	City-owned	Abandoned
LS #228	Arena LS	1201 Northwest Ave.	2	Private	Abandoned
LS #229	*Now LS #242*	701 W National Guard Dr.	2	Private	Abandoned

Table 3.7 Lift/Pump Station Operation Characteristics within the City of Sioux Fall's Existing Collection System

Pump ID	Number of Pumps	Dry Well Depth (ft)	Wet Well Depth (ft)	Pump Rating (gpm)	Average Actual (gpm)	Total Dynamic Head (ft)	2013 Flow Testing (gpm)	2009 Flow Testing (gpm)	Firm Capacity (mgd)
LS #200 Brandon Road	4	-	-	*9400*	-	*105*	*No Data*	*No Data*	*40.6* *65.5 with 36 & 42*
LS #201	2	20	19.33	200	166	50	*No Data*	*No Data*	0.24
LS #202	2	21	18.5	300	215		214	214	0.31
LS #203	3	22	21	1,100		56	1,093	1,128	3.15
LS #204	2	17	16.33	200	460		470	433	0.66
LS #205	2	14	14	150	450	19	224	460	0.65
LS #206	2	19	19.5	500	525	23	547	558	0.76
LS #207	-	-	-	-	-	-	-	-	-
LS #208	-	-	-	-	-	-	-	-	-
LS #209	-	-	-	-	-	-	-	-	-
LS #213	2	14	13.08				102	160	0.15
LS #215	4	24	43.5	2,000/ 3,333		90/66	3,264	*No Data*	10.46

Table 3.7 Lift/Pump Station Operation Characteristics within the City of Sioux Fall's Existing Collection System

Pump ID	Number of Pumps	Dry Well Depth (ft)	Wet Well Depth (ft)	Pump Rating (gpm)	Average Actual (gpm)	Total Dynamic Head (ft)	2013 Flow Testing (gpm)	2009 Flow Testing (gpm)	Firm Capacity (mgd)
LS #216	2	22	19	660	580	100	*No Data*	*No Data*	0.84
LS #217	-	-	-	-	-	-	-	-	-
LS #218	4	31	31	3500	3,343	30	3,435	3,427	14.44
LS #219	-	-	-	-	-	-	-	-	-
LS #220	2	20	20.5		335		346	378	0.48
LS #221	2	18	15	100	158	45	175	178	0.23
LS #224	2	31	29	800	665	27	915	643	0.96
LS #225	2	21	18.67		158		155	135	0.23
LS #226	2	18	16		125		118	115	0.18
LS #227	2	30	29	750	630	130	680	683	0.91
LS #228	-	-	-	-	-	-	-	-	-
LS #229	2	13	11.75		160	50			0.23
LS #230	2		1	45		124			0.06
LS #233	2	26	25.5	300	330	34		283	0.48
LS #234	2	26	25.5		225			203	0.32
LS #235	2	21	21		125			135	0.18
LS #236	2	0.8	23.17		120			118	0.17
LS #237	2		26						0.08
LS #239	2	31	29.5	*1255*		-	935	1,110	1.35
LS #240	3	36	36.83	2,000		170	1,623	1,622	3.5
LS #241	2			200		18			0.29
LS #242	2	28	28.08	100		41	118		0.17

Sources: City of Sioux Falls GIS Geodatabase, February, 2016; City Lift Station table; City Flow Testing Results; 2002 Black & Veatch Hydraulic Model

Table 3.8 presents the city-owned forcemain information associated with each lift station in Table 3.5, for a total length of 151,390 feet in the existing collection system.

Table 3.8 Forcemains within the City of Sioux Fall's Existing Collection System

Pump ID	Alternative ID	Location	Diameter (inch)	Length (feet)
LS #200 Brandon Road	Brandon Rd. (Main) Pumping Station	3300 E. Rice S.	Dual FMs @ 36/42	12,306
LS #201	2nd & Brookings	1000 Blk. N. 2nd	4	408
LS #202	Air Terminal	South End of Costello Terminal	6	3,852
LS #203	Cherokee and "C"	Cherokee and C Ave.	Dual FMs @ 2 @ 12	6,336
LS #204	Modern Press	806 N. West Ave.	8	678
LS #205	6th & Hawthorne	6th & Hawthorne, 300 Blk. N.	6	370
LS #206	Burnside	1800 Burnside	8	477
LS #213	23rd & Kiwanis	1421 S. Kiwanis	4	463
LS #215	Sioux River North	3301 W. 12th St.	36	18,041
LS #218	Tuthill Park Lift Station	3500 S. Blauvelt	42	716
LS #220	Rock Island, Riverside Park	1260 S. Blauvelt	8	1,457
LS #221	Sycamore & Vail	1116 N. Sycamore	4	403
LS #224	50th Street North	50th Street North	10	1,130
LS #225	40th Street North	210 E. 40th Street North	4	573
LS #226		Airport	4	5,993
LS #227	Highway 38A	201 Powderhouse Rd.	8	4,475
LS #229		701 W National Guard Dr.	4	2,471
LS #230		3720 E Benson Rd	2.5	6,912
LS #239	Diamond Valley	7301 S Cliff Ave.	10	16,937
LS #240	ESSS Lift Station	9400 E 57th St.	16	50,303
LS #241	Park 8 LS	4500 N Sycamore Ave	6	--
LS #242	National Guard LS	North end of airport	4	2,470

The abandoned forcemains within the city are listed in Table 3.9.

Table 3.9 Abandoned Forcemains within the City of Sioux Fall's Existing Collection System

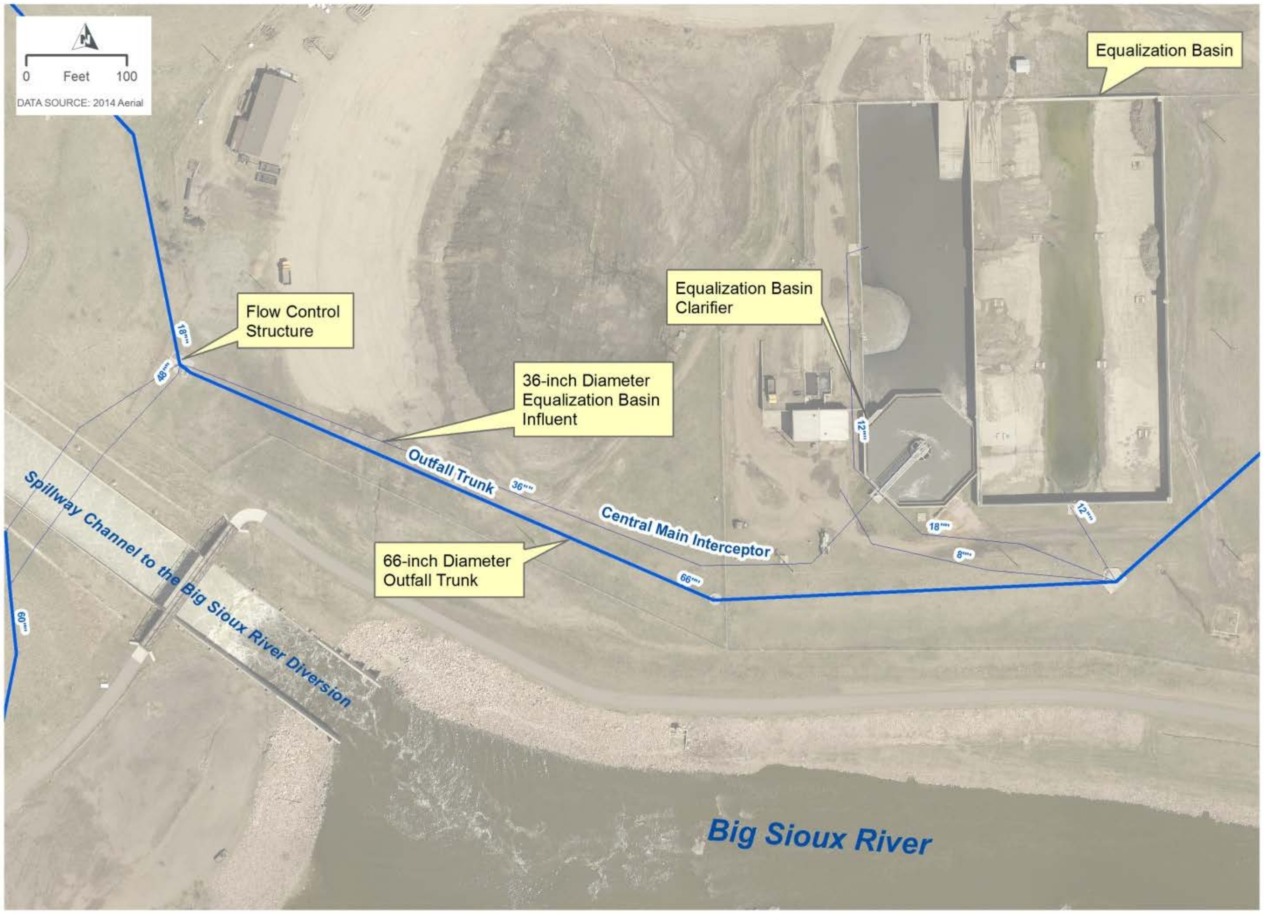
Pump ID	Alternative ID	Location	Diameter (inch)	Length (feet)
LS #207	Ramada Inn	2902 W. Russell	Abandoned	Abandoned
LS #208	Rice & Kiwanis	1400 N. Kiwanis	Abandoned	Abandoned
LS #209	9th & Kiwanis	101 N. Kiwanis	Abandoned	Abandoned
LS #216	Summerhill South	4813 S. Sycamore	Abandoned	Abandoned
LS #217	26th & Dubuque	5211 E. 26th St.	Abandoned	Abandoned
LS #219	Haley & Bailey	1231 N. Haley Ave.	Abandoned	Abandoned
LS #228	Arena LS	1201 Northwest Ave.	Abandoned	Abandoned

3.3.7 Flow Equalization Facilities

There is an existing flow equalization (EQ) facility that is located upstream of the LS #200 Brandon Pumping Station (BRPS) at Cliff and Chambers which is used to handle peak flows in excess of the BRPS capacity. The equalization facility consists of one 5 million gallon cell (with Clarifier) and one 7 million gallon cell with a total volume of approximately 12 million gallons (MG). There is a 1 MG clarifier located in the primary cell which lowers the level of solids going to the BRPS. Flows are directed to and from the facility by gravity flow, which is based on valve adjustments at a control valve structure outside the facility. The Cliff and Chambers flow EQ facility is operated based on flow rates measured upstream of the BRPS. The flow into the flow EQ facility from the flow control weir is allowed when the measured flow rate approaches maximum pumping capacity of a single pump operating at BRPS. When the flow in the sewer is peaking, the flow EQ facility is set to operate to smooth the flow, minimize the cycling of the pumps, and maintain optimum pump operation rates. These flows are generally resulting from wet-weather events, with normal dry-weather flows bypassing the flow EQ facility.

Figure 3.4 shows an aerial view of the flow EQ facility and the model layout of the system in that vicinity. The pipe into the flow EQ facility is allowed to flow at 75% capacity until there is a 5 foot depth at the BRPS, at which point the pipe into the flow EQ facility is allowed to flow at max capacity.

Figure 3.4 Aerial View of the Model at the Flow Equalization Facility



3.3.8 Waste Receiving Facilities

The flow equalization basins have provided a location for high strength industrial waste, septage and Vactors[tm] to be discharged. The waste receiving facilities include the following major components:


Grit Cyclones and Grit Washer at the EQ Basins

Large tankers are dumped directly into the equalization basin.
A concrete dump station divided into two (2) sides with potable water for wash-down.
Waste is transferred via a grit removal unit that includes one (1) Wemco Torque-Flow, Model C Grit pump, two (2) WEMCO grit cyclones, and one (1) grit classifier which empties to a commercial dumpster.

Recommended improvements are provided in the Appendix 3.B Technical Memorandum. A new replacement system is currently in the preliminary design stage.

3.3.9 Recent Improvement Projects

Tables 3.10 thru 3.12, summarize the major collection system improvement projects completed since the 2010 Sanitary Sewer Assessment.

Table 3.10 Tier 1 - Sanitary Sewer Collection and Treatment System Projects

PROJECT	DESCRIPTION	CONSTRUCTION YEAR
Walnut and Main Trunk Sewer Slip lining	Repair 850' of collapsed 36-inch trunk sewer by Slip lining a new 30-inch Hobas pipe through the existing pipe.	2010
Collection System Flow Metering Improvements	Purchase and install 20 flow meters and data loggers in the SRSI upstream of Tuthill Lift Station to monitor the flows and develop an estimate of I/I from this area. This project was originally budgeted for 2011.	2010
Pipe Lining Program	Line various areas within the City as identified in past facility plan.	Annual Program
Manhole Rehabilitation	Rehabilitate manhole lids, castings, cone sections, leaking joints, etc. throughout the various sewer collection basins.	Annual Program
Tomar Heights Trunk Sewer and Drainage Way Improvements	Repair portions of trunk sewer exposed in drainage channel during heavy rainfall events. The sanitary sewer is also proposed to be replaced to eliminate infiltration and root intrusion concerns. In addition to the sanitary sewer improvements, it is recommended to perform drainage way improvements that will limit the erosion of the drainage channel and, therefore, not expose the pipe in the future.	2012
Central Main Interceptor Replacement - Segment 5	Segment 5 was originally scheduled for completion in 2012. The project includes replacing approximately 7,200 feet of existing sanitary sewer pipe with 60-inch sanitary sewer pipe to increase the capacity and replace the deteriorated 40-year old concrete pipe. This project is currently being constructed in 2011, so that the pipe capacity downstream of Tuthill Lift Station can be increased.	2012
Central Main Interceptor Replacement - Segment 6	Segment 6 was originally scheduled for completion in 2013. The project includes replacing approximately 8,550 feet of existing sewer pipe with 54- and 60-inch sewer pipe. As part of this project, the City is revising the discharge piping in the Tuthill Lift Station.	2012
WRF Effluent Filter	Replace existing effluent filter underdrains and media. Media being used will allow a higher flow rate, thus increase the capacity.	2012

Table 3.11 Tier 2 - Sanitary Sewer Collection and Treatment System Projects

PROJECT	DESCRIPTION	CONSTRUCTION YEAR
Manhole Rehabilitation	Rehabilitate manhole lids, castings, cone sections, leaking joints, etc. throughout the various sewer collection basins	Annually - (10+ years)
Pipe Lining Program	Line various areas within the City as identified in past facility plan.	Annually – (10+ years)
Collection System Flow Metering Improvements	Purchase and install flow meters and data loggers throughout the sanitary sewer collection system.	2013
Western Interceptor Relief Sewer Improvements - Phase 1	CIPP Line 2,900 feet of 36-inch sewer from Walnut Street and Main Avenue to Lake Avenue. It is not expected that the Western Interceptor Relief Sewer will need to be upsized; thus the line is proposed to be CIPP lined. Hydraulic modeling indicated that this upsizing is not necessary.	2011 - 2012
Sioux River Interceptor Replacement - Tuthill to Duluth - Phase IA and IB	• Replace the existing 42-inch RCP sewer with 54-inch sewer to increase capacity and replace deteriorated concrete pipe. • Also, replace the I-229 crossing west of Minnesota Avenue from SRSI to Duluth and 41st Street to allow flow from Basin 8 (41st and Pam Road) to flow into the new higher capacity SRSI sewer and reduce flows on the 41st Street sanitary sewer. Black & Veatch 2002 Sanitary Sewer Facilities Plan recommended that if the flow from 41st and Duluth was diverted south the SRSI, the sewer along 41st to Cherry Rock Park would not need to be upsized. • As part of this project, revise the access driveway to the Tuthill lift station for better access during flooding. • Update pump station including pumps, motors, generators, discharge pipes, wet well improvements. • Review diversion from 41st and Cliff Avenue, south to Tuthill LS to eliminate backflow north into 41st Street Basin 8 Sewer.	2012
Trickling Filter Improvements	Replace trickling filter distributor arms that have sever corrosion and limit the capacity of the four First Stage and four Second Stage Trickling Filters.	2012
Solberg Avenue Drainage Improvements	Remove and replace storm sewer system under Solberg Avenue from W. Custer Lane to Detention Pond at 49th and Solberg.	2011-2012

Table 3.11 Tier 2 - Sanitary Sewer Collection and Treatment System Projects

PROJECT	DESCRIPTION	CONSTRUCTION YEAR
Sioux River Interceptor Replacement - Duluth to Prairie View Drainage - Phase II	Replace the existing 42-inch RCP sewer with 54-inch sewer to increase capacity and replace deteriorated concrete pipe. Consider relocation closer to I-229 and away from the Big Sioux River for better access and less potential for river impacts on flows. Rock removal will be required. Major I/I is suspected along the SRSI sewer.	2012-2013
Sanitary Sewer Collection System Master Plan	Perform a comprehensive collection system master plan of the sanitary sewer after significant flow metering data has been collected from the Flow Metering Program.	2013-2018
Roosevelt Channel Drainage Improvements	Clean out channel and install bank stabilization between Sertoma Avenue and 26th Street.	2011-2012
Hayward Trunk Sewer CIPP Liner	Install a CIPP liner within the existing 12-, 21-, and 24-inch sewer pipe (6330') to alleviate I/I permanently in the Hayward Trunk Sewer.	2011-2012
Western Interceptor Relief Sewer Improvements - Phase 2	CIPP line 4,050 feet of 36-inch sanitary sewer from Russell Street to Lake Avenue.	2012
Odor Control Program	Continuation of current collection system odor control projects to eliminate odors and reduce corrosion rates in the collection system.	2014-2019
Sioux River South Interceptor CIPP Lining - Prairie View drainage ditch to 41st Street - Phase 3	CIPP line or Slip line of 5,000' of 36-inch Trunk Sewer to reduce I/I in subbasin 07A along the Big Sioux River. The City may also consider relocating the pipe outside the existing levee.	2011-2012
Elimination of LS 208 (Rice and Kiwanis) - Phase 2	Phase 2 of trunk sewer to eliminate LS 208.	2015-2020
Otonka Channel Drainage Improvements	Install a new low flow pipe system with channel erosion protection to better convey flows.	2015-2020

Table 3.11 Tier 2 - Sanitary Sewer Collection and Treatment System Projects

PROJECT	DESCRIPTION	CONSTRUCTION YEAR
Western Interceptor Relief Sewer Improvements - Phase 3	CIPP line 4,800' of 36-inch sewer from Lake Avenue to 10th and Western.	2017-2022
Elm Street and North Drive, NE of WPP; Northeast Trunk Sewer at 6th and I-229	CIPP line 18-inch DIF under North Drive (165'). CIPP line 18-inch RCP under 6th Street and under I-229 (875').	2019-2024

Table 3.12 Tier 3 - Sanitary Sewer Collection and Treatment System Projects

PROJECTS/TASKS	COMPLETED	RECOMMENDATIONS
Sioux River Stream Bank Stabilization	Yes	Stabilize the Big Sioux River bank where it turns to flow east on the east side of Cliff Avenue (riprap, etc) near Tuthill Lift Station and at 02A trunk sewer.
Siphon Pipe Replacement	Yes	The sanitary sewer pipe downstream of 06CB002 is a siphon pipe that flows north under the river. With improvements to the Sioux River South Interceptor, this could be changed to a gravity line if leaking in the siphon is an issue. Further investigation and evaluation is needed for this project.

Source: City of Sioux Falls

3.4 Lift Station and Force Main Condition Assessments

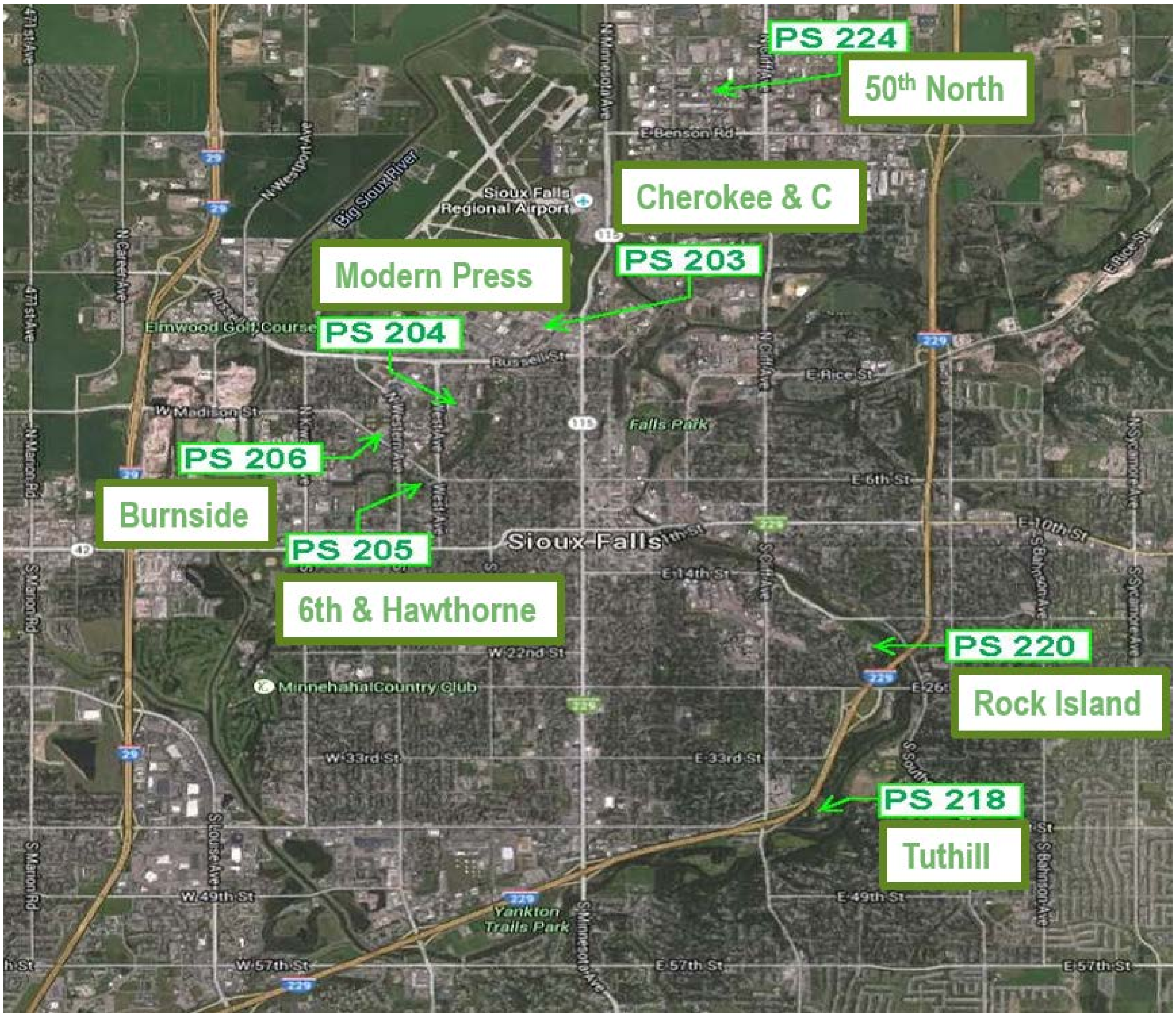
Not all the lift stations were assessed through field visits in this Master Plan; instead focus was placed on the most critical facilities and those understood to be generally in the worst condition. The scope for this Master Plan included assessing the condition of seven existing lift stations. The following Figure 3.5 illustrates the general location of each of the seven existing lift stations assessed for condition. The following sections contain a listing of the recommended improvements for the collection system lift stations that were reviewed as part of the detailed condition assessment technical memorandum contained in Appendix 3.B.

3.4.1 PS-203 Cherokee & “C” Operation

This lift station is outdated and has been identified as highest risk due to safety issues and access to the wetwell. The following are a list of recommended improvements to PS-203:

- Laser scan for as-built as there is no as-built documentation.
- Address potential new construction of hotels, restaurants, and their associated increased wastewater flows.
- Replace roofing.
- Construct a new dual wetwell and fill old wetwell to grade for electrical and generator equipment.
- Extend forcemains so both enter the lift station independently with a wye and control valve on each line to control discharge location.
- Sandblast and coat pump room and piping.
- Move the generator to the "Old Wetwell" location and renovate room.
- Construct pigging station for the dual forcemains.
- Change pumps to self-priming pumps.
- Provide access hatches over dual wetwell for Vactor truck cleaning.
- Extend suction lines through current wetwell to new wetwell.
- Install baffles or pre-rotation basin inserts to prevent vortexing.
- Replace electrical switchgear, motor control center, and VFDs.
- Provide new generator.
- Install seal-offs to isolate per code requirements.
- Provide new HVAC system for the pump room and electrical room.

Figure 3.5 Lift Station Assessment Location Map



3.4.2 PS-204 Modern Press – 806 N. West Avenue

The following are the recommended improvements to PS-204:

- Move the generator transfer switch outside and mounted on a pole.
- Construct new circuit breakers at upper (intermediate) level at a minimum with true lockable disconnects.
- Add Davit Crane bases on the top slabs for both the wetwell and drywell.

Combining Pump Stations 204, 205, and 206 was evaluated and it was determined that the cost to combine these three lift stations into one lift station would be significantly higher than upgrading the three lift stations separately. The approximate total project cost to construction gravity sewer from the three existing lift station to a location in the southeast corner of Burnside Park where a new lift station would be construction would be $8.0 Million; whereas the cost to upgrade each lift station in its current location would be $360,000.

Combining Pump Stations 204 and 206 only was evaluated as well and it was similarly determined that the cost to combine these two lift stations into one lift station would be significantly higher than upgrading the two lift stations individually. The approximate total project cost to construction gravity sewer from PS-204 to PS-206 and then replacing or upgrading PS-206 would be $5.8 Million. Whereas the cost to upgrade each lift station in its current location would be $360,000.

3.4.3 PS-205 - 6th and Hawthorne

A ships ladder, which is unsafe, is used for access down to the drywell/pump room of the lift unsafe access. Installation of a safe access maintenance lift is recommended for safer access down to the drywell/pump room.

SCADA and Controls are either outdated or very limited in capability. Updates to the SCADA system and controls are recommended.

A permanent standby generator is not currently provide for emergency power outages and City maintenance staff are limited in the amount of time to respond to an outage before a sewer backup occurs. Installation of a permanent standby generator is recommended.

3.4.4 PS-206 Burnside

The following are the recommended improvements to PS-206:

- The structural condition of PS-206 is poor and the above-grade pump station structure is recommended to be completely rebuilt.
- A new supply and exhaust HVAC system is recommended for this station.
- A new generator is recommended.

3.4.5 PS-218 Tuthill Park – 3500 S. Blauvelt

The following are the recommended improvements to PS-218:

- Install removable floodgates at all the doors, as the 100-year flood elevation is 6 to 12 inches above the main floor elevation.
- Raise the curb around the wetwell opening to prevent water from entering the wetwell during flood events.
- Pump #4 has a slight rattle/tapping noise. Continue to monitoring pump for noise and repair.
- Modify the seal water system
  - Change operation of seal water so that the seal water runs to pumps at all times, even when pumps are not running.
  - Replace metallic seal water piping with PVC or FRP.
  - Add flow tubes to all seal water lines to monitor seal water flow rate.
- Close off doorway between the electrical room and the pump room with a masonry wall to isolate the electrical. Include window in masonry wall.
- Replace MCC, Switch Gear.
- Install video monitoring cameras to allow the City to view the station from a remote location and determine if there is flooding at the station.
- Raise the odor control transformer if verified to be in the flood plain.
- Raise/rotate the gas regulator if verified to be in the flood plain.
- Provide additional ventilation in the electrical room when it is isolated from the pumping room.

3.4.6 PS-220 Rock Island

Short-term, immediate recommended improvements to PS-220 include:

- Both the pump suction piping and the forcemain piping are in poor condition due to leaking at the wall penetrations. Repair or removal and replacement of the pipe link seals is recommended.
- The drywell room is damp and installation of a dehumidifier is recommended.
- The unit heater in the drywell needs to be moved as water that is leaking through the wall is running onto the heater.
- Install a permanent standby generator.

Long-term recommended improvements to PS-220 include demolishing the entire existing station and a new lift station to address flood elevation issues. A drywell wet-well replacement is recommended to be located away from the river to address flood elevation issues.

3.4.7 PS-224 – 50th Street N

Recommend installing dry-pit pumps (i.e. Flygt-N type) or recessed impeller pumps (Wemco) to address ragging issues.

3.4.8 PS-201, PS-213, and PS-221

These three lift stations were not reviewed, but do not have permanent standby generators. Installation of standby generators at these three lift stations is recommended.

3.4.9 All Lift Stations – SCADA Systems

Supervisor Control and Data Acquisition (SCADA) equipment and system was noted in the individual reviews of the lift stations.

3.4.10 Summary of Recommended Lift Station and Force Main Condition Improvements

Table 3.13 is a summary of the High Priority and Medium Priority Improvements and Estimate Project Cost for the lift stations and forcemains.

Table 3.13 Lift Station Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Estimated Cost
High	PS-203 Cherokee & "C" Operation	General	No as-built of station	Laser scan for as-built drawings of lift station	$21,000
			Provide for future capacity of station.	Address hotels, restaurants, and increased flows.	$21,000
		Process	Maintenance accessibility	Extend forcemains so both tie together in station	$63,000
			Deterioration, rusting and corrosion.	Sandblast and coat pump room and piping.	$16,000
			Access for forcemain cleaning.	Provide pigging station for the dual forcemains.	$31,000
			Need for suction capability with potentially deeper wetwell.	Change pumps to self-priming type pumps.	$151,000
			Required for PS upgrades	Extend suction lines through current wetwell to new wetwell.	$63,000
			Scour grease and clean wetwell.	Provide baffles or pre-rotation basin inserts (Ogee style wetwell)	$21,000
		Structural/Architectural	Old and deteriorated.	Replace roof	$44,000
			Maintenance & reliability	Construct new dual wetwell and fill old wetwell to grade.	$176,000
			Access for Vactor truck for cleaning.	Provide access hatches over dual wetwell.	$21,000
		HVAC	Required for PS upgrades	New HVAC system for the pump room and electrical room.	$65,000
		Electrical	Required for PS upgrades	Provide new electrical switchgear, motor control center, and VFDs.	$151,000
			Required for PS upgrades	Provide new generator and move to "Old Wetwell" location.	$71,000
			Required for PS upgrades	Provide seal-offs to isolate per code requirements.	$11,000
				PS-203 Cherokee & "C" Subtotal	**$926,000**

Table 3.13 Lift Station Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Estimated Cost
High	PS-204 Modern Press - 806 N West Avenue	Process	Safe removal of pumps and equipment.	Add Davit crane base on top slab of both wetwell and drywell	$5,000
		Electrical	Currently below grade in unsafe location	New circuit breakers at upper (immediate) level with true lockable disconnects	$31,000
			Currently below grade in unsafe location	Move generator transfer switch outside on pole.	$21,000
				PS-204 Modern Press - 806 N West Avenue Subtotal	**$57,000**
High	PS-205 6th and Hawthorne	Architectural	Currently no safe access to the below grade pump room	Add Safe Access Maintenance Unit	$81,000
		Electrical	Currently have to use portable generator.	Provide Standby Generator with Self Contained Enclosure	$81,000
		Electrical	Controls are outdated.	Upgrade the Controls	$61,000
				PS-205 6th and Hawthorne Subtotal	**$223,000**
High	PS-206 Burnside	Structural/Architectural	Groundwater leaks into vault	Reseal mag meter vault	$31,000
			Deteriorated building	Replace above grade building	$112,000
		HVAC	Old and outdated	New supply and exhaust HVAC System	$41,000
		Electrical	Existing is older, salvage generator.	New generator and electrical upgrades	$121,000
				PS-206 Burnside Subtotal	**$374,000**

Table 3.13 Lift Station Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Estimated Cost
High	PS-218 Tuthill Park - 3500 S. Blauvelt	Process	Rattling/tapping noise.	Monitor pump 4 for noise.	
			Assurance there is seal water.	Change operation of seal water to run to pumps at all times.	$21,000
			Corrosion on metallic piping	Replace seal water piping with PVC.	$21,000
			Monitor seal water flow.	Add flow tubes to seal water lines.	$29,000
		Structural/Architectural	Prevent flood water from entering building.	Install removable floodgates at the doors.	$36,000
			Prevent flood water from entering wetwell.	Raise curb around wetwell openings.	$21,000
				Construct new wall with a window to isolate electrical room.	$15,000
			Currently below flood elevation.	Raise odor control transformer	$11,000
		HVAC	Inadequate ventilation	Provide additional ventilation for HVAC System.	$31,000
		Electrical	Corrosion	Clean and coat or replace bus bars.	$151,000
				Install video monitoring cameras.	$31,000
			Currently below flood elevation.	Raise/rotate gas regulator.	$11,000
				PS-218 Tuthill Park - 3500 S. Blauvelt Subtotal	**$378,000**
High	PS-220 Rock Island	Process	Leaking at wall of pipe penetrations.	Remove and replace link seal on suction and forcemain piping.	$15,000
		HVAC	Room is damp.	Install dehumidifier.	$10,000
			Water is dripping on heater in current location.	Move unit heater.	$20,000
		Electrical	Currently have to use portable generator	Provide Standby Generator with Self Contained Enclosure	$80,000
				PS-220 Rock Island Subtotal	**$125,000**
High	All Lift Stations	SCADA & Controls	Some equipment and Software is outdated	Upgrade SCADA Equipment.	$275,000
				Total High Priority Recommended Lift Station Improvements	**$2,289,000**

Table 3.13 Lift Station Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Estimated Cost
Medium	PS-201	Electrical	Currently have to use portable generator	Provide Standby Generator with Self Contained Enclosure	$81,000
	PS-213	Electrical	Currently have to use portable generator	Provide Standby Generator with Self Contained Enclosure	$81,000
	PS-220 Rock Island	Process	Address flooding issues	Convert to submersible style station.	$914,000
	PS-221	Electrical	Currently have to use portable generator	Provide Standby Generator with Self Contained Enclosure	$81,000
	PS-224 - 50th Street N	Entire Station	Ragging problems	Replace pumps with Flygt-N or recessed impeller pumps	$151,000
Total Medium Priority Recommended Lift Station Improvements					**$1,310,000**
Total Combined High and Medium Priority Recommended Lift Station Improvements					**$3,600,000**

3.5 Existing Water Reclamation Facility

3.5.1 Facility Background

The City of Sioux Falls WRF is located on the northeast side of Sioux Falls on Sycamore Avenue, south of the intersection of Sycamore Avenue and 60th Street. The WRF facility receives pumped flows from Pump Station 240, LS #200 Brandon Road (Main) Pump Station (BRPS), the City of Brandon, the Humane Society, and flow from an adjacent industrial park. The WRF discharges treated water to the Big Sioux River.

The original facility was constructed in phases beginning in 1980. The final phase was constructed in 1986. Several improvements have been made to the facility since the final phase was completed. The original facility was designed to accommodate an average day flow of 13.4 MGD and a peak instantaneous flow of 27 MGD. The history of the major WRF improvements is summarized in Figure 3.6.

As part of the 2009 WRF master plan the re-rated capacity of the facility was increased to 21 MGD average day flow and 35 MGD peak equalized flow. Refer to Table 3.14 for associated rated loading capacities.

Figure 3.6 Water Reclamation Facility History of Major Improvements

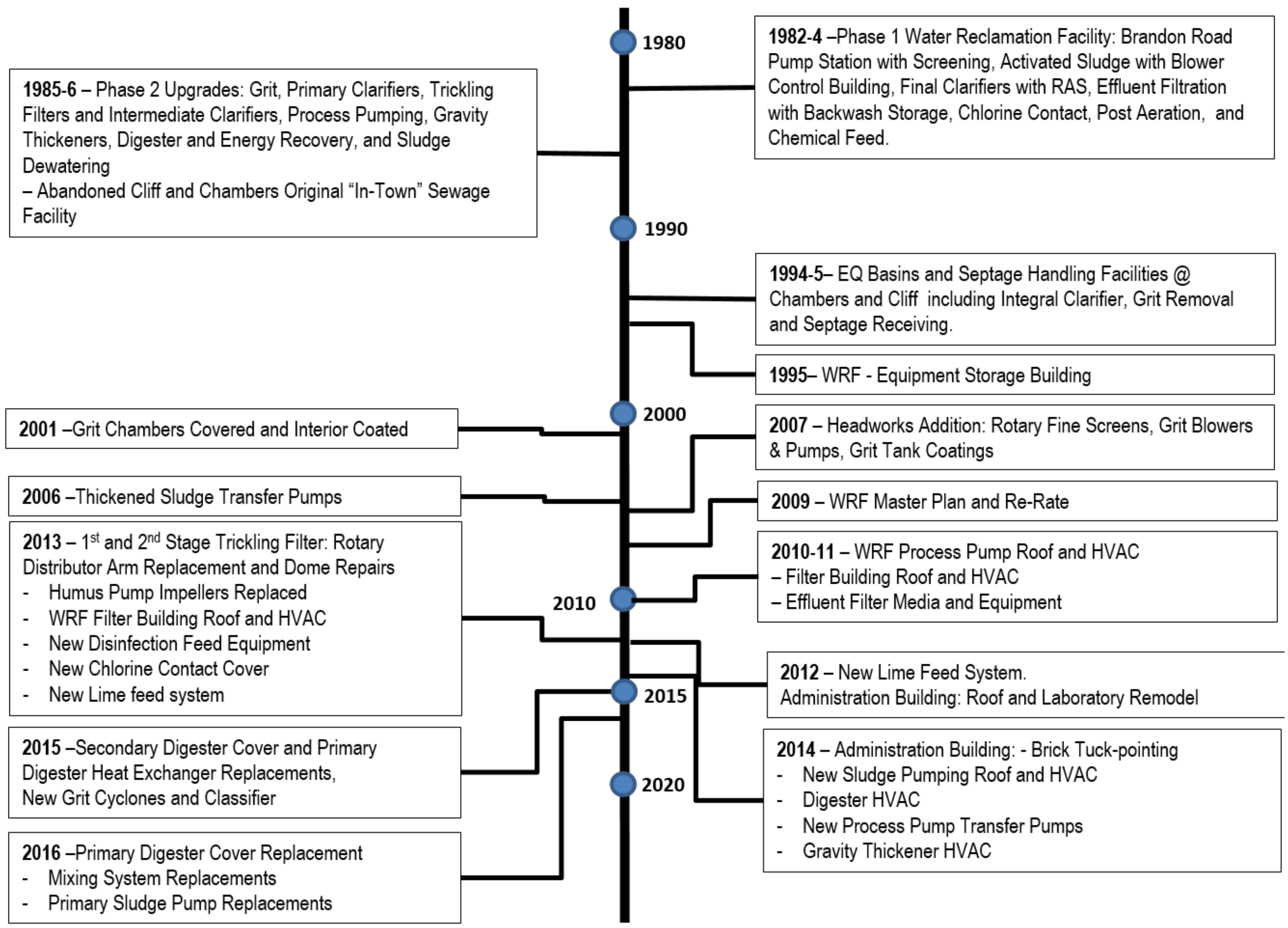


Table 3.14 Re-Rated Sioux Falls WRF Capacity - 2009

Parameter	Value
Average Daily Flow	21.0 mgd
Peak Hourly Flow (Equalized)	35.0 mgd
TBOD	51,240 lb/d
TSS	43,900 lb/d
TKN	9,440 lb/d

3.5.2 Process Overview

The WRF consists of primary treatment followed by a trickling filter train which is pumped to the activated sludge train which discharges to tertiary gravity filtration and on to chlorine disinfection. Solids handling consists of gravity thickeners which discharge to anaerobic digestion followed by liquid sludge storage which is then land applied.

The following section identifies and provides descriptions of each WRF process which are illustrated and tabulated as follows:

- Figure 3.7 illustrates the general location of each component at the Water Reclamation Facility and the numbering system use to identify each component.
- Figure 3.8 is a liquid and solids process flow schematic for a visual of how these flows proceed through the WRF.
- Table 3.15 summarizes the major unit processes at the Sioux Falls WRF including each unit process, number of units, and the installation or latest major improvement date.

Figure 3.7 Water Reclamation Facility Process Components

Figure 3.8 Water Reclamation Facility Existing Process Flow Schematic

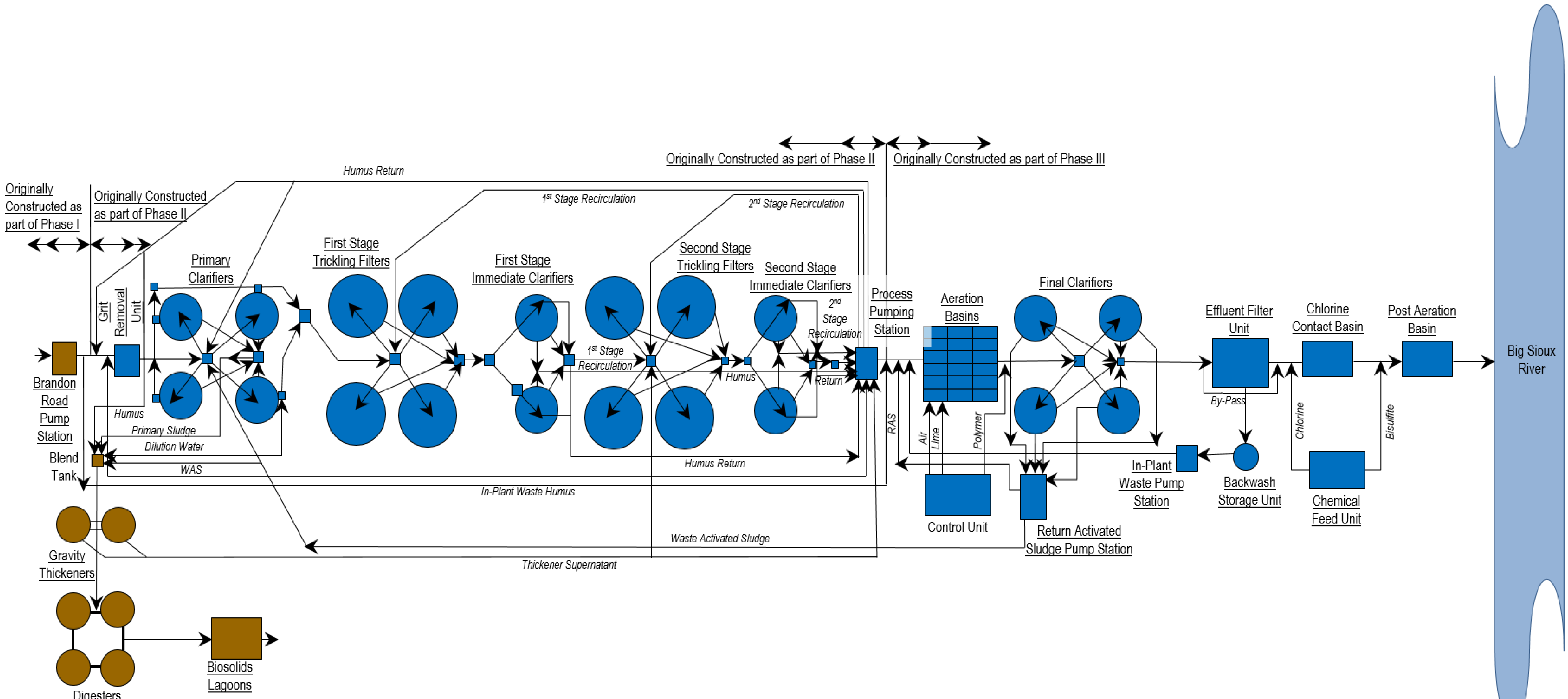


Table 3.15 Summary of Major Unit WRF Processes

Unit Processes	Quantity	Details	Installation / Improvement Date
Influent Flow Measurement	1	42-inch magnetic flow meter	2016
Drum Screens	3	¼-inch bar spacing	2007
Aerated Grit Units	2	27 ft x 27 ft, 14 ft SWD	1986
Aerated Grit Blowers	3	15 hp, 224 scfm	1986
Primary Clarifiers	4	90 ft diameter, 8 ft SWD	1986
Primary Sludge Pumps	4	175 gpm (approximate)	2016
First Stage Trickling Filters	4	135 ft diameter, 7 ft SWD	1986(1)
First Stage Intermediate Clarifiers	2	105 ft diameter, 10 ft SWD	1986
Second Stage Trickling Filters	4	145 ft diameter, 7 ft SWD	1986(1)
Second Stage Intermediate Clarifiers	2	105 ft diameter, 10 ft SWD	1986
Process Pump Station Transfer Pumps	4	250 HP, 31,250 gpm	2014
Aeration Basins	6	43 ft x 280 ft, 15 ft SWD	1984
Activated Sludge Blowers	4	800 HP, 15,500 scfm	1984
Final Clarifiers	4	100 ft diameter, 14 ft SWD	1984
Return Activated Sludge Pumps	5	40 HP, 4,700 gpm	1984
Waste Activated Sludge Pumps	2	10 HP, 300 gpm	1984
Tertiary Filters	8	17 ft x 34 ft, 36” anthracite depth	1984(2)
Chlorine Contact Basins	2	18,900 cubic ft	1984
Effluent Flow Measurement	1	4-ft Parshall Flume	1984
Cascade Aerator	2	10 steps @ 36 feet long x 4 feet wide x 2 feet high	1984
Gravity Thickeners	2	55 ft diameter, 12 ft SWD	1986
Anaerobic Digesters	4	65 ft diameter, 31 ft SWD	1986
Sludge Lagoons	2	Two 8.4 MG Earthen Cells at 16.8 MG	1995

Notes:

(1) New distributor arms were mechanisms installed in 2013.

(2) A new underdrain system and new media were installed in 2011.

SWD = Side Water Depth

Headworks

Several forcemains discharge into the WRF influent box. The combined flows travel through a 42-inch magnetic flow meter and then to the screenings channel.

Three Huber drum screens with integral screenings wash/press systems remove debris from the influent wastewater channel and then transport the collected screenings onto a conveyor belt. The drum screens are 6 ft in width and have ¼ spacing between the bars.

A grit removal system is located downstream of the screening units. The grit removal system consists of a splitter box with weir gates which split the flow evenly between two aerated grit tanks. four grit pumps draw settled grit off of the bottom of the grit tanks. The grit is pumped to the grit cyclone and then disposed of in a dumpster.

Primary Treatment

The existing primary clarifiers at the WRF include four 90 feet diameter, 8 feet deep clarifiers. Flow is split equally to each unit through Splitter MH No. 3. Skimmer arms in the clarifier collect scum off the top of the clarifier. The scum and oil and grease is pumped to the digesters. Waste Activated Sludge (WAS) and primary sludge are co-settled in the primary clarifiers. The solids that settle to the bottom of the primary clarifier are pumped to one of two gravity thickeners. Four double disk pumps are used to pump the primary sludge.

Secondary Treatment

For secondary treatment, the WRF utilizes trickling filters primarily for BOD removal and activated sludge processes for nitrification.

Trickling Filters

From the primary clarifiers, flow is conveyed from the primary clarifiers to Splitter MH No. 4. The splitter manhole divides flow evenly among four first stage trickling filters by the use of weir gates. Each first stage trickling filter is 145 ft in diameter and 8 ft in depth. The trickling filter distributor arms were replaced in 2013.

Downstream of the first stage trickling filters, the flow combines and enters Splitter MH No. 5. The splitter manhole splits flow evenly between the two first stage intermediate clarifiers. Each first stage intermediate clarifiers is 105 ft in diameter and is 10 feet deep.

Downstream of the first stage intermediate clarifiers the flow combines and enters Splitter MH No. 6. The splitter manhole splits flow evenly among four second stage trickling filters by the use of weir gates. Each second stage trickling filter is 145 ft in diameter and 8 ft in depth. The trickling filter distributor arms were replaced in 2013.

Downstream of the second stage trickling filters, the flow combines and enters Splitter MH No. 7. The splitter manhole splits flow evenly between the two first stage intermediate clarifiers. Each first stage intermediate clarifiers is 105 ft in diameter and is 10 feet deep.

The WRF has pumps and piping in place to allow for trickling filter effluent flows to be recycled back to each set of trickling filters. However, the facility is typically not operated with these recycle flows in service.

Process Pump Station

The WRF Process Pump Station Process Pump Station contains four sets of pumps:

1. Four Transfer Pumps
2. Three Humus/In-plant Pumps
3. Three First Stage Recirculation Pumps
4. Two Second Stage Recirculation Pumps

The Transfer Pumps receive flow from the second stage intermediate clarifiers and conveys it to Splitter MH No. 1. The transfer pumps were replaced in 2008. The transfer pumps wetwells and piping were also retrofitted at this time.

The Humus/In-plant Pumps convey humus from the intermediate clarifiers and in-plant waste to the head of the plant.

The First Stage Recirculation Pumps recycle flow to the first stage trickling filter inlet splitter box.

The Second Stage Recirculation Pumps recycle flow to the second stage trickling filter inlet splitter box.

Activated Sludge Basins

Splitter MH No. 1 contains six weir gates that split the flow evenly between the aeration basins. Splitter MH No. 1 also has six additional weir gates that are used to split RAS flow to the six aeration basins. Flow to an aeration basin can be stopped by raising one of the weir gates.

Each of the six aeration basins is 280 ft long by 43.3 ft wide. The water depth is15 ft and each basin is divided into three cells. Four 800 HP, 15,500 scfm centrifugal blowers supply air to the aeration basins through coarse bubble diffusers. The aeration rate in each cell can be adjusted manually opening or closing valves on the air supply piping.

Final Clarifiers

The flow leaving the aeration basins combines in Manhole No. 1 and is then conveyed to Splitter MH No. 2. Splitter MH No. 2 contains four weir gates which are used to split flow between the four final clarifiers. Each final clarifier is 100 ft in diameter and has a side water depth of 14 ft. The final clarifiers settle the MLSS. Five RAS pumps located in the RAS Building recycle the activated sludge to Splitter MH No. 1. Each RAS pump is has a capacity of 4,700 gpm. Two WAS pumps are also located in the RAS Building. The two (2) WAS pumps have a capacity of 300 gpm each. The WAS is either returned to the headworks building or is sent to the gravity thickeners.

Tertiary Treatment

Tertiary Filters

Flow leaves the final clarifiers and combines in Manhole No. 2. The flow is then conveyed to the tertiary filters. There are eight tertiary filters each 34 ft in length by 17 ft in width. Weir gates are manually actuated to control flow to each filter.

A new underdrain system was installed in the filters in 2011. The underdrain system is a nozzle type rated for 6 gpm/sq. ft. The filter media is anthracite at a depth of 36 inches.

Three vertical turbine backwash pumps are provided to backwash the filters. The backwash pumps are 125 HP and have a capacity of 6500 gpm each. The backwash pumps draw out of the backwash clearwell.

The backwash waste flows by gravity to the 1.3 million gallon backwash storage tank which are returned by one or two of three backwash return pumps rated at 850 gpm each.

There is an overflow weir in the filter influent channel that allows high flows to bypass the tertiary filters and be diverted directly to the chlorine contact basin.

Chlorine Contact Basins

The flow leaves the filters and travels to a splitter box at the head of the chlorine contact basins. Weir gates in the splitter box split the flow evenly between the two chlorine contact basins. A Parshall flume is used to measure the chlorine contact basin effluent. Sodium hypochlorite is fed as the disinfectant upstream of the chlorine contact basins. Sodium bisulfite is fed to remove the chlorine prior to discharge to the river.

Cascade Aerator

From the chlorine contact basins, flow is conveyed to another splitter box. Weir gates in this splitter box split the flow between two cascade aerators. After aeration, the flow travels through an 48-inch pipe and discharges to the Big Sioux River.

Solids Handling

The WRF has solids handling facilities made up of gravity thickeners, anaerobic digesters and sludge lagoons followed by land disposal of liquid sludge . These processes are discussed in greater detail in Chapter 8.

3.5.3 WRF Hydraulic Capacity Analyses

A hydraulic profile of the Sioux Falls Water Reclamation Facility was modelled using Visual Hydraulics modeling software. This was a shop drawing-level analysis of the existing facility using as-recorded plans, specifications and equipment shop drawings to obtain dimensions and elevations for model inputs.

To check the accuracy of the hydraulic model, actual water surface elevations were measured in the field. Measurements were taken on May 2, 2016 when the recorded influent flow was 31.6 MGD following a major storm event. This flow is just short of the maximum equalized capacity of the plant, which is 35 mgd. Water surface elevations were recorded under this high flow condition in an attempt to better identify bottlenecks in the facility’s unit processes and piping.

Several locations in the WRF were identified as having less hydraulic capacity than was calculated by the hydraulic model. These discrepancies have been noted in detail in the Appendix. The locations in which the measured hydraulic capacity most deviated from the actual measured capacity include the following:

- Primary clarifiers splitter box and inlet piping
- Trickling filter inlet and outlet piping
- Intermediate clarifier outlet piping
- Final clarifier inlet piping

Given the impact of the 2014 peak event along with future growth, hydraulic improvement Scenarios 1-3 were developed to circumvent bottlenecks and pass a peak flow which exceed the projected design event, as follows:

Scenario 1 – Primary Clarifier Influent Diversion

Per Figure 3.9, construct a weir diversion structure on the Primary Clarifier influent line to overflow directly to the Aeration Basins.

Scenario 2 – New Headworks and/or Primary Clarifiers directed to Activated Sludge

Provide diversion of the primary clarifier influent to the activated sludge process train. A new headworks and/or primary clarifiers ultimately becomes part of the recommended long-term treatment flow scheme which eliminates the need for secondary pumping.

Scenario 3 – Process Pump Discharge Diversion to Filtration

First, construct a bypass from the PC Influent to the PC Effluent line.

Second an actuated valve (for modulating/throttling service with controls to the SCADA) could be added for direct bypass from the Process Pump Forcemain to filtration influent splitter box. This valve would not be used during normal design peak flows and only used to prevent SSOs if equalization has been fully utilized. The function requires very slow opening and should only be slowly opened during a Process Pump wetwell high-high level.

Hydraulic Improvement Recommendations

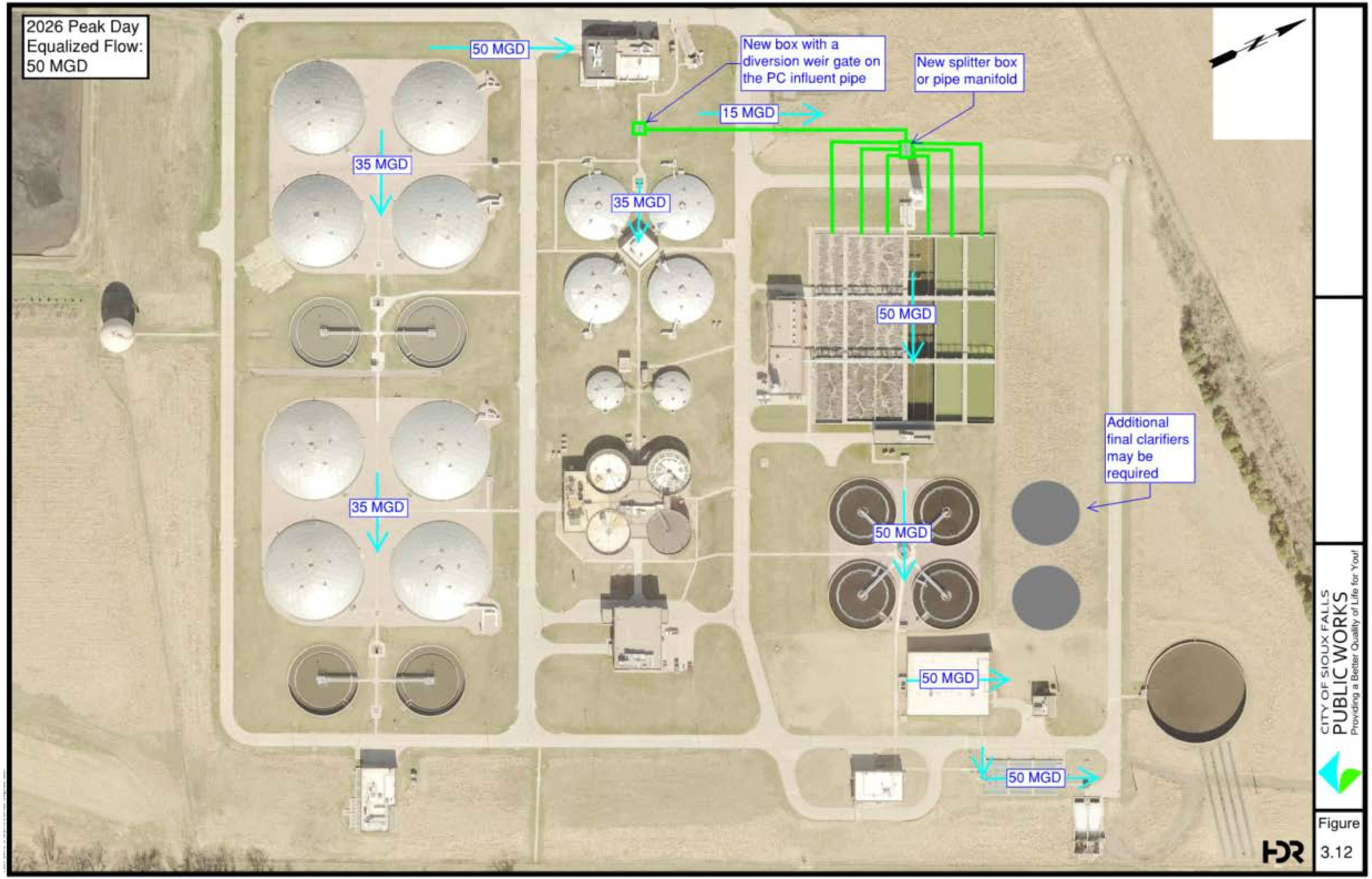
The following is a list of recommended capital improvement action items related to the Water Reclamation hydraulics:

- Grit Influent Pipe: The existing 36-inch grit basin influent pipe needs to be upsized in order to accommodate future flows.

- Primary Clarifier Influent Diversion: To address peak events, it is recommended to construct a weir diversion structure on the Primary Clarifier influent line to overflow directly to the Aeration Basins. To avert the cost of a splitter box, overflow could be direct to the Aeration Basins. For the long-term, a new headworks and/or primary clarifiers is recommended which will direct flow to the activated sludge process train. A new headworks ultimately becomes part of the recommended treatment flow scheme which eliminates the need for secondary pumping.

- Gravity Filter Overflow Weir: The gravity filter influent channel overflow weir will need to be raised in the future. Currently, the weir will be overtopped at flows approaching 48 MGD. (Alternatively, this weir could be replaced with an adjustable weir gate to allow for an adjustable bypass, directing flow to the chlorine contact basins.)

Figure 3.9 WRF Flow Diversion Site Schematic



3.5.4 Existing WRF Plant Capacity

This section provides an evaluation of flows and loads and loading capacity of the existing WRF to support a rating of the plant capacity. It is important to note that several recommended capacity improvements identified as bottlenecks have been completed since the 2009 WRF Re-rate and are summarized as follows:

- Effluent Filter Media and Equipment (*Increased hydraulic capacity*)
- 1st and 2nd Stage Trickling Filter Rotary Distributors (*Increased hydraulic capacity*)
- Disinfection (*Increased treatment reliability*)
    - New disinfection feed equipment
    - New Chlorine Contact Basin cover
- New Process Pump Transfer Pumps and Up-sized Impellers (*Increased hydraulic capacity*)

City engaged HDR to proceed with an evaluation/rerate study to determine if there is additional capacity beyond the previous re-rate, which involved further calibrating the BioWin™ model through stress testing the WRF and refinement of the characterization of the resulting wastewater composition at strategic points throughout the facility.

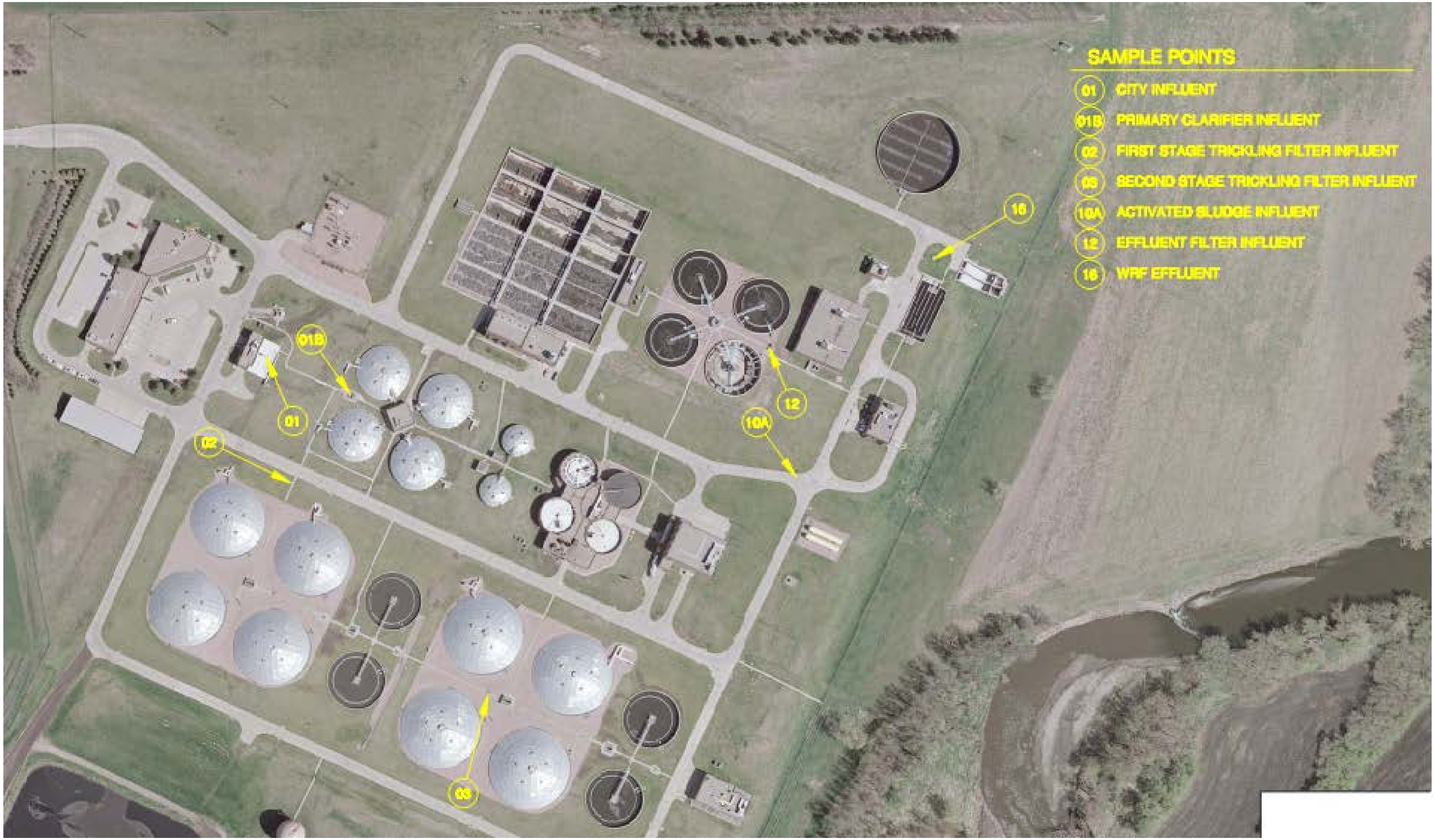
Facility Samples, Supplemental Sampling and Stress Testing

Samples are collected throughout the WRF. The samples are analyzed in order to monitor treatment efficiency, assist in making operational decisions and to meet the requirements of the WRF discharge permit. Figure 3.10 shows the locations of the sampling locations in WRF.

As noted, supplemental sampling was conducted to provide additional characterization of treatment and primary and final clarifier process removal efficiencies so that the current plant capacity could more accurately be evaluated. In summary, the BioWin™ model parameters were further calibrated with:

- Influent WW characteristics, strength, ratio
- Influent BOD versus cBOD
- Primary Clarifier Performance
- Trickling Filter Performance
- Aeration Basin DO/airflow

Figure 3.10 Summary of Sample Points at Sioux Falls WRF (Per 2008 Master Plan,Ulteig)



3.5.5 Unit Process Capacity

This section presents the current capacity of each of the unit processes at WRF and a projection of the point in time when each will reach its rated capacity. The average day and maximum month equalized flow conditions were evaluated for each unit process.

Equalization

Equalization is a key component of the treatment capacity evaluation. The goal is to reduce the peak flow as much as practicable without constructing extreme volumes of equalization tankage. The result is an overall reduction in cost for facility improvements as equalization tankage is less expensive than treatment capacity.

The current process flow schematic for equalization Cliff and Chambers Equalization is described in Section 3.3.7 and depicted in Figure 3.4. Following in-progress upgrades, equalization volume at the Cliff and Chambers site will total 32 MG.

Modeled Equalization -Based on 25-Year, 96 Hour Storm

Existing and future equalization was modeled for the 25-Year, 96 Hour storm as summarized in Table 3.16.

Table 3.16 Equalization Required Based on Selected Collection Scenario

SELECTED SCENARIO			
Facilities / Interceptors (future in italics)	**2026**	**2036**	**2066**
	MG	**MG**	**MG**
Central Equalization Expansion In addition to Existing 32 MGD		Total Needed 14.3 MG	
LS 215 (Sioux River North) Equalization		3.3	
LS 218 (Tuthill) Equalization	-	-	Allowed to Surcharge
LS 240 Equalization	0.3	0.75	2.1
Foundation Park Equalization	0.6	0.6	0.69
Basins 30/31 LS Equalization	0.75	0.85	0.90
Basin 28 LS - Interim Equalization	N/A	N/A	-
Basins 27/28 LS Equalization	1.1	1.6	2.6
Basins 34 LS Equalization	0.1	3.3	8.5
Basins 15 LS Equalization	0.7	1.6	EQ tied to Basin 34
Total	3.5 MG	12 MG	17 MG

Calibrated Equalization -Based on June 2014 Storm

The peak equalized flow of approximately 40.5 MGD at the WRF occurred in June 2014. Based on calibrations of that storm event including flow bypassed to the City's lime lagoons; approximately 5-7 million gallons of additional equalization was required to contain the event even while maintaining over 40 mgd through the WRF. Equalization volumes were modeled utilizing 2026 flows to determine the 10-year EQ volumes as presented in Table 3.17.

Table 3.17 WRF/Cliff and Chambers Total Equalization Requirements

	BASED ON 25-YEAR, 96-HOUR DESIGN EVENT - FULL TREATMENT REQUIRED			JUNE 2014 STORM HYDROGRAPH PROJECTED FOR GROWTH		
Flow Through WRF	**Existing**	**2021 (approximated)**	**2026**	**Existing**	**2021 (approximated)**	**2026**
	MG[1]	**MG[1]**	**MG[1]**	**MG[1]**	**MG[1]**	**MG[1]**
35 MGD	12 MG	22	25	29	54	74
		(12 MG existing + 10 MG additional)	(12 MG existing + 13 MG additional)	(12 MG existing + 17 MG additional)	(12 MG existing + 42 MG additional)	(12 MG existing + 62 MG additional)
40 MGD	12 MG	15	17	17	33	50
(Current Hydraulic Capacity)		(12 MG existing + 3 MG additional)	(12 MG existing + 5 MG additional)	(12 MG existing + 5 MG additional)	(12 MG existing + 21 MG additional)	(12 MG existing + 38 MG additional)
50 MGD	12 MG	7	9	5	11	17
		(All existing)	(All existing)	(All existing)	(All existing)	(12 MG existing + 5 MG additional)

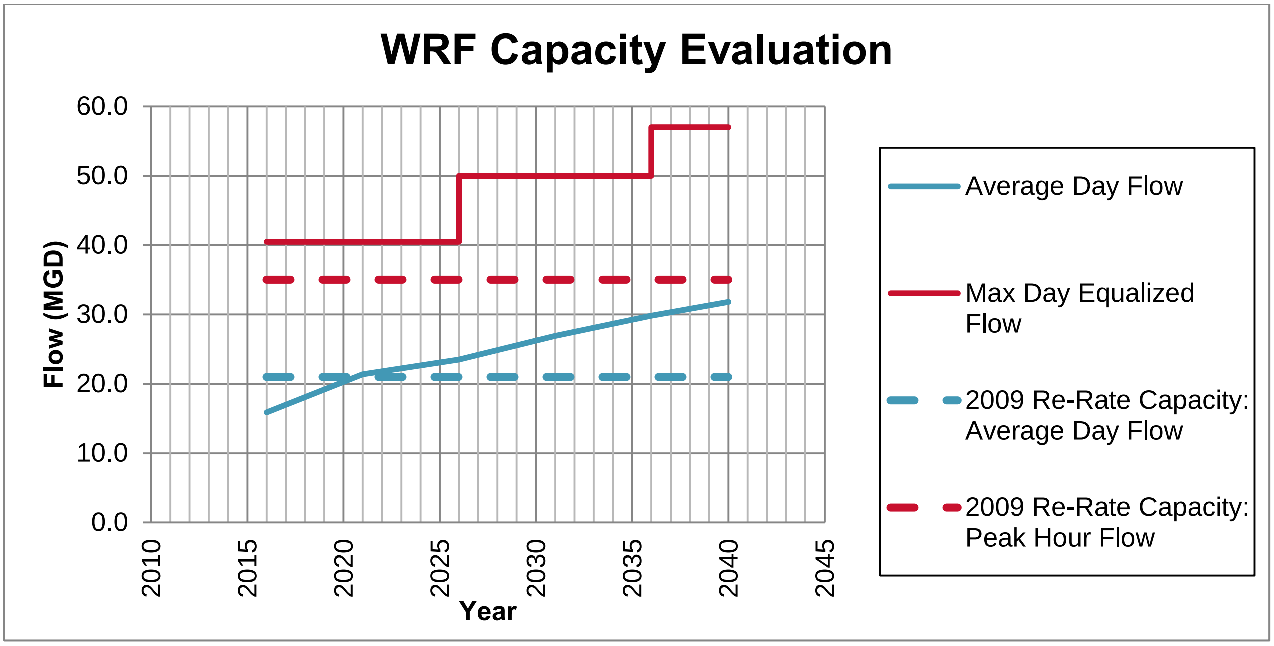
The planning goal was to provide treatment for the 25-year, 96-hour design event and be able to reliably pass the projected peak event of record. The WRF can currently pass 40 mgd and with the previously described improvements to bypass to the activated sludge train could pass 50 mgd.

As shown in Figure 3.11, the average day flow entering the plant is projected to exceed the rerated average day capacity of 21 MGD by the year 2021. The 2016 peak equalized flow (40.5 MGD) currently exceeds the rerated peak day capacity of 35 MGD.

Since that time, the City has taken action to construct an additional 20 million gallons of equalization at the Cliff and Chambers site. This project allows the City to maintain a peak equalized flow of 35 mgd through year 2021 at which time additional equalization is required at the WRF facility. The plan is for a minimum of 14-16 MG of equalization at this time. Therefore, the charted capacity evaluation for future conditions have been adjusted to 35 MGD peak flow through 2025 at which time the Phase 1 project will be put on-line.

For the maximum day equalized flow condition, it is assumed that equalization basin capacity will be added in the future, resulting in a maximum equalized flow of 50 MGD by 2026 and 57 MGD by 2036.

Figure 3.11 WRF Capacity Evaluation



3.5.6 Recommendations

The rated capacity of the entire plant is a peak equalized flow of 35 mgd. It has been determined as described later in Chapter 7 that the trickling filter train of the plant will not be utilized in the plant of the future for nutrient removal but will continue to be used through Phase 1 (2029). Therefore, major improvements have not been recommended for the trickling filter process through process pumping. In addition, it was determined that there is not an overall benefit to add additional primary clarification as, in the long term, additional carbon is required for the anoxic nutrient removal process.

The recommendation is to utilize the re-rated capacity of the trickling filter train of 35 MGD and add equalization and pump additional flows to the activated sludge side of the plant. The trickling filter train can physically pass approximately 40 mgd through the Process Pumping Station but there is diminishing returns on treatment due to a drop in clarifier removal efficiencies.

Headworks

Screening

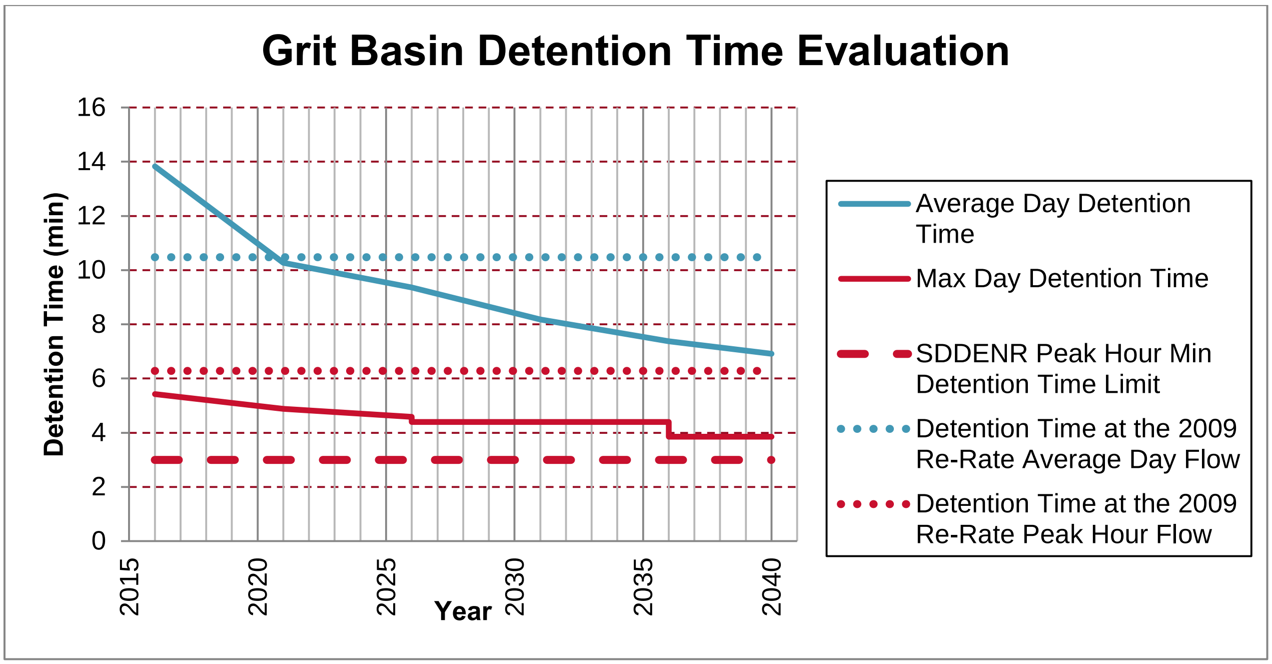
Each of the three drum screens is rated for the peak hour hydraulic flow of 17.3 mgd. Therefore, the total rated capacity of the influent screens is 52 MGD, with a firm capacity of 34.6 MGD (one screen out of service). According to Ten States Standards, where two or more mechanically cleaned screens are used, the design shall provide for taking any unit out of service without sacrificing the capability to handle the design peak instantaneous flows; therefore, additional screening capacity will be required as part of the Phase 1 project. Screening manufacturers were contacted and the existing channels can be retrofitted with a different type of fine screen and screenings dewatering unit and meet the required future capacity within the existing channels.

Substantial channel modifications along with bypassing are required to provide for 57 mgd through the facility. The grit influent channels are showing signs of deterioration. The preferred option is to rebuild and relocate the headworks building.

Grit Removal System

According to Ten States Standards, facilities for larger plants serving separate sanitary sewers should have at least one grit unit with a bypass. The WRF grit removal system is rated for the peak hour hydraulic flow of approximately 73 mgd with both units in service. As shown in Figure 3.12 the minimum SDDENR peak hour detention time is met through 2040.

Figure 3.12 WRF Grit Basin Detention Time Evaluation



The main hydraulic bottleneck in the headworks building is the 36-inch pipe that conveys flow from the screening channel to the aerated grit basins. There is 3.7 ft of headloss across the 36-inch pipe at 50 MGD, and the freeboard in the channel upstream of the screens is less than 0.5 ft at this flow rate.

Headworks Capacity Recommendations

Influent Screening

According to Ten States Standards, where two or more mechanically cleaned screens are used, the design shall provide for taking any unit out of service without sacrificing the capability to handle the design peak instantaneous flows. Therefore, additional screening capacity is recommended.

However, given there are multiple units which are only 10 years old and two bypass channels, this work can be delayed and coupled with the larger plant capacity improvement project.

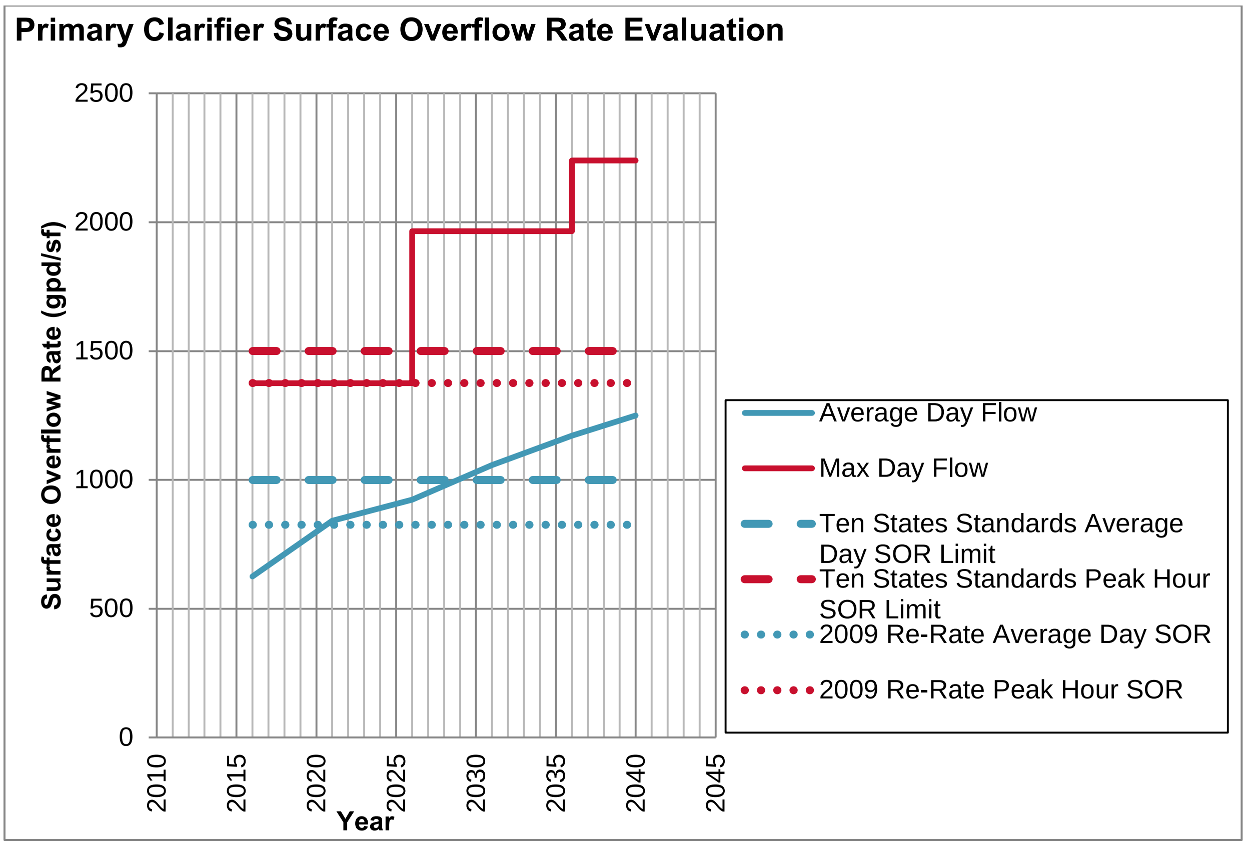
Grit Removal System

The grit units have sufficient detention capacity. The grit influent pipe needs to be increased to a minimum of 48-inch.

Primary Treatment

Figure 3.13 shows surface overflow rate (SOR) projections over the next 24 years for the average day flow (ADF) and maximum day flow (MDF). The primary clarifier SOR is defined as the flow rate that overflows the surface area to the secondary treatment process. SOR is the main capacity rating measurement for primary clarifiers.

Figure 3.13 WRF Primary Clarifier SOR Evaluation



The SDDENR requirements are shown for reference. These criteria are 1,000 gpd/sf for average design flow and 1,500 gpd/sf for maximum day flow. Figure 3.13 illustrates that the present day max day flows exceed the peak hour surface overflow rate limit. The average day SOR limit is expected to be exceeded by the year 2028.

The primary clarifier splitter manhole (Splitter MH No. 3) is a hydraulic bottleneck in the WRF. There is less than 1 ft of freeboard in this structure at flows approaching 40 MGD. Also, the primary clarifier effluent weirs become submerged at 40 MGD. The primary clarifiers and primary clarifier splitter box are hydraulic bottlenecks in the WRF. At flows exceeding 40 MGD, the water surface in Splitter MH No. 3 approaches the top of the box.

Primary Clarifier Capacity Recommendations

In the recommended alternative, flow in excess of 35 MGD primary clarifier influent flow will be diverted directly to the activated sludge process as this is the rerated capacity of the primary clarifiers. To address immediate peak flow issues this will include a new diversion structure located between the aerated grit and primary clarifiers which would have the capacity to divert future flows to the activated sludge process via gravity to directly to the aeration basins.

For the long-term, a new headworks and/or primary clarifiers is recommended which will direct flow to the activated sludge process train. A new headworks ultimately becomes part of the recommended treatment flow scheme which eliminates the need for secondary pumping. This would include provision for a new headworks and/or primary clarifiers with means to divert primary influent via a diversion structure, to be incorporated with the selected secondary treatment alternative.

The reason for incorporating the primary influent is to provide hydraulic capacity and the capability to divert additional carbon to the secondary activated sludge process to enhance nutrient removal and avoid methanol addition. Refer to Figure 3.14.

Secondary Treatment

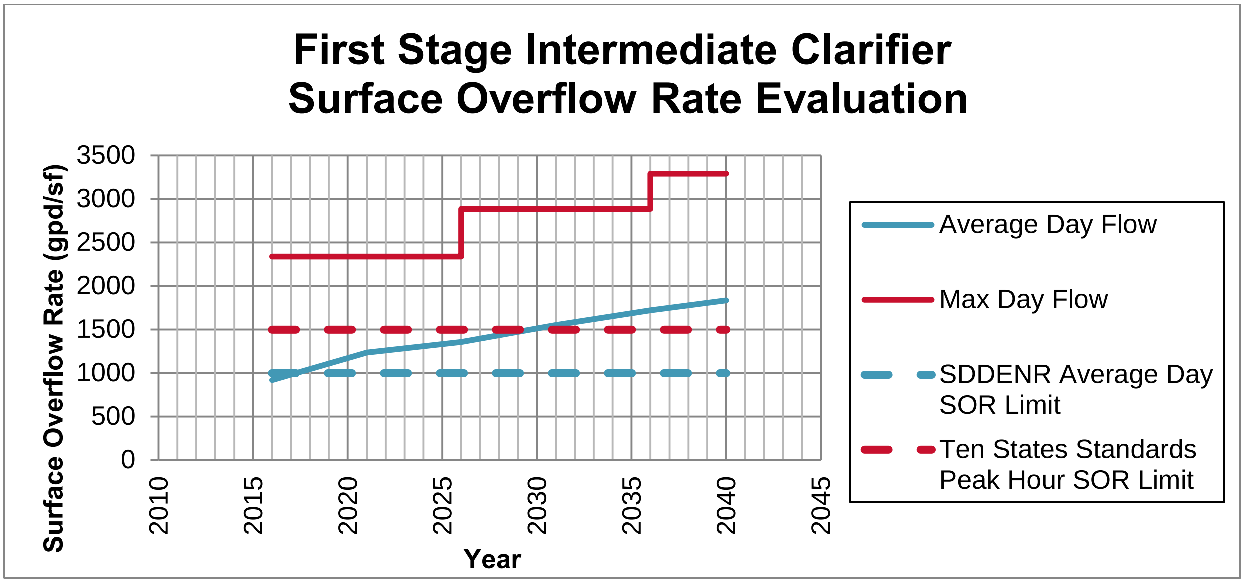
The WRF utilizes trickling filters and activated sludge processes in series for secondary treatment. As part of the 2009 WRF Master Plan, the WRF was formally re-rated at 35 MGD through SD DENR. Since that time, the WRF has demonstrated treatment for flows in excess of 35 mgd on several occasions with no process related violations. However, the rated BOD and TKN loadings have not occurred in parallel with these high flows.

Trickling Filters

The first stage trickling filter underdrain system begins to submerge at flows exceeding 30 MGD. However, the re-rated capacity of the first stage trickling filters is 35 mgd.

The re-rated capacity of each first stage intermediate clarifier is 35. The first stage intermediate clarifier effluent weirs begin to submerge at flows exceeding 36 MGD.

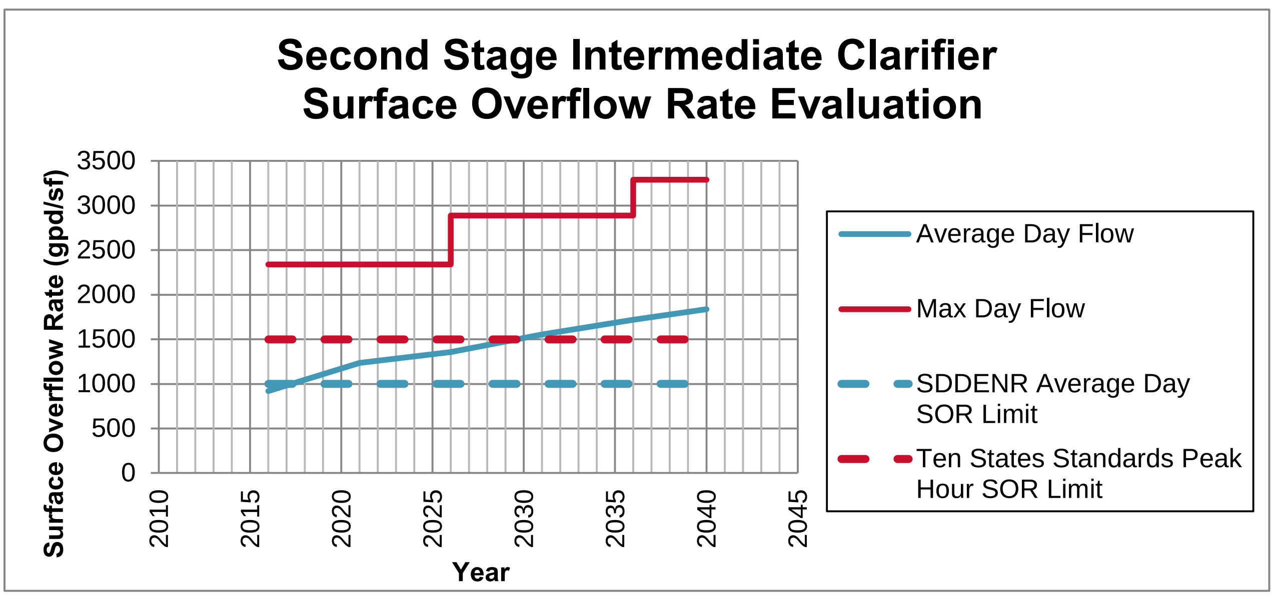
Figure 3.14 First Stage Intermediate Clarifier SOR Evaluation



The second stage trickling filter underdrain system begins to submerge at flows exceeding 30 MGD. However, the demonstrated re-rated capacity of the second stage trickling filters is 35 MGD even when partially submerged.

The second stage intermediate clarifier effluent weirs begin to submerge at flows exceeding 28 MGD. However, the demonstrated re-rated capacity of the second stage intermediate clarifiers is 35 mgd even with submerged weirs.

Figure 3.15 Second Stage Intermediate Clarifier SOR Evaluation



Process Pump Station

The WRF Process Pump Station firm capacity is 43 mgd. The maximum facility peak equalized flow to date is 40.5 mgd. No improvements are needed at the Process Pump Station as in the Phase 1 plan, flow will be diverted or pumped from the headworks/primary clarifiers to the activated sludge process, bypassing the Process Pump Station.

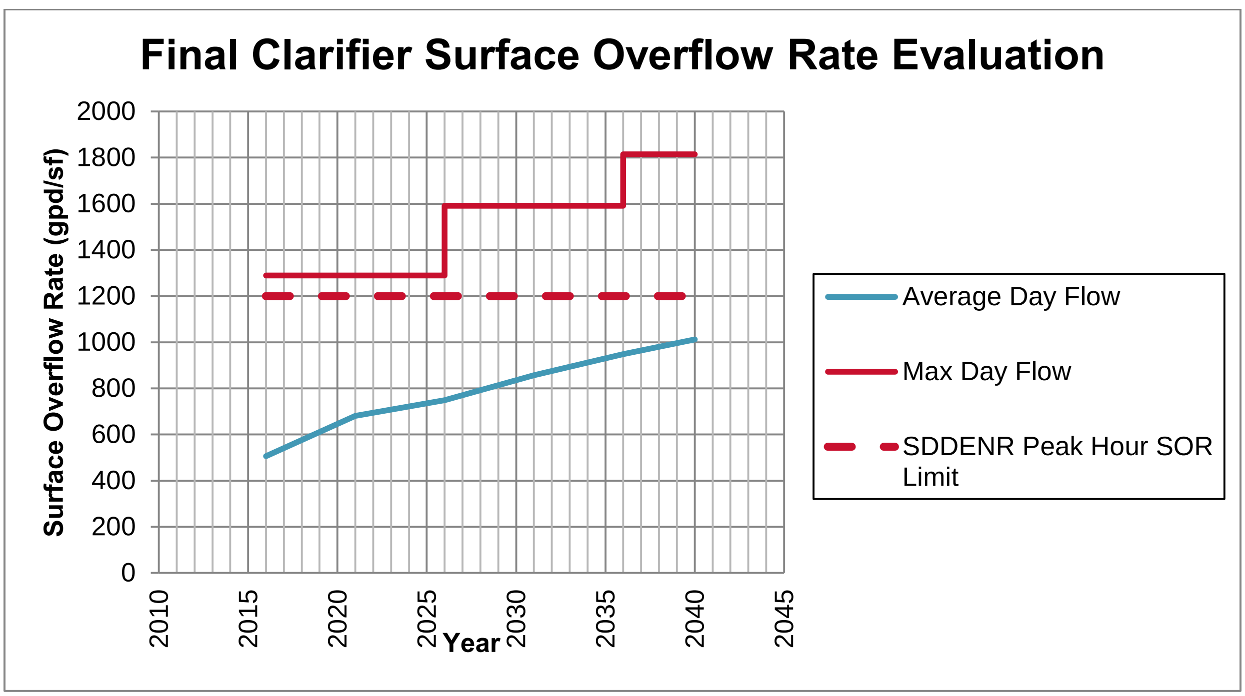
Activated Sludge Basins

The Aeration Basin influent splitter manhole (Splitter MH No. 1). Splashing occurs in Splitter MH No. 1 at flows exceeding 35 mgd. It has been determined that turbulence, not freeboard is the issue and it is recommended that Splitter MH No. 1 be covered in order to prevent splashing out of the box.

Final Clarifiers

Ten States Standards requires the SOR for final clarifiers be less than 800 gpd/sf at average design flow and 1,200 gpd/sf at peak hour flow. Figure 3.16 provides current and future surface overflow rate projections which is used for hydraulic capacity. The curve for peak hour flow is based on the assumed shaving of peak flow to WRF when the facility flow reaches 50 mgd. The dashed lines in the figure represent the design criteria for average surface overflow rate and peak hour surface overflow rate. These limits agree with commonly accepted literature sources (i.e. Metcalf & Eddy Wastewater Treatment Design Guide, 10 State Standards, and Manual of Practices, Volume 8, Book 2).

Figure 3.16 Final Clarifier SOR Evaluation



Additionally, the final clarifier effluent weirs submerge at flows exceeding 49 MGD.

Secondary Treatment Capacity Recommendations

In the recommended alternative, flow in excess of 35 MGD will be diverted directly to the activated sludge process to avoid exceeding rerated capacity of the primary clarifiers.

Short term recommended improvements are as follows:

- Provide permanent covers for the aeration basin influent and effluent splitter boxes.
- Provide 14-16 MG of on-site equalization.
- Provide secondary pumping capability from the headworks to the aeration basins.

Long term recommended improvements are as follows:

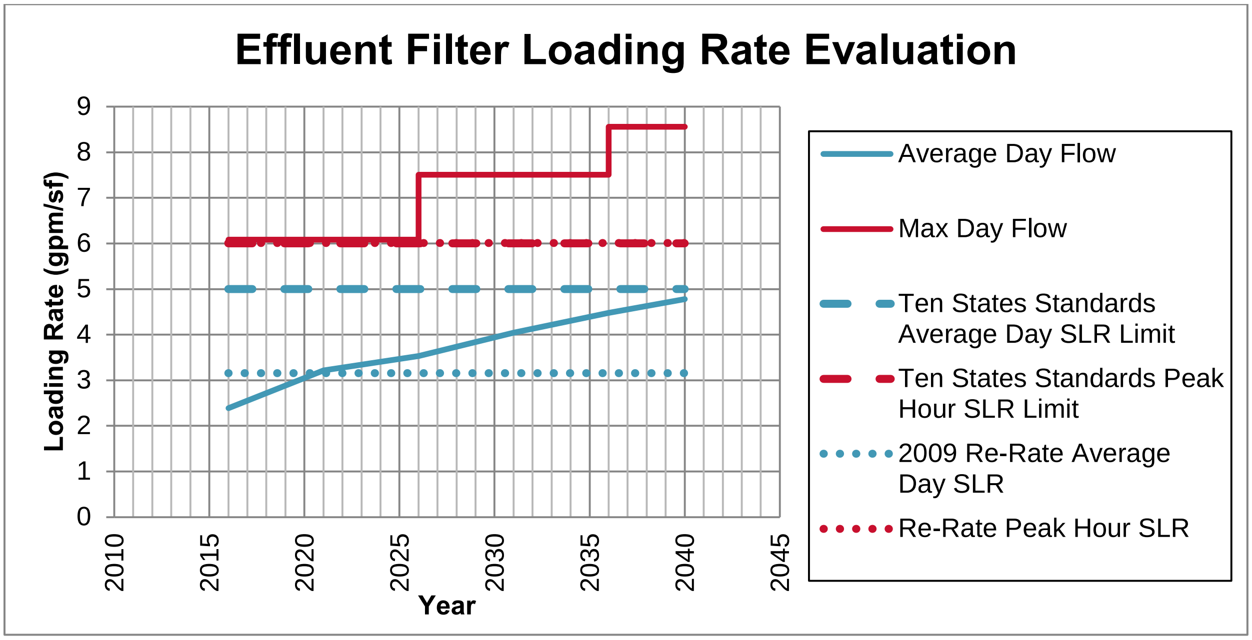
- Renovate the existing final clarifiers with Stamford Baffles ™ and modern inboard weirs to provide for improved flow characteristics to limit short circuiting.
- Provide additional secondary treatment capacity including the equivalent of 4 new clarifiers by year 2025.
- For the long-term, a new headworks and/or primary clarifiers is recommended which will direct flow to the activated sludge process train. A new headworks ultimately becomes part of the recommended treatment flow scheme which eliminates the need for secondary pumping. This would include provision to divert both primary influent via a diversion structure, for the selected secondary treatment alternative.

Tertiary Treatment

Tertiary Filters

There is currently a fixed overflow weir in the tertiary filter influent channel. The overflow weir will be overtopped at flows exceeding 48 mgd.

Figure 3.17 Tertiary Effluent Filter Loading Rate Evaluation

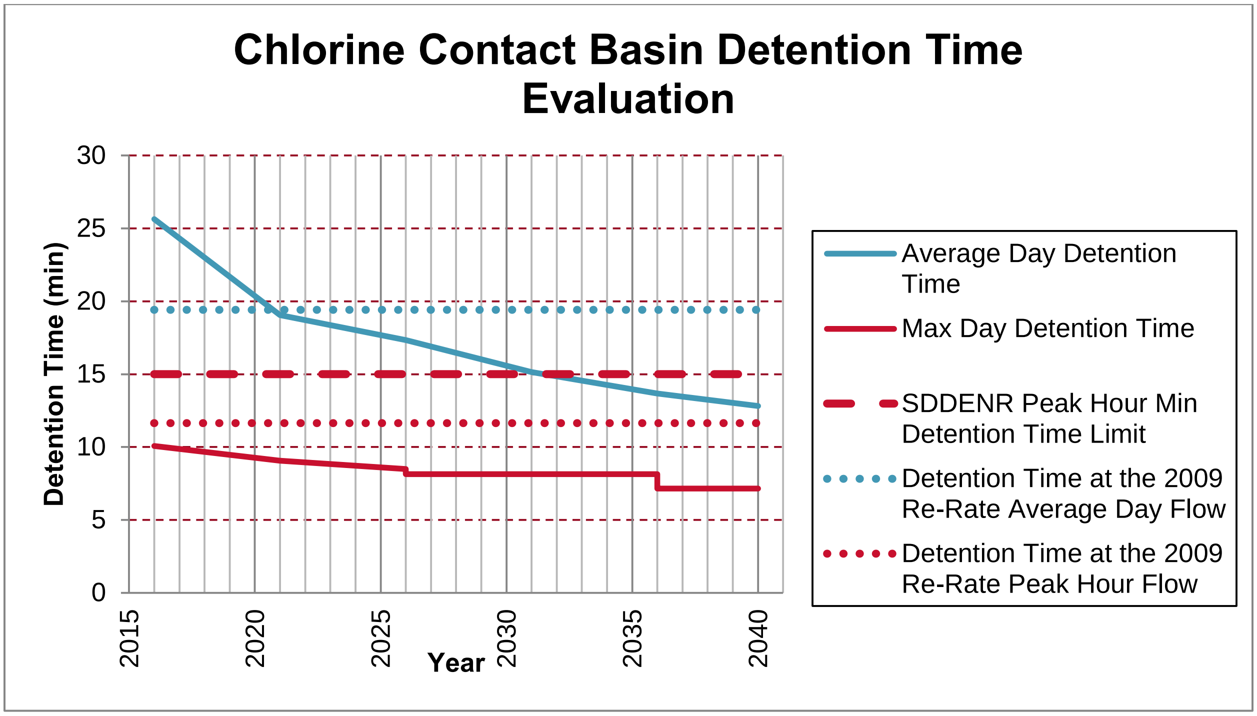


Tertiary Filter Recommendations

The long term recommendation is to expand capacity of filtration by year 2025.

Disinfection System

Figure 3.18 Chlorine Contact Basin Detention Time Evaluation



Chlorine contact basin DT and capacity is summarized as follows:

- Ten States Standards requires 15 minutes detention time at peak hourly flow.
- The current chlorine contact basin volume is 0.28 MG, which equates to a rated peak hour capacity of 27 MGD.
- 57 MGD peak flow: An additional 0.35 MG of capacity will need to be added to the chlorine contact basins in order to achieve 15 minutes of detention time at the 2036 projected equalized peak flow.
- This will provide 30 minutes of detention time at the 2036 average day flow rate (29.8 MGD).
- Additional contact time occurs in the pipe upstream of the chlorine contact basin, but this pipe volume was not included as part of the contact volume.

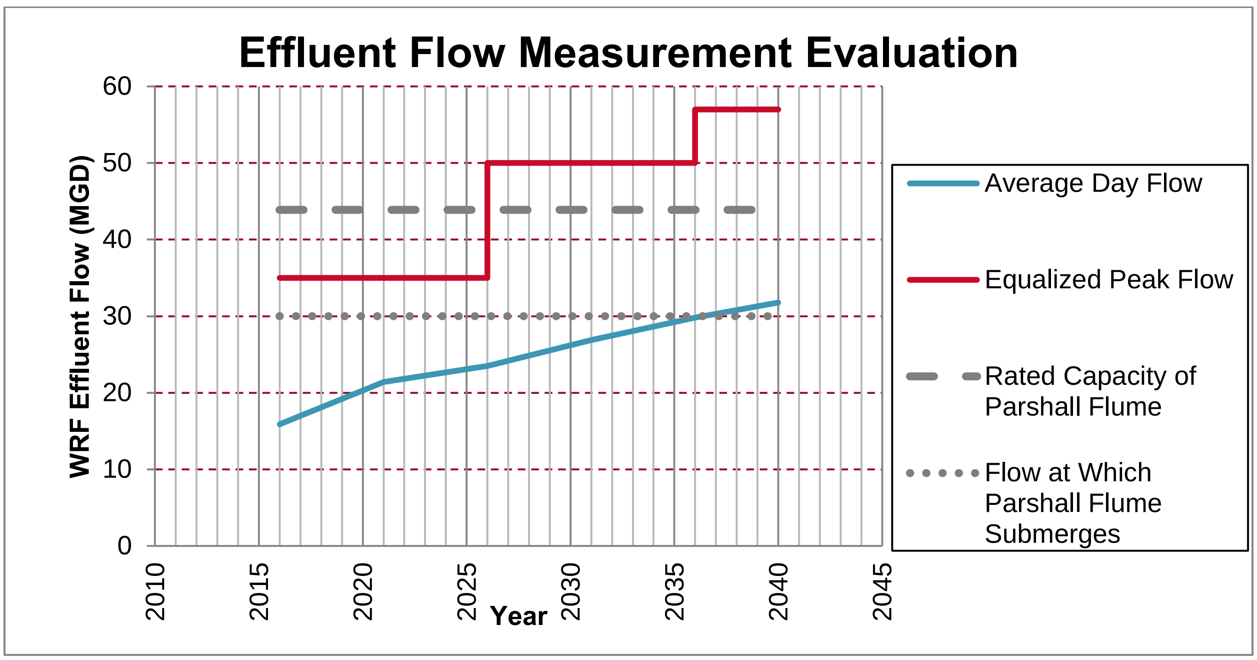
Chlorine Contact Recommendations

The long term recommendation is to add an additional 0.35 MG of capacity to the chlorine contact basins in order to achieve 15 minutes of detention time at the 2036 projected equalized peak flow.

Effluent Measurement

The rated capacity of the Parshall flume is 43.9 MGD, however, the Parshall flume becomes submerged at flows exceeding 30 MGD.

Figure 3.19 Effluent Flow Measurement Evaluation



Effluent Flow Measurement Recommendations

The long term recommendation is to add an effluent magnetic flow meter and the associated structures.

3.6 Summary of Unit Process Capacity Evaluations

Figure 3.20 provides a summary of major unit processes in WRF, the average rated capacity of each unit process, and the year at which the WRF average day influent flow will exceed average rated capacity of each unit process.

Figure 3.21 provides a summary of major unit processes in WRF, the peak hour rated capacity of each unit process, and the year at which the WRF equalized peak influent flow will exceed the rated peak hour capacity of each unit process.

Figure 3.20 Process Evaluation at WRF Average Flow

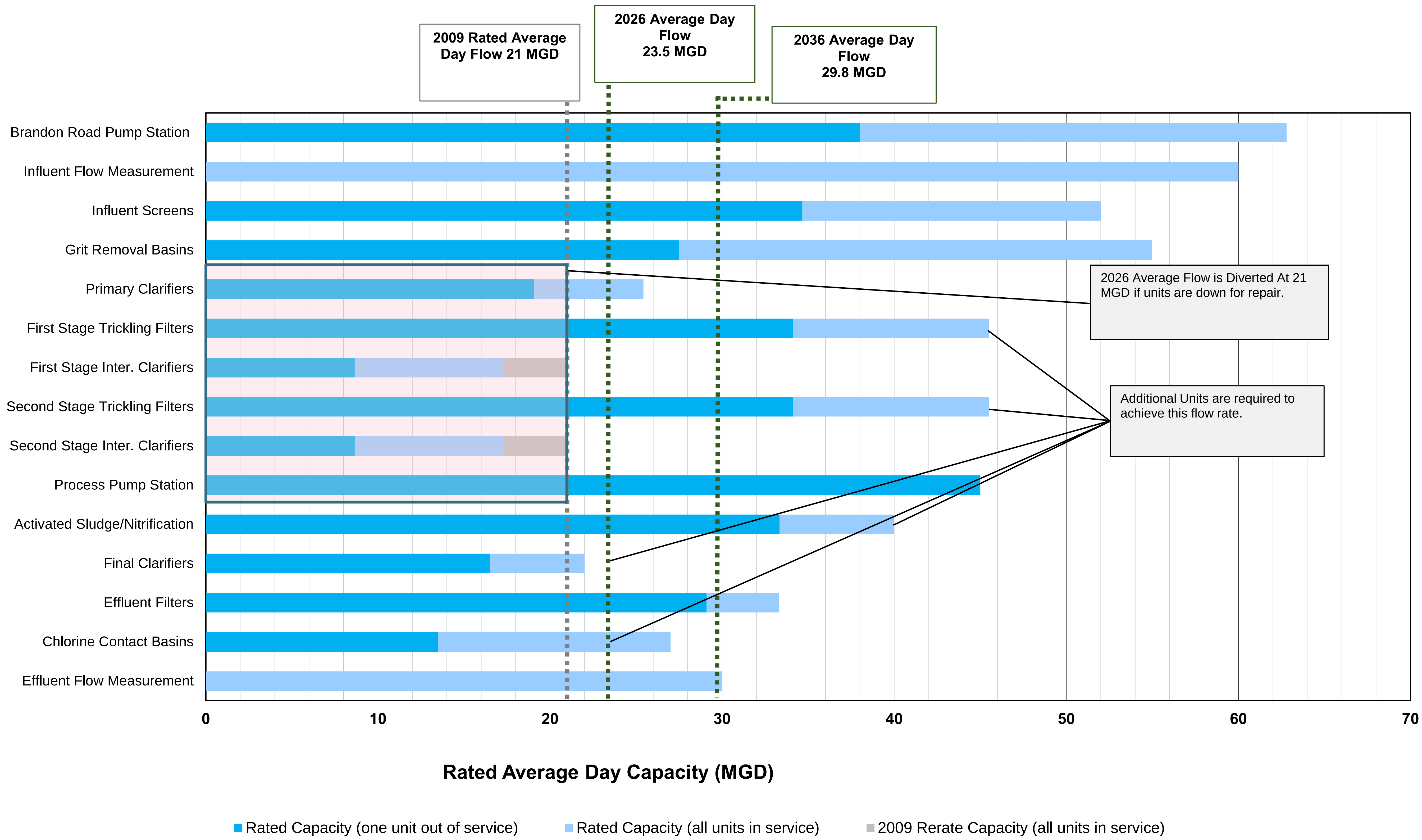
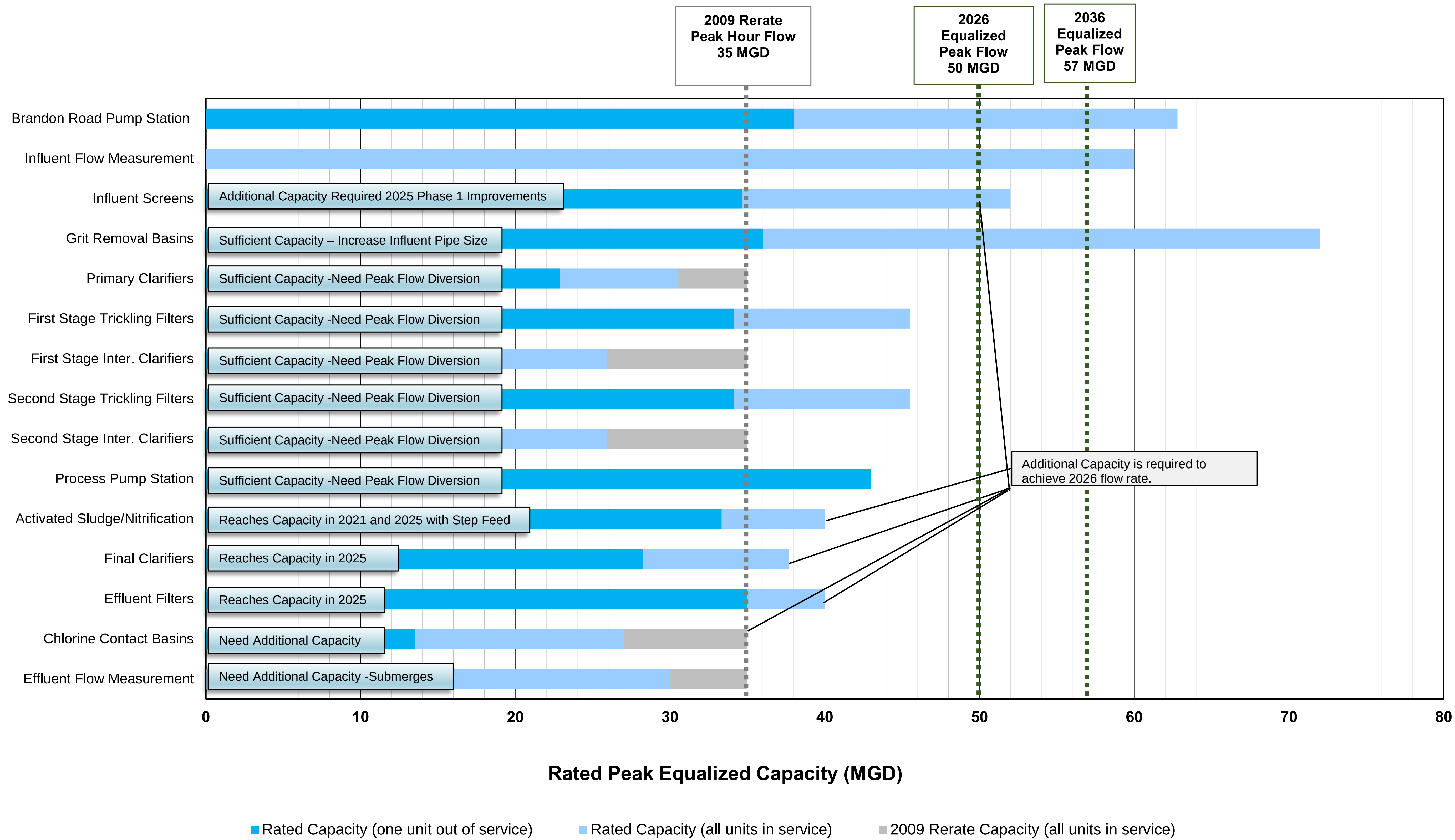


Figure 3.21 Process Evaluation at WRF Peak Equalized Flow



Treatment Capacity Limits and Trigger Years

A detailed analysis was conducted for the WRF treatment processes to determine the capacity of the existing treatment facility. Reliability with requisite units out-of-service was evaluated and the analyses confirmed that without improvements the rerated loading capacity is met at 21 mgd due to reliability requirements. Secondly, coarse bubble aeration, blower and final clarification capacity was evaluated annually for projected average and maximum month loadings.

Interim improvements including converting the system to fine bubble aeration with new blowers and implementing step feed were evaluated to determine the effect on the projected year at which flows and loads met or exceeded plant capacity.

Capacity Year – 2021 Maximum Month

The results of the analysis indicate that at the projected 2021 maximum month flow and loads, the activated sludge basins are limited with regard to dissolved oxygen (D.O.) as the first stage of the aeration basins are overloaded. The projected treatment analysis is illustrated in Figure 3.22 and summarized in Table 3.18.

It was determined that the dissolved oxygen limitation could be overcome and extend the capacity through 2025 by incorporating step feed, or bypassing flow to the second “B” basin. In addition, peak flow above 35 mgd would be diverted directly to the aeration basins (via new diversion structures and piping).

Capacity Year with Step Feed Improvements - 2025 Maximum Month

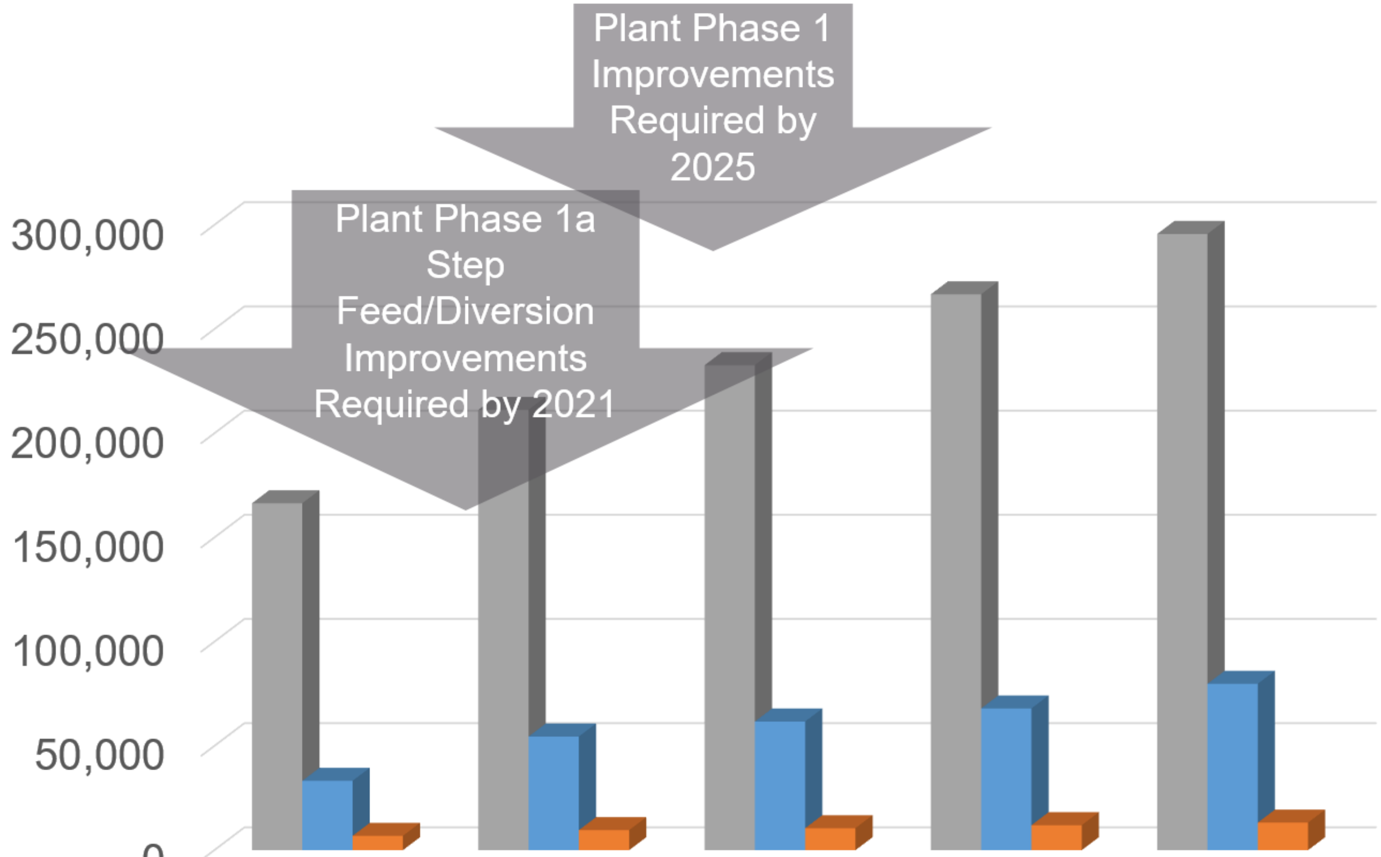
As illustrated in Figure 3.22, incorporating step feed, or providing the ability to transfer loading to the second “B” basin, increased the capacity through year 2025.

However, at the projected 2025 equalized max day flow and loads, significant improvements to the existing facility are required in order to meet the current ammonia discharge permit limits.

Phase 1 improvements required to treat projected max day flow and loads beyond 2025 include the following:

- Additional WRF EQ capacity
- Additional influent screening capacity
- Increase Grit Influent Piping
- Provide peak primary clarifier influent diversion facilities
- Additional aeration basin and blower capacity
- Additional final clarifier capacity
- Additional RAS pumping capacity
- Additional filtration capacity
- Additional chlorine contact capacity

Figure 3.22 Maximum Month Capacity Limitations



	2013-15	2021	2026	2031	2036
Population	166,467	211,252	232,689	266,739	295,664
BOD	33,272	54,520	61,729	67,999	79,814
TKN	6,850	9,605	10,553	11,980	13,211

Table 3.18 Projected Treatment Capacity Analysis

	YEAR W/ NO CHANGES	LIMITATION	AVERAGE FLOW, MGD[1]	AVERAGE BOD, LB/D[1]	AVERAGE TKN, LB/D[1]	MAX. MONTH FLOW, MGD	MM BOD, LB/D	MM TKN, LB/D	FC LOADING, GPD/S.F.
WRF Capacity	2021	MM Aeration - Oxygen Transfer	22.2	48,700	8,800	31.1	54,500	9,600	23.0
	Year w/ Step Feed								
2016 Master Plan Projections Including Existing Industrial Allocations	2025	Blower Limiting at Maximum Month Condition	23.5	52,600	9,200	33.4	60,200	10,300	34.4

Average Capacity Checked under the following conditions: Primary Clarifiers: 3 out of 4, Trickling Filters: 7 out of 8, Aeration Basins: 6 out of 6, Final Clarifiers: 3 out of 4, Blowers: 3 out of 4.

3.7 WRF Unit Process Condition Assessments

In accordance with the City's scope of services, HDR performed multiple field investigations in order to determine the current condition of the City's wastewater collection and treatment facility assets. This section of the report provide the summary of deficiencies and recommended improvements. The detailed asset evaluation technical memorandum is included in the appendix.

The following is a listing of High Priority (Immediate) and Medium Priority (5-10 Years) recommendations for the Water Reclamation Facility based on the condition assessments.

The numeric values associated with each asset condition have been developed in order to provide a complete picture of the value, condition, risk and impact of its loss or failure. Considerations such as run-to-fail operations, need for redundancy, risk tolerance, worker safety, etc. all need to be recognized in their proper priority.

Priority for improvement has been rated as High, Medium and Low. Those assets with a High rating should be addressed immediately. Assets rated as Medium can continue operating, but should be upgraded and/or replaced within the next 5 – 10 years. The Low priority rated assets are assumed to be operational for the next 10 – 20 years.

The asset building number is included in the subheading line i.e. Maintenance Building is building "2".

3.7.1 High Priority Recommendations

Maintenance Building (2)

The roof and HVAC system have exceeded their useful life, have become unreliable, and need to be replaced. There is also a missing rail on the ladder to the mezzanine and missing toe plates around the mezzanine with creates a safety concern. The missing rail and missing toe plates need to be replaced.

Grit Building (Headworks) (3)

Copper piping, which runs through the screenings room, is severely corroded. The copper piping needs to be replaced with PVC piping or FRP.

The roof and HVAC system of the older portion of the building have exceeded their useful life, have become unreliable, and need to be replaced.

There are several building defects that were noted, which affect the integrity of the building as well as create safety concerns. The following are recommended for addressing these defects:

- Repair the concrete around the railings of the stairway.
- Remove the concrete sidewalks, compact the soils and replace the sidewalks and stoops.
- Repair the concrete floor at the overhead door to screenings room.
- Repair the roof access ladder immediately for safety reasons. Repairs will have to be made to the brickwork surrounding this area to eliminate water intrusion.
- Repair damaged brick on the SE corner of the building.
- Replace the four (4) exterior single access doors in the older grit portion of the building due to age and weathered condition.

The electrical conduits, supports, and wiring on the interior and exterior of the older grit portion of the building needs to be replaced due to age, corrosion, and deterioration. Seal-offs need to be installed on the electrical conduits at the wall separating the old grit room from the screenings room to meet NFPA 820 requirements. This would allow the old grit room to be declassified.

The concrete in the aerated grit chambers were coated in 2001. However, the influent channels to the grit chambers were not coated and have severe corrosion on the concrete. The influent control gates also have signs of corrosion. The influent channel should be coated with a corrosion protective coating and the influent control gates should be replaced with stainless steel gates.

Sludge Pumping Building (4)

Electrical conduit and wiring is original and needs to be replaced to bring it up to current NFPA 820 codes. The fiber optic line needs to be extended to the Sludge Pumping Building to provide better monitoring and control of the sludge pumping equipment.

Primary Clarifiers (5)

The seals around the operable observation windows of the catwalks are worn resulting in corrosion on the interior walls of the catwalks. The entire window system should be replaced on the windows that are severely damaged. The weather stripping should be replaced on the remaining windows.

There is severe corrosion on the electrical boxes at the access platform to the clarifier walkway bridges and the lightning protection down-leads are missing or broken. All the conduit and associated electrical equipment between the Sludge Pumping Building and the access platforms of the Primary Clarifiers should be replaced. The lightning protection system should also be replaced.

First Stage Intermediate Clarifiers (7)

The electrical boxes on the walkways have severe corrosion. Replacement of these electrical boxes and conduit on the walkways is recommended.

Second Stage Intermediate Clarifiers (9)

Concrete has deteriorated around some of the guardrail posts and repair of the concrete is recommended. The electrical boxes on the walkways have severe corrosion. Replacement of these electrical boxes and conduit on the walkways is recommended.

Process Pumping Building (10)

There is corrosion on the electrical junction box near the entrance and replacement of the conduit and junction box is recommended.

There is leaking through the wetwell wall into the drywell and sealing the joints and repairing of the concrete is recommended to stop the leaking.

The humus piping and humus suction and discharge valves are thin from wear. Replacement of all the humus piping and valves with glass lined ductile iron is recommended.

Gravity Thickeners/Tunnels (11)

Gravity Thickeners

The equipment in the gravity thickeners, including the sludge collectors, mechanism drives, weirs, and scum troughs are over 30 years old and have visible wear and corrosion. The interior concrete surfaces in the basins have pitting, cracking, and are deteriorated. There is also exposed aggregate and staining on the exterior concrete walls.

The mechanism drives should be replaced and a spare drive provided for emergency replacement. The metal surfaces of the sludge collection equipment including the center column, influent well, drive cage, arms, skimmer, cross collectors; weirs and scum trough should be replaced or sandblasted and recoated. Concrete surfaces of the gravity thickeners should be coated and restored to minimize further deterioration. The stairway and platform on Thickener No. 2 sways and is not properly secured to the structure. The stairway and platform should be secured. Sandblasting and recoating the supports for the odor control blowers is recommended due to visible corrosion and pitting on the supports.

There is significant corrosion on the conduits at the Gravity Thickener platforms and replacement of the conduit, supports, and wiring is recommended.

Tunnel

The existing roof system and HVAC system for the Tunnel exit stair two is original, is in poor condition, and is not reliable. Replacing and upgrade of the roof system and HVAC system is recommended.

The south end of the tunnel at the Digester Building has severe water damage due to a failing expansion joint system. There is also severe water damage to the CMU and brick veneer on the exit stair tower. Removal of the ground cover and replacing any damaged waterproofing membrane and the entire expansion joint system is recommended. Installation of a drainage system to divert water away from the low spots is also recommended. Tuck-point portions of the brick veneer and interior CMU wall is needed where there is water damage.

The exterior single access door should be replaced due to age and weathered condition.

Process piping in the tunnels has severe corrosion and peeling paint due to moisture. Sandblasting and recoating the process piping in the tunnels is recommended.

Electrical conduits in the tunnel at the wall penetration to the Digester Building are failing due to moisture and corrosion and replacement of the failed conduits, supports, and wiring is recommended.

The thickened sludge pumps located in the west tunnel are worn, inefficient, and require a significant amount of maintenance. Replacement of the thickened sludge pumps is recommended.

Digester Building (12)

Several improvements have been made to the digester facilities and several other improvements are in the process of being made. These improvements include replacement of the roof and HVAC system, replacement of the digester covers, mixing and heating equipment, and relocation of some of the electrical equipment to a new building to meet NFPA 820 requirements. Electrical equipment no relocated as part of the current improvements should be relocated to fully meet the NFPA 820 requirements. Other improvements scheduled for the digester facilities include construction of fat, oil, and grease (FOG) receiving and feeding facilities.

There is water damage at the west door from the digester building to the tunnel. Installation of a drainage system is recommended and is addressed in the recommended tunnel improvements.

Energy Recovery Building (13)

Along with the digester facilities, several improvements have been made to the Energy Recovery Facilities and other improvements are already planned in the City's current capital improvements plan (CIP). These improvements include replacement of the roof and some of the HVAC equipment and replacement of the energy recovery equipment including changing out the engine generators to micro-turbines. Gas conditioning is also planned for improvements to the Energy Recovery Facilities.

There are however, some high priority improvements that are recommended for the Energy Recovery Building, which are not including in the City's current CIP. These improvements include:

- Replacing Exhaust Fans #3 and #4 and the supply fans, which are over 30 years old
- Replacing the boiler and boiler pumps, which are outdated
- Replacing the heat exchanger tubes

There are also issues with the operation, size, and function of the one (1) set of exterior double doors on the south side of the Energy Recovery Building. Replacement of this door with an electric operated rollup door is recommended. Replacement of the exterior single access door and second set of exterior double access doors is also recommended.

Solids Dewatering Building (14)

The Solids Dewatering Building was decommissioned several years ago and has been used strictly for storage. A new solids dewatering system is included in a future CIP project. The roof system and HVAC system of the solids dewatering building have reached their useful life and replacement is recommended with the future solids dewatering project. The electrical is also outdated and replacement is recommended with the future solids dewatering project.

The exterior single access doors to the building should also be replaced due to age and weathered condition.

Engine Generator and Utility Service Entrance (15)

Installation of a utility bypass circuit that would bypass the generator and associated paralleling switchgear is recommended to improve service reliability.

Equipment Storage Building (17)

The office area in the northwest part of the building is not large enough to support the number of staff that currently use the office area. Additionally, there are no restrooms, shower and locker rooms in the Equipment Storage Building, which creates and inconvenience for the staff that use the facility. Expansion of the office within the west side of the building along with construction of restrooms and locker room facilities is recommended.

The HVAC system is old and inefficient and will need to be replaced and updated to accommodate the additional office area, restrooms, showers, and locker rooms.

Control Building (18)

The existing HVAC system is over 30 years old, is inefficient and unreliable and needs to be replaced.

The exterior masonry joints of the building are deteriorated and replacement of the backer rod and joint sealant in the control joints is recommended. Tuck-pointing of the exterior masonry is also recommended.

The age and location of the switchgear in the blower room is a potential hazard. The current blower room can be reconfigured into a new MCC room, after the new blower building is constructed. Replacement of the switchgear should be done in combination with replacement of the aeration blowers. These improvements are included as part of the Phase I Improvements to the WRF.

The blower and controls for the aeration system are old, outdated and inefficient, using a large amount of energy when operating. Replacement of the blowers with high efficiency blowers is recommended. Replacement of the blowers should be done in combination with replacement of the diffusers in the aeration basins. These improvements are also included as part of the Phase I Improvements to the WRF.

Water ponds in the northwest area of the building and runs into the blower room through the overhead door. Grading the northwest side of the building so water flows away from the building and constructing an intake and storm sewer to carry the water south and east to the existing storm sewer is recommended.

Aeration Basin (18C)

The existing aeration valves and actuators are old and difficult to operate and maintain. Air also leaks out of the air header piping at the mechanical couplings. Replacement of the valves and actuators is recommended along with replacement of the couplings and gaskets on the air header piping as part of the Phase I Improvements to the WRF.

The electrical PVC conduit around the aeration basins has expanded and contracted due to weather and there is visible corrosion on the electrical junction boxes and supports. Replace of all the electrical conduit, junction boxes, and supports is recommended.

The air diffusers are an older inefficient coarse bubble system. Replacement with a fine bubble diffuser system is recommended. Replacement of the air diffuser system will need to be done in combination with the aeration blowers as part of the Phase I Improvements to the WRF.

RAS Building (19)

The existing roof system and HVAC system for the RAS Building are original, in poor condition, and are not reliable. Replacing and upgrade of the roof system and HVAC system is recommended.

The electrical conduit supports, and wiring on the interior of the RAS Building need to be replaced due to age, corrosion, and deterioration. The electrical transformers located on the east side of the building are in poor condition and also need to be replaced along with the associated conduit and wiring.

Filter Building (21)

There is surface rusting of electrical equipment, conduits, and wiring due to building humidity. The electrical equipment, conduits, and wiring should be replaced.

The actuators for the filter function valves are old and outdated and were not replaced with the filter upgrades completed in 2012. These valve actuators should be replaced.

The elevation of the bypass weir limits the amount of flow that goes to the filters. The bypass weir should be adjusted to allow more flow to be directed through the filters during high flows.

Chemical Feed Building (22)

The electrical transformer is in poor condition with corrosion on the enclosure. Replacement of the transformer and associated electrical conduit and wiring is recommended.

In-Plant Pumping (24)

The existing roof system and HVAC system for the In-Plant Pumping Building are original, in poor condition, and are not reliable. Replacing and upgrading of the roof system and HVAC system is recommended.

There is old and outdated electrical equipment, conduits and conduit supports that are in poor condition and need to be replaced.

Equalization Basins (32)

Several high priority improvements are planned for the Equalization Basins under the current CIP. These improvements include:

- Automation of the screening, wash water, grit removal, and grit conveying.
- Providing manifests.
- Sampling of septage received and high strength waste.
- Addition of a scale house for billing loads.
- Improving access for larger trucks.
- Extension of the existing building over dumping pit for freeze protection.
- Updates to the electrical.

Improvements no included in the current CIP for the Equalization Basins is replacement of the electrical conduit supports in the clarifier basin. Replacement of the electrical conduits, supports, and wiring is recommended.

Site Electrical

The electrical duct-bank loop that provides service to the buildings around the plant is the original from 1984. Half of the loop has already been replaced. Replacement of the second half of the electrical duct-bank is recommended.

3.7.2 Medium Priority Recommendations

Maintenance Building (2)

The compressed air system in the maintenance building is old, worn, and unreliable. Replacement with a new compressed air system is recommended.

Paint on the interior Maintenance Building walls and ceiling, primarily in the maintenance bays is peeling. Sandblasting and repainting is recommended.

Grit Building (Headworks) (3)

Grit Blowers #1 and #3 are the original blowers installed in 1986 and should be replaced, as the reliability is uncertain due to age and wear.

The grit pump and blower piping and many of the suction and discharge valves are from the original construction of the facility in 1986. The piping should be sandblasted and recoated or replaced and the valves replaced.

Sludge Pumping Building (4)

The sludge pumping building lacks heat at times, because of competing heat requirements with other buildings that are also provided with heat from the central boiler system. Supplemental natural gas heat should be provided or the hot water loop to the sludge pumping building removed and primary heat provided by natural gas heating. Additional ventilation or dehumidification needs to be provided to control condensation.

Replace the one (1) set of exterior double doors and one (1) single access door due to age and weathered condition.

Primary Clarifiers (5)

The equipment in the primary clarifiers, including the sludge collectors, mechanism drives, weirs, and scum troughs are over 30 years old and have visible wear and some corrosion. The scum telescoping valves also have severe corrosion. The concrete in the basins is in good condition. However, there are some cracked, deteriorated, and discolored concrete surfaces.

The mechanism drives should be replaced and a spare drive provided for emergency replacement. The metal surfaces of the sludge collection equipment including the center column, influent well, drive cage, arms, skimmer, cross collectors; weirs and scum trough should be replaced or sandblasted and recoated. If still used, scum telescoping valves on the clarifiers should be replaced, otherwise remove the telescoping valves. Concrete surfaces of the clarifiers should be coated and restored to minimize further deterioration. The metal steps at the entrance to the catwalks should also be replaced due to severe corrosion.

Manhole #8 (6B)

The concrete sidewalk steps and narrow sidewalks make it difficult to clear snow with the UTV. The sidewalks around the manhole are also settling and cracking. The sidewalk steps should be removed and the area regarded and the sidewalk configured so that the steps can be eliminated as part of the overall pavement and sidewalk replacement plan. The sidewalks should be removed and replaced with wider sidewalks from Splitter Manhole #4 to Splitter Manhole #5 as part of the overall pavement and sidewalk replacement plan.

First Stage Intermediate Clarifiers (7)

The ground has eroded away under the concrete support for the drain valve operator stands. Filling and grading under the concrete support is recommended.

Manhole #10 (8B)

The concrete sidewalks are too narrow for clearing snow with a UTV. Removal and replacement of the sidewalks with wider sidewalks from Splitter Manhole #6 to Manhole #10 is recommended as part of the overall pavement and sidewalk replacement plan.

Splitter Manhole #7 (9A)

The concrete sidewalk steps and narrow sidewalks make it difficult to clear snow with the UTV. The sidewalks around the manhole are also settling and cracking. The sidewalk steps should be removed, the area regarded and the sidewalk configured so that the steps can be eliminated. The sidewalks around the manhole should be removed, the base below compacted and the sidewalks replaced with wider sidewalks as part of the overall pavement and sidewalk replacement plan.

Manhole #11 (9B)

The sidewalks are cracked and there is settling around the manhole. Removal of the sidewalks, filling and re-compacting the base under the sidewalks and then replacement with wider sidewalks is recommended as part of the overall pavement and sidewalk replacement plan.

Process Pumping (10)

The exterior north double doors do not shut properly and need to be replaced. The three (3) single access doors are also weathered and in poor condition and should be replaced.

The exterior and interior masonry control joint sealant is significantly deteriorated and replacement with backer rod and new sealant is recommended to eliminate future water damage.

The rear exit is missing a stoop and stairs and construction of a landing and steps is recommended.

The interior paint is deteriorating due to condensation and water intrusion around the windows. Replacing the sealant and backer rod around all the windows to eliminate future water damage is recommended.

Digesters (12)

A detailed inspection of the digester gas storage sphere was not performed as part of the scope of the Master Plan preparation. However, inspection of the gas storage sphere was contracted out by the WRF and was found to be in good condition. Regular inspections, every 5-10 years, should be scheduled as it is a corrosive environment.

Engine Generator and Utility Service Entrance (15)

The exhaust of the generator is very rusty and there are rust spots on the enclosure. Either wrapping the exhaust with an aluminum product or arc sprayed with an aluminum coating is recommended on the exhaust. On the enclosure, removal of the rust spots and application of a protective coating is recommended.

The steps into the enclosure do not have hand railing or a platform, which creates an unsafe condition. Construction of a stairway with platform is recommended to improve access to the generator enclosure.

The asphalt and concrete pavement at the generator is worn, has several low spots and open control joints. Complete replacement of the driveway and parking area to the generator is recommended.

Dumping Station (16)

The electrical conduit and conduit supports at the dumping station have significant corrosion and should be replaced.

Splitter Manhole #1 (18A)

Water splashes out of the splitter manhole when pumped flows exceed 35 MGD. Covering the splitter structure with aluminum checker plate is recommended to prevent splashing.

Manhole #1 (18B)

Water also splashes out of Manhole #1 when flows exceed 35 MGD and there is mineral buildup on the grating over the manhole. Replacement of the grating over the manhole with aluminum checker plate to prevent splashing is recommended.

Aeration Basin (18C)

There are minor cracks in the concrete floor and walls of the aeration basins. Operations staff is unable to completely drain the basins without the use of sump pumps. Repair of the concrete walls and floor surfaces is recommended along with grout sloping the basin floors to provide better drainage.

The conduit, boxes, and supports for the dissolved oxygen (DO) sensor cables have corrosion and should be replaced.

The light stands and fixtures around the aeration basins are outdated and inefficient and should be replaced with more efficient LED lighting.

RAS Building (19)

The Return Activated Sludge (RAS) pumps and Waste Activated Sludge (WAS) pumps are original and have reached the useful life and replacement is recommended. Replacement of the RAS and WAS pumps, including the costs, are incorporated into the Phase I Improvements to the WRF.

The exterior masonry sealant of the building is severely deteriorated and the building has signs of settlement. Mitigating building settlement and repair of the exterior masonry is recommended. The backer rod and sealant should be replaced in the exterior masonry control joints and tuck-pointing should be done on the entire building.

There is water intrusion into the drywell of the building. The concrete joints should be sealed and the concrete repaired to stop water from leaking into the drywell.

The one (1) set of exterior double doors should be replaced due to age and weathered condition.

The grating on the north side of the building is severely bent and poses a safety hazard. Replacement of this grating is recommended.

Final Clarifiers (20)

Several concerns were noted with the final clarifiers including old mechanisms with corrosion, draft tubes that provide suboptimal sludge removal, center wells that are outdated and effluent weirs that are hard to access for cleaning. Past issues with foaming and rising sludge during high flows was also noted by the operations staff. Other issues with the final clarifiers are moderate delamination of the surface coating on the concrete tanks and concrete steps and sidewalks that have settled and cracked.

Recommendations for the Final Clarifiers include constructing in-board weirs mounted off external walls, replacing the draft tube mechanisms with updated removal system, such as Tow-bro sludge removal mechanisms, and providing stainless steel mechanisms and components to minimize or eliminate corrosion. Installation of state of the art flocculation center wells and weir covers to control algae is also recommended.

The deteriorated concrete surfaces of the clarifier basins should be recoated and the concrete sidewalks and steps should be removed and replaced.

The electrical conduits and boxes on the walkway bridges of the final clarifiers have severe surface corrosion and should be replaced with upgrades to the mechanisms.

Upgrades to the Final Clarifiers, including the costs, are incorporated into the Phase I Improvements to the WRF.

Filter Building (21)

There is moderate cracking on the inside face of the southeast building wall and there is deterioration of the paint around the inside of the windows due to condensation and water intrusion around the windows. The exterior masonry joint sealant has also deteriorated. The masonry damage should be repaired and tuck-pointing completed on the exterior. Backer rod and sealant should be replaced on all the windows to stop the water intrusions.

The wall paint finish in the lower pipe gallery is peeling and faded. Repainting the lower level pipe gallery walls is recommended.

The one (1) set of exterior double doors and one (1) exterior single access door should be replaced due to age and weathered condition.

Chemical Feed Building (22)

The sidewalks around the chemical feed building need to be replaced due to settling and cracking and the repairs to the exterior stairways need to be made due to cracking concrete. Replacement of the sidewalk around the chemical feed building is recommended as part of the overall pavement and sidewalk replacement plan.

The one (1) set of exterior double doors and three (3) exterior single access doors should be replaced due to age and weathered condition.

Chlorine Contact Basin (23)

Effluent flow is monitored via a Parshall flume, which is not a highly accurate device. At or above a 100-year flood event water will back up effluent from the Chlorine contact basin to where the existing Parshall flume flow meter will become submerged and less accurate. Additionally, even under normal flow conditions the changes in flow direction upstream and downstream of the flume also negatively impact its accuracy. Removal of the Parshall flume (or it could be left in place but not used) and installation of a magnetic flow meter on the effluent line between the Chlorine Contact Basin and the Cascade Aerator is recommended. Manhole #3 could be eliminated when the new flow meter is installed.

Replacement of the effluent flow meter and expansion of the chlorine contact basin to accommodate projected future flows, including the costs, is incorporated into the Phase I Improvements to the WRF.

In-Plant Pumping (24)

The exterior masonry sealant of the building is severely deteriorated and there is moderate cracking on the exterior face of the building in the southwest corner. The masonry needs to be repaired and the backer rod and sealant replaced in the exterior masonry control joints. Tuck-pointing should be done on the entire building.

The one (1) set of exterior double doors should be replaced due to age and weathered condition.

There is water intrusion into the drywell between the floor and wall. The concrete joints should be sealed and the concrete repaired to stop water from leaking into the drywell.

The Non-Potable Water (NPW) pumps and the In-Plant Waste pumps are original and have visible corrosion on the pumps and replacement of these pumps is recommended.

The volume of filter backwash water was reduced with the upgrades to the filters and the addition of an air backwash system and the rate the In-Plant Waste Pumps return backwash wastewater to the final clarifiers or aeration basins could be reduced. Installation of VFDs on the In-Plant Waste Pumps is recommended to allow varying the return of backwash wastewater by the pumps, to reduce cycling and flow peaks.

The NPW pumping system is inefficient and operations staff has to make sure non-potable water is in use year-round to make sure the NPW Pumps are not cycling on and off continuously. Installation of a constant pressure pumping system (Aquavar type system) including a small pressure tank, pressure control and valves, and control panel and variable frequency drives is recommended. Replacement of the original strainers is also recommended.

The piping, valves, meters, and strainers on both the NPW system and In-Plant Waste system are old and outdated. Replacement of all the valves, meters, and strainers is recommended along with sandblasting and recoating the piping.

The link seals on the suction lines in the wall between the In-Plant Waste wetwell and drywell leak, causing staining on the walls. Replacement of the link seals is recommended.

Site Pavement and Sidewalks

The concrete pavement is in poor condition and the concrete sidewalks have several areas where there is settlement, cracking, and both vertical and horizontal separation from adjacent structures. The narrow sidewalks make it difficult to clear snow using the City's UTV. Steps on the sidewalk also make it difficult to clear snow with the UTV.

All concrete pavement needs replacing at the WRF. As such, removal and replacement of the concrete pavement throughout the WRF is recommended.

Removal of existing concrete sidewalks and replacement with minimum 6 feet wide sidewalks were practical is recommended to allow better access for clearing snow with the City's UTV.

Removal of the steps in the sidewalks by the Filter Building, from the Primary Clarifiers to the Digester Building, and at Manhole No. 8 and No. 10 is recommended and reconfiguring the sidewalks considered, allowing removal of the steps.

Equalization Basins (32)

The center well of clarifier has rust and the influent pipe to the clarifier has corrosion. There is also corrosion on the bypass pipe and valve of the clarifier. Sandblasting and recoating the center well, influent piping and bypass piping and valve are recommended.

3.7.3 Summary of WRF Condition Improvements

Table 3.19 is a summary of the High Priority and Medium Priority Improvements and Estimate Project Cost.

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
High	Maintenance Building (2)	Building Structure	Age & reliability	Replace roof, trim, coping, & flashing	$367,000
		Mezzanine	Safety	Replace missing ladder rail and missing toe plate.	$3,800
		HVAC System	Age & reliability	Replace HVAC system	$680,000
High	Grit Building (Headworks) (3)	Copper Piping	Pipe is severely corroded	Replace copper piping with PVC piping	$13,000
		Grit Chambers/ Control Gates	Very corrosive area that requires frequent rehab.	Rehabilitate influent channel and replace gates	$610,000
		Concrete Floor	Cracking/deterioration of floor.	Repair concrete floor at overhead door of screen room	$18,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		Building Structure	Damaged/missing brick	Repair brick on SE corner of bldg.	$5,000
		Concrete Stairway and Railing	Safety concern	Replace concrete around railing.	$1,200
		Sidewalks & Stoops	Settling/separating from bldg.	Replace sidewalks & stoops as part of Facility Sidewalk Replacement Plan	-
		Roof Access Ladder	Safety concern	Repair roof access ladder	$1,000
		Building Structure	Age & weathered	Replace the exterior doors (4 Single Doors)	$24,000
			Age & reliability	Replace roof, coping, trim, & flashing	$74,000
		HVAC	Age/reliability & efficiency	Replace HVAC system	$143,000
		Electrical - General	Update to meet NFPA 820 requirements	Replace electrical	$151,000
		Electrical	Age and deterioration	Repair exterior electrical conduits and supports	$51,000
High	Sludge Pumping Building (4)	Electrical - Fiber Optic		Extend fiber optic line	$60,000
		Electrical - General	Update to meeting NFPA 820 requirements	Replace electrical	$60,000
High	Primary Clarifiers (5)	Primary Clarifier #1	Worn seals around observation windows	Replace windows system of catwalk	$5,750
		Primary Clarifier #2	Worn seals around observation windows	Replace windows system of catwalk	$5,750
		Primary Clarifier #3	Worn seals around observation windows	Replace windows system of catwalk	$5,750
		Primary Clarifier #4	Worn seals around observation windows	Replace windows system of catwalk	$5,750
		Electrical	Corrosion	Replace conduit and boxes at platforms	$121,000
			Down leads missing or broken	Replace lightning protection system	$13,000
High	First Stage Intermediate Clarifiers (7)	Electrical	Corrosion	Replace conduit and boxes on walkways	$50,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
High	Second Stage Intermediate Clarifiers (9)	Structural	Age & safety	Replace concrete at the guardrail posts	$5,000
		Electrical	Age & corrosion	Replace conduit and boxes on walkways	$50,000
High	Process Pumping (10)	Humus & In-Plant Piping	Age & wear	Replace humus line with glass lined pipe	$360,000
		Building Structure	Leaking between joints	Seal joints & repair concrete between wetwell & drywell	$224,000
		Electrical	Age & corrosion	Replace conduit and j-box near entrance	$30,600
High	Gravity Thickeners/ Tunnel (11)	Gravity Thickener #1	Cracks/wear and discoloration of concrete	Restore int./ext. concrete surfaces	$145,000
			Corrosion	Replace mechanism	$547,000
			Corrosion on supports	Rehab support for odor control blowers	$4,500
		Gravity Thickener #2	Cracks/wear and discoloration of concrete	Restore int./ext. concrete surfaces	$145,000
			Not properly secured	Repair stairs and landing	$4,000
			Corrosion/thin metal	Replace mechanism	$547,000
			Corrosion on supports	Rehab support for odor control blowers	$4,500
		Tunnel	Deteriorated walls	Concrete walls	$109,000
			Water leaks into tunnel through walls.	Install drainage system.	$50,000
			Water damage	Replace brick/tuck-point exit stair tower	$23,000
			Water damage	Replace roof, coping, trim & flashing on exit stair tower	$9,000
			Door is old and weathered	Replace the single access door at the tunnel tower exit	$7,000
			Corrosion on scum and sludge piping	Sandblast and recoat piping	$91,000
		Thickened Sludge Pump #1	Pump is worn and inefficient	Replace pump	$91,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		(11PUM1100)	Pump is worn and inefficient	Replace motor	
		Thickened Sludge Pump #2 (11PUM1101)	Pump is worn and inefficient	Replace pump	$91,000
			Pump is worn and inefficient	Replace motor	
		Thickened Sludge Pump #3 (11PUM1102)	Pump is worn and inefficient	Replace pump	$91,000
			Pump is worn and inefficient	Replace motor	
High	Gravity Thickeners/ Tunnel (11)	Thickened Sludge Pump #4 (11PUM1103)	Pump is worn and inefficient	Replace pump	$91,000
			Pump is worn and inefficient	Replace motor	
		HVAC	Code Compliance	Update HVAC system to meet NFPA 820	$156,000
		Electrical	Age & condition	Replace conduit at thickener platforms	$49,000
			Age & condition	Replace conduit/supports and wiring in tunnel	$45,000
High	Digesters (12)	Building Structure	Water leaks into bldg. At west side	Install drainage system (addressed in tunnel improvements).	-
		Electrical	Code compliance	Remove electrical from existing electrical rm.	$1,044,000
High	Energy Recovery (13)	Generator #1	Requires frequent overhauls due to non-scrubbed biogas.	Caterpillar (Under current CIP for replacement)	Included in Current CIP
		Generator #2	Requires frequent overhauls due to non-scrubbed biogas.	Caterpillar (Under current CIP for replacement)	Included in Current CIP
		Generator #3	Requires frequent overhauls due to non-scrubbed biogas.	Jenbacker (Under current CIP for replacement)	Included in Current CIP
		Building Structure	Issues with operation, function, & size of existing double doors.	Replace south door w/rollup door	$62,000
		Building Structure	Doors are old and weathered	Replace the exterior access doors (2 double and 1 single)	$31,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		Gas Fired Hot Water Boilers	Age & condition	Replace the boilers	$241,000
		Heat Exchanger Tube (5 Each)	Age & condition	Replace the heat exchanger tubes	$251,000
		Boiler Hot Water Pump (2 Each)	Age & condition	Replace the boiler hot water pumps	$101,000
		Supply Fans (2 Each)	Age & condition	Replace the supply fans	$21,000
		Roof Exhaust Fans #3 & #4	Age & condition	Replace exhaust fans #3 & #4	$21,000
High	Solids Dewatering (14)	Building Structure - Roof	Age & condition	Replace with dewatering project	$260,000
		Building – Exterior Doors	Age & condition	Replace the exterior access doors (5 single)	$37,000
		HVAC	Age & condition	Upgrade and rezone heat and add natural gas heating	$289,000
		Electrical	Age & condition	Replace/upgrade with dewatering project	$621,000
High	Engine Generator (15)	Controls	Service reliability	Install utility circuit bypass	$252,000
High	Equipment Storage (17)	Building Structure	Space requirements	Expand office area to NW part of bldg.	$428,000
		HVAC	Old tube heaters	Update HVAC system and expand to new office area	$141,000
High	Control Building (18)	Civil/Site	Water ponds and runs into bldg.	Correct drainage on N & W sides of bldg.	$61,000
High	Control Building (18)	Blower #1 (18BLO001)	Age and efficiency	Replace blower	Included in Phase I Impr.
			Age and efficiency	Replace motor	
		Blower #2 (18BLO002)	Age and efficiency	Replace blower	Included in Phase I Impr.
			Age and efficiency	Replace motor	
		Blower #3 (18BLO003)	Age and efficiency	Replace blower	Included in Phase I Impr.
			Age and efficiency	Replace motor	

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		Blower #4 (18BLO004)	Age and efficiency	Replace blower	Included in Phase I Impr.
			Age and efficiency	Replace motor	
		Electrical	Age & efficiency	Update controls	Included in Phase I Impr.
		Building Structure	Deterioration and water damage	Replace ext. sealant and tuck-point	$622,000
		Building – Exterior Doors	Aged & worn	Replace the exterior access doors (2 single)	$16,000
		HVAC	Age/reliability	Replace entire HVAC system	$603,000
		Electrical	Age/reliability	Replace/relocate switchgear/separate switchgear circuits	Included in Phase I Impr.
High	Aeration Basins (18C)	Air Header Piping	Leaks at couplings	Replace leaking couplings	Included in Phase I Impr.
		Diffusers	Inefficient. Missing diffuser tubes	Replace with fine bubble diffusers	Included in Phase I Impr.
		Influent Valves	Corrosion	Replace the valve actuators	Included in Phase I Impr.
		Electrical	Corrosion	Replace electrical J-boxes and conduit	$164,000
High	RAS Building (19)	Building Structure	Age/condition & reliability	Replace roof, coping, trim & flashing	$107,000
		Electrical - General	Age, condition & reliability	Upgrade electrical conduit and wiring.	$621,000
		HVAC - General	Age/reliability	Update/replace HVAC equipment	$258,000
High	Filter Building (21)	Piping & Valves	Valve actuators are original	Replace filter inf. & eff. valve actuators	$644,000
		Filter Bypass Weir	Restricts flow to filters	Raise filter bypass weir	$51,000
		Electrical	Age, condition & reliability	Update conduit and wiring.	$321,000
High	Chemical Feed Building (22)	Electrical	Age, condition & reliability	Replace transformer and update conduit and wiring.	$252,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
High	In-Plant Pumping (24)	Building Structure	Age & condition	Replace roof, coping, trim & flashing	$38,000
		Electrical – General	Age, Condition, & Reliability	Update Electrical	$321,000
High	In-Plant Pumping (24)	HVAC	Age, Condition, & Reliability	Replace HVAC System Including Heat Recovery and MAU	$236,000
High	Site Electrical	Electrical Feed Loop	Age, Condition & Reliability	Replace electrical duct bank feed loop	$423,000
High	Equalization Basins (32)	Building Structure	Freeze potential	Expand building to cover dump pits (Part of a current design project).	Under Design
		Electrical	Corrosion	Replace bottom channel of MCC (Included as part of a current design project).	Under Design
			Obsolete	Replace light fixtures in bldg. (Included as part of a current design project).	Under Design
			Corrosion	Replace conduit supports in clarifier basin	$50,000
		Entire Facilities	Labor intensive, outdated, and difficult truck access.	Expand and upgrade facilities as Part of Current Design Project	Under Design
Total High Priority Recommended WRF Improvements					$14,026,600
Medium	Maintenance Building (2)	Compressed Air System	Age/wear & reliability	Replace air compressor	$20,100
		Building Structure	Faded/peeling paint	Sandblast maintenance bay walls and ceiling & repaint	$87,000
Medium	Grit Building (Headworks) (3)	Grit Blower #1 (03BL0301)	Age/wear & reliability	Replace blower	$10,500
			Age/wear & reliability	Replace motor	
		Grit Blower #3 (03BL0303)	Age/wear & reliability	Replace blower	$10,500
			Age/wear & reliability	Replace motor	
		Grit Pump & Blower Piping	Age & deterioration	Sandblast and recoat or replace piping	$314,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		Grit Pump Suction Valves	Age/wear & reliability	Replace 2 Gate Valves	$8,000
		Grit Pump & Blower Discharge Valves	Age/wear & reliability	Replace 13 Valves	$50,000
Medium	Sludge Pumping Building (4)	Building – Exterior Door	Aged & worn	Replace exterior doors (1 double & 1 single)	$29,000
		HVAC - General	Lacking heat at times during the colder months. Condensation Issues.	Add supplemental natural gas heat or remove from hot water loop and install natural gas heating. Add dehumidification.	$64,000
Medium	Primary Clarifiers (5)	Primary Clarifier #1	Cracks/wear & discoloration of concrete	Restore int./ext. concrete surfaces	$188,000
			Age/reliability	Replace mechanism drive	$151,000
			Age and wear	Replace/restore sludge collector	$459,000
			Significant Corrosion	Replace telescoping valve	$16,000
Medium	Primary Clarifiers (5)	Primary Clarifier #2	Cracks/wear and discoloration of concrete	Restore int./ext. concrete surfaces	$188,000
			Age/reliability	Replace mechanisms drives	$151,000
			Age and wear	Replace/restore sludge collector	$459,000
			Significant corrosion	Replace telescoping valve	$16,000
		Primary Clarifier #3	Cracks/wear and discoloration of concrete	Restore int./ext. concrete surfaces	$188,000
			Age/reliability	Replace mechanisms drives	$151,000
			Age and wear	Replace/restore sludge collector	$459,000
			Significant corrosion	Replace telescoping valve	$16,000
		Primary Clarifier #4	Cracks/wear and discoloration of concrete	Restore int./ext. concrete surfaces	$188,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
			Age/reliability	Replace mechanisms drives	$151,000
			Age and wear	Replace/restore sludge collector	$459,000
			Significant corrosion	Replace telescoping valve	$16,000
		HVAC/Odor Control	Compliance with NFPA 820	Evaluate compliance with NFPA 820	
Medium	Manhole #8 (6B)	Civil/Site	Sidewalks are difficult to clear snow with UTV	Eliminate sidewalk steps and replace sidewalk from Splitter MH#4 to Splitter MH#5 part of facility sidewalk replacement plan	-
Medium	First Stage Intermediate Cl. (7)	Civil/Site	Space under stands.	Fill/grade under humus valve supports	$3,600
Medium	Manhole 10 (8B)	Civil/Site	Sidewalks are difficult to clear snow with UTV	Replace Sidewalks as part of facility sidewalk replacement plan	-
Medium	Splitter Manhole #7 (9A)	Civil/Site	Cracking & settling	Replace concrete sidewalk as part of facility sidewalk replacement plan	-
			Steps and sidewalks difficult to clear snow with UTV	Eliminate Sidewalk Steps/Widen Sidewalk as part of facility sidewalk replacement plan	-
Medium	Manhole #11 (9B)	Civil/Site	Cracked sidewalks	Replaced cracked sidewalks as part of facility sidewalk replacement plan	-
Medium	Process Pumping (10)	Building Structure	Doors do not shut properly	Repair/ replace all exterior doors.	$41,000
			Deterioration/water damage	Replace Sealant/backer rod. Tuck-point.	$90,000
			Safety Reasons	Installed a landing /stairs on the rear exit.	$7,000
			Leaks/water damage	Sealant/backer rod on all windows.	$6,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
Medium	Digesters (12)	Gas Storage Sphere	Very corrosive environment	Sandblast and Recoat Interior and Exterior Surfaces	$640,000
Medium	Engine Generator (15)	Civil/Site	Cracked/deteriorated	Replace driveway and pavement	$84,000
		Enclosure	Corrosion & safety requirements	Rehabilitate enclosure and provide platform and stairs	$12,000
Medium	Dumping Station (16)	Electrical	Electrical no longer used	Remove & Demolish conduit/supports and wiring.	$10,000
Medium	Control Building (18)	Electrical	Safety	Evaluate changing the blower voltage to 480 V.	
Medium	Splitter Manhole #1 (18A)	Concrete Structure	Wastewater splashing out during high flows	Cover concrete structure with aluminum tread plate to prevent splashing.	$239,000
Medium	Manhole #1 (18B)	Concrete Structure	Wastewater splashing out during high flows	Cover concrete structure with aluminum tread plate to prevent splashing.	$21,000
Medium	Aeration Basins (18C)	Concrete Basins	Standing water in bottom of basins when drained	Slope bottom of basins with grout	$452,000
			Cracking on the upper walls and basin bottoms	Repair basin bottom and wall surfaces	$738,000
		Electrical	Corrosion on conduits	Replace dissolved oxygen sensor conduit	$103,000
			Corrosion & outdated lighting	Replace lighting around basins	$47,000
Medium	RAS Building (19)	RAS Pump #1 (19PUMR01)	Age/wear & reliability	Replace pump	Included in Phase I Impr.
			Age/wear & reliability	Replace motor	
		RAS Pump #2 (19PUMR02)	Age/wear & reliability	Replace pump	Included in Phase I Impr.
			Age/wear & reliability	Replace motor	
		RAS Pump #3 (19PUMR03)	Age/wear & reliability	Replace pump	Included in Phase I Impr.
			Age/wear & reliability	Replace motor	
		RAS Pump #4	Age/wear & reliability	Replace pump	Included in

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		(19PUMR04)	Age/wear & reliability	Replace motor	Phase I Impr.
		RAS Pump #5 (19PUMR05)	Age/wear & reliability	Replace pump	Included in Phase I Impr.
			Age/wear & reliability	Replace motor	
		WAS Pump #1 (19PUMW01)	Age/wear & reliability	Replace pump	Included in Phase I Impr.
			Age/wear & reliability	Replace motor	
		WAS Pump #2 (19PUMW02)	Age/wear & reliability	Replace pump	Included in Phase I Impr.
			Age/wear & reliability	Replace motor	
		Building Structure	Masonry cracking	Mitigate settling	$51,000
			Groundwater leaks into drywell	Seal drywell	$186,000
			Grating is bent	Replace grating on North-side of bldg.	$58,000
			Deterioration/ water damage	Replace sealant/backer rod. Tuck-point.	$95,000
Medium	RAS Building (19)	Building – Exterior Door	Age & weathered	Replace exterior double door	$17,000
Medium	Final Clarifiers (20)	Clarifier #1	Cracking/ deterioration of concrete	Basin - Repair concrete structure (Included in Phase I Improvements).	Included in Phase I Impr.
			Age & wear	Mechanism - Replace sludge collection mechanism (Included in Phase I Improvements).	Included in Phase I Impr.
			Weirs function poorly at high flows	Construct new in-board launderer off external wall (Included in Phase I Improvements).	Included in Phase I Impr.
		Clarifier #2	Cracking/deterioration of concrete	Basin - Repair concrete structure (Included in Phase I Improvements).	Included in Phase I Impr.
			Age & wear	Mechanism (Included in Phase I Improvements).	Included in Phase I Impr.
			Weirs function poorly at high flows	Construct new in-board launderer off external wall (Included in Phase I Improvements).	Included in Phase I Impr.

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
		Clarifier #3	Cracking/deterioration of concrete	Basin - Repair concrete structure (Included in Phase I Improvements).	Included in Phase I Impr.
			Age & wear	Mechanism (Included in Phase I Improvements).	Included in Phase I Impr.
			Weirs function poorly at high flows	Construct new in-board launderer off external wall (Included in Phase I Improvements).	Included in Phase I Impr.
		Clarifier #4	Cracking/deterioration of concrete	Basin - Repair concrete structure (Included in Phase I Improvements).	Included in Phase I Impr.
			Age & wear	Mechanism (Included in Phase I Improvements)	Included in Phase I Impr.
			Weirs function poorly at high flows	Construct new in-board launderer off external wall (Included in Phase I Improvements).	Included in Phase I Impr.
		Site/Civil	Cracking and settling concrete steps and sidewalks	Replace concrete steps and sidewalks as part of Facility Sidewalk Replacement Plan.	Included in Phase I Impr.
		Electrical	Age & condition	Replace with new mechanisms as part of the Phase I Improvements.	Included in Phase I Impr.
		Piping/Valves	Age & condition	Replace as part of new mechanisms (Included in Phase I Improvements).	Included in Phase I Impr.
Medium	Filter Building (21)	Building Structure	Damaged masonry	Repair masonry on south side of Bldg.	$215,000
			Water intrusion	Repair cracks on the SW wall of Bldg. (inside and out)	$76,000
			Water damage	Replace Sealant/backer rod. Tuck-point.	$19,000
			Water intrusion	Replace Sealant/backer rod on windows	$13,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
Medium	Filter Building (21)	Building – Exterior Doors	Age & weathered	Replace Exterior Doors (1 double door and 1 single)	$24,000
		Building Structure	Paint is peeling	Repaint walls in lower pipe gallery	$7,000
Medium	Chemical Feed Building (22)	Civil/Site	Concrete sidewalk is cracked and settling	Replace sidewalk as part of Facility Sidewalk Replacement Plan.	$0
		Building Structure	Cracking concrete	Rehab exterior west stairway	$2,000
		Building – Exterior	Age & weathered	Replace exterior doors (1 double door and 3 single)	$47,000
Medium	Chlorine Contact Basin (23)	Parshall Flume	Questionable accuracy during flooding.	Replace with magnetic flow meter on effluent line (Included as part of Phase I Improvements.	Included in Phase I Impr.
		Concrete Structure	Expansion required for future capacity	Expand as part of Phase I Improvements	Included in Phase I Impr.
Medium	In-Plant Pumping (24)	NPW Pump #2 (24PUMP02)	Age & frequent maintenance required	Replace pump	$30,333
			Age & frequent maintenance required	Replace motor	
		NPW Pump #3 (24PUMP03)	Age & frequent maintenance required	Replace pump	$30,333
			Age & frequent maintenance required	Replace motor	
		NPW Pump #4 (24PUMP04)	Age & frequent maintenance required	Replace pump	$30,333
			Age & frequent maintenance required	Replace motor	
		NPW Pump Controls	Pumps run continuously to prevent frequent cycling	Add constant pressure pumping system to NPW Pumps.	$166,500
		Strainer #1 (24STR001)	Age & frequent maintenance required	Replace NPW strainer #1	$24,500
		Strainer #2 (24STR002)	Age & frequent maintenance required	Replace NPW strainer #2	$24,500
		NPW Flow Meter (24FLM038)	Age	Replace NPW flow meter	$21,000

Table 3.19 WRF Condition Assessment Recommendations

Priority	Major Structure	Major Component	Risk Description	Recommendation	Cost
Medium	In-Plant Pumping (24)	In-Plant Waste Pump #1 (24PUMW01)	Age & frequent maintenance required	Replace pump	$50,333
			Age & frequent maintenance required	Replace motor	
Medium	In-Plant Pumping (24)	In-Plant Waste Pump #2 (24PUMW02)	Age & frequent maintenance required	Replace pump	$50,333
			Age & frequent maintenance required	Replace motor	
		In-Plant Waste Pump #3 (PUMW03)	Age & frequent maintenance required	Replace pump	$50,333
			Age & frequent maintenance required	Replace motor	
		In-Plant Waste Controls		Add VFDs to In-Plant Waste Pumps	$86,500
		In-Plant Waste Flow Meter (24FLM037)	Age & condition	Replace In-Plant Waste Flow Meter	$21,000
		Piping & Valves	Age & condition	Replace/upgrade piping and valves	$185,000
		Building Structure	Damaged masonry	Repair brick on SW corner of bldg.	$6,000
			Water damage	Replace sealant/backer rod. Tuck-point.	$44,000
		Building – Exterior Door	Age & weathered	Replace exterior double door	$17,000
Medium	Civil/Site	Concrete Sidewalks/ Steps	Cracking, settlement, worn	Replace, widen, re-grade and eliminate concrete steps	$937,000
		Concrete Pavement	Cracking, settlement, worn	Remove and replace pavement and curb & gutter	$4,734,000
Medium	Equalization Basins (32)	Clarifier	Corrosion on inlet well	Sandblast and recoat center well	$24,000
			Corrosion on influent piping	Sandblast and recoat piping	$5,000
Total Medium Priority Recommended WRF Improvements					$13,690,00
Total Combined High and Medium Priority Recommended WRF Improvements					$27,720,000

Chapter 4 – Wastewater Flows and Loads

Wastewater Treatment and Collection System Master Plan

Sioux Falls, SD

February 2018

Table of Contents

Tables

Figures

Chapter 4 Wastewater Flows and Loads

4.1 Introduction

This chapter presents the evaluation of the anticipated flows and loads from the study area, defined in Chapter 2.

When planning or evaluating facilities to collect and treat wastewater, two primary wastewater characteristics are considered: (1) the quantity or volume of wastewater, expressed as "flows"; and (2) wastewater loads, which include Biological Oxygen Demand (BOD), Ammonia, Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS), and other physical parameters. Wastewater flow and load projections are used to evaluate the ability of existing facilities to adequately collect, transport, and treat future wastewater flows. These projected capacity requirements for each system (Collection System and Water Reclamation Facility - WRF) are provided as a basis for evaluation in the subsequent Chapters of this report.

4.1.1 WRF

To evaluate future WRF capacity requirements, population and land use projections over a 20-year planning period at 5-year intervals were used to establish the magnitude and areas of future wastewater flows and loads with a planning year of 2036. A 50-year horizon at 2066 is also presented to objectively review long-term impacts of major decisions. Additionally, flows and loads are similarly generated for prospective Eastside and Westside WRF options.

4.1.2 Collection System

Establishing appropriate wastewater sanitary sewer collection utilities to service the WRF Study Area utilizes future populations and capacity requirements for 10-, 20-, and 50-year intervals for the overall planning period. The longer-term, a 100-year horizon is presented and applied to establish planning corridors and is also used to size sewers in confined basins. This chapter will address existing and projected flows at the WRF. Calibrated flows and projected 25-year, 96-hour flows will be outlined in Collection System Model Development and Calibration (Chapter 5).

4.1.3 Related Chapters

Development of flow projections and the comparisons of existing capacity capabilities versus future capacity requirements for each system are provided as a basis for evaluation in the subsequent chapters of this report. The chapters that follow include:

- WRF Liquid Process Alternatives Evaluation (Chapter 7)
- WRF Solids Handling Evaluation (Chapter 8)
- WRF Plant of the Future (Chapter 10)

4.2 Flow Data Analysis

4.2.1 Flow Forecast Terminology & Abbreviations

Wastewater flows vary throughout the year and during different hours of the day. The types of flow rates typically used to design the different components of wastewater collection and treatment systems are discussed below, along with other abbreviations utilized throughout this chapter.

- **Gallons per Minute (gpm)**
- **Million Gallons per Day (MGD)**
- **Base Sanitary Flow (BSF).** This is the wastewater volume generated by the customers without any infiltration and inflow (I/I).
- **Infiltration and inflow (I/I).** Infiltration is flow into the sewer system from groundwater through cracks, defective pipe joints, etc. Inflow is flow derived from runoff entering the sewer system via open manholes, open pick holes or vents in manhole lids, non-gasketed manholes lids, illicit connections, etc.
- **Dry Weather Flow (DWF).** Dry weather flows represent all flows within the sanitary sewer lines on a typical day without being impacted by precipitation or snowmelt. Winter months are considered to be dry weather flows in northern climates.
- **Rainfall Derived Infiltration and Inflow (RDII).** The flow in a sanitary sewer caused directly from storm events
- **Average Day Flow (ADF).** This is the total amount of wastewater flow treated throughout the year divided by 365 days per year. Average day flow is used primarily as the basis for making peak flow projections. ADF includes I/I averaged over the year.
- **Average Daily Dry Weather Flow (ADWF).** This is the total amount of wastewater flow treated throughout the dry weather flow period (December through February for this evaluation) divided by the total number of days in the period. Average daily dry weather flow is considered to be indicative of sanitary sewage discharged to the sewer system without being impacted by precipitation or snowmelt.
- **Maximum Day Flow (MDF).** The maximum day is the day with the highest flows, which typically occurs after a rainfall event. Certain processes in the WRFs, such as determining equalization basin volumes, depend on having MDF flow projections.
- **Maximum Month Flow (MMF).** The maximum month is the highest of the average monthly wastewater flow values. Typically, the maximum month occurs in the early summer or late spring when groundwater rates reach their peak. Maximum month flow is the design condition for the biological treatment processes at the WRFs. MMF includes I/I averaged over the month with the maximum amount of flow.
- **Peak Hour Flow (PHF).** Wastewater systems experience peak flows during intense rainfall events. Inflow of runoff from a rainfall event can cause significant peak flows in the collection system and at the WRFs. Both the collection system and the hydraulically-sensitive components of the WRFs are designed to handle the peak flow. PHF includes I/I averaged over the hour with the peak flow.
- **Peak Hour Wet Weather Flow (PHWWF).** The peak hourly wet weather flow is the peak flow during the peak hour of the day at a time when the ground water when a storm event is occurring

- **Peaking Factor:** Peaking factor is the Peak flow or load divided by the Average.

4.2.2 General

Wastewater flows vary throughout the year, although the magnitude of the change is considerably less than water demands since the base sanitary flow (BSF) varies little throughout the year. The majority of the seasonal variation in wastewater flow is attributable to inflow and infiltration into the wastewater collection system. Wastewater collection systems can be significantly influenced by daily variations in wastewater flow as a result of potable use patterns throughout the City. The travel time within the collection system helps dampen the peak flows reaching the WRFs, is commonly referred to as flow attenuation. In addition, rainfall-derived inflow and infiltration (RDII), the flow portion caused directly from storm events, can contribute significantly to peak flows.

4.2.3 Flow Components

Wastewater flow is made up of two main components: BSF and I/I. BSF is that portion of the total wastewater flow directly attributable to what is predominantly indoor water use by WRF's customers. BSF is assumed to have little seasonal variation. Similar to most utilities, WRF does not meter the majority of its wastewater accounts. Therefore, the BSF is estimated from potable water billing records, significant industrial user (SIU) information, and regional customer information. Refer to Chapter 5 for further discussion on how water meter and billing records were used to generate BSF.

For the Master Plan, the difference between the ADF and the BSF is assumed to consist of a combination of I/I. I/I is made up of two components, infiltration that occurs from groundwater contributions and rainfall-derived infiltration and inflow (RDII) from storm event contributions. The groundwater infiltration is part of average day and maximum month flows. RDII is added to average day flows to represent maximum day and peak hour flows.

I/I contributes significantly to the overall wastewater flow treated at the WRFs. Approximately 21 portable flow monitors along with lift station and sump pump flows are used to identify those areas of the collection system that are significantly impacted by I/I. These basin-specific I/I factors are discussed in more detail in Chapter 5.

4.3 Existing Flows and Loads

Total permanent population and system-wide average daily flow are the basis for all wastewater flow calculations. WRF flows include flows from City of Sioux Falls, Brandon, Renner, Prairie Meadows, and Harrisburg.

Fluctuations in WRF influent flow follow the fluctuations in rainfall and groundwater levels. Inflow and infiltration contribute to flows into the wastewater treatment plant during wet weather. Inflow enters through sump pumps, roof drains, manhole castings and any direct connections. Infiltration enters the system underground and is related to groundwater and rainfall that infiltrates into the ground. Therefore, the maximum monthly plant influent occurs simultaneous to periods of above average rainfall and high groundwater levels in the sewershed.

A peaking factor is used to forecast the maximum flows and loads for the planning design basis. The term “peaking factor” as used in this chapter refers to the ratio of maximum, or peak, flow and loadings to the annual average day value. For example, the peaking factor for maximum month was determined as follows.

$$\text{Peaking Factor} = \frac{\text{Maximum Monthly Flow}}{\text{Annual Average Daily Flow}} = \frac{23.3\ \text{MGD}}{15.9\ \text{MGD}} = 1.47$$

The above average and maximum/peak flows are highly impacted by I/I and wet weather events. For facilities the size of the Sioux Falls WRF, typical flow peaking factors are 2.0 for peak hour, 1.5 for maximum day, and 1.2 for peak month. As discussed in the following sections, storms in excess of a 100-year event have predictably resulted in above-average peaking factors.

WRF Existing Flows and Loadings

The WRF measures influent, Advanced Wastewater Treatment Process Pump flow (AWT) and effluent flow rates on a continuous basis. The influent flow meter is a Parshall Flume meter located in the influent channel upstream of the headworks screening. AWT flow is measured by a magnetic flow meter. Effluent flow is measured by a Parshall flume at the outlet of the effluent disinfection system just prior to discharge to the Big Sioux River. The influent Parshall Flume is being replaced with a full pipe magnetic flow meter as the influent Parshall Flume provides unreliable flow measurement due to screening system flow back-up conditions at flows exceeding 40 MGD. The influent flume measurements have been selected for analysis and future flow projections, with flows over 40 MGD corrected utilizing the AWT meter as a basis for correction for maximum day and peak hour flows.

The historical flow data was obtained from plant records. Wastewater influent flow records for the WRF were reviewed for the last three years from May 24, 2013 through May 23, 2016 and provide the basis for evaluating historic wastewater flows. After discussions with the City, 2013 data was omitted due to both flow metering and numerous outlier data issues. Wastewater influent flow records for the WRF were included from January 1, 2014 through May 23, 2016 and provide the basis for evaluating historic wastewater flows. All flows are in units of million gallons per day (MGD).

The flows and loads were distributed by Central, Westside and Eastside contribution areas to accommodate planning needs for potential future treatment facilities. These areas were evaluated separately to determine feasibility of treating flows and loads separately from the existing WRF.

The following sections describe the WRF flows and loadings and are also compared to the 2009 Master Plan projections and typical industry standard values to provide a reference check and determine if there has been any major changes in the wastewater characteristics.

WRF Average Day Flows and Loadings

As shown in Table 4.1, average day WRF flow was 16.1 MGD (96.7gpd/capita) with average loadings for BOD at 29,847pounds per day (lb/d) (0.179 lb/day/capita), TSS at 29,357 lb/day (0.176 lb/day/capita), ammonia at 4,077 lb/day (0.024 lb/day/capita) and TKN at 6,035 lb/d (0.036 lb/day/capita).

Table 4.1 Average Day Flows and Loads (January 1, 2014 through May 23, 2016)

Area	Population	Flow	BOD	TSS	NH3-N	TKN
		MGD	*lb/day*	*lb/day*	*lb/day*	*lb/day*
Sioux Falls - Central, Sioux River South (SRS), Northeast & Foundation Park	144,788	14	26,368	25,935	3,602	5,331
Sioux Falls - Westside	8,137	0.74	1,375	1,352	188	278
Sioux Falls - Eastside	13,542	1.13	2,104	2,070	287	425
Sioux Falls WRF -Areas Total	**166,467**	***16.1***	***29,847***	***29,357***	***4,077***	***6,035***
lb/day/capita			**0.179**	**0.176**	**0.024**	**0.036**
gpd per capita		**96.7**				

Assessment

The daily flow is in-line with the previous 2009 Master Plan 2015 planned flow of 16.54 MGD. The average daily BOD and TKN loadings are 20% and 5% less than projected, respectively, while the population is about 4.5% more than projected. The organic loadings in terms of lb/day/capita and flow in terms of gpd per capita are within typical wastewater industry standard values.

WRF Existing Industrial Flows and Loadings

Significant Industrial Users (SIUs) including John Morrell, Sioux Falls Regional Airport, and North End Truck Wash currently have allocations for BOD, TSS and TKN via City issued permits. Other industrial users include West Rock (Smurfit-Stone Container Corporation), Metz Baking Co. and Land O' Lakes. In addition, the WRF began by taking Bel Brands Cheese Plant waste at the Equalization (EQ) basin and switched to loading at the WRF digester facility. Bel Brands waste is no longer being discharged at the WWTF and has not since 2016.

Table 4.2 lists both the permitted allocation and actual loadings from the industries.

Please note that all of the industrial flows and loads are included in the WRF existing flows and loads summaries as they are measured at the WRF, however, the unused portion of the permitted allocations needs to be addressed for future capacity analysis.

WRF Maximum SIU Loadings

As shown in Table 4.2, maximum monthly average permitted allocations for the SIUs are 9,821 lb/d for BOD, 5,212 lb/d for TSS, and 788 lb/d for TKN.

The actual BOD and TSS discharged to the WRF are a fraction of the permitted allocation at less than 300 lb/d and TKN is less than 50 lb/d.

The basis of planning for the WRF needs to include the allocated organic loading for the instance that the allocation is fully consumed. This current unused capacity is approximately 9,500 lb/d for BOD, 5,000 lb/d for TSS, and 740 lb/d for TKN. This is a significant portion (19% of BOD, 11% of TSS, and 8% of TKN) of the existing plant capacity.

Table 4.2 Significant Industrial User Permitted Load Allocations versus Actual Loading

	BOD (Permitted)	BOD (Actual)	TSS (Permitted)	TSS (Actual)	TKN (Permitted)	TKN (Actual)
	lb/d	lb/d	lb/d	lb/d	lb/d	lb/d
Maximum Month Limits						
John Morrell	4,582	0	2,939	0	478	0
Airport	3,073	21				
North-End Truck Wash	2,166	264	2,273	240	310	49
Maximum Monthly Limit Total	**9,821**	**285**	**5,212**	**240**	**788**	**49**

The sum totals of the monitored industrial loadings are tabulated in Table 4.3 and include:

- John Morrell
- Sioux Falls Regional Airport
- North End Truck Wash

Along with other industrial loadings from:

- West Rock (Smurfit – Stone Container)
- Metz Baking Co.
- Land O' Lakes

Bel Brands has been tabulated separately in Table 4.4 as this load is now discharged directly to the digester at WRF.

Table 4.3 illustrates that the total industrial flows are less than 1% of the existing average day flow and the organic loading is 2.2% or less of the existing loading for BOD, 1.1% for TSS, 1.1% for ammonia and 1% for TKN. The table further illustrates that total load is only a fraction of the maximum allowable industrial load as the permitted industries have not utilized their allocations in recent years.

Table 4.3 Industrial Flows and Loads (2015)

Parameter	2015*	Percent of Current Load	Maximum Allowable Industrial Load (MAIL)	Permitted by Ordinance
Influent Flow	**MGD**			
Annual Average Day	0.14	0.9%		
Maximum Month	0.17	0.7%		
Maximum Day	0.34	0.8%		
	lb/day	**%**	**lb/day**	**lb/day**
Biochemical Oxygen Demand				
Annual Average Day	549	1.8%		
Maximum Month	791	2.0%		9,821
Maximum Day	1,098	2.2%	20,692	19,642
Total Suspended Solids				
Annual Average Day	286	1.0%		
Maximum Month	472	1.1%		5,212
Maximum Day	572	0.9%	15,095	10,424
Ammonia				
Annual Average Day	34	0.8%		
Maximum Month	51	0.9%		
Maximum Day	67	0.9%		
TKN				
Annual Average Day	57	0.9%		
Maximum Month	87	1.0%		788
Maximum Day	114	1.0%	3,527	1,576

*Note: Excludes Bel Brands as now Bel discharges directly to the digester. This waste is no longer being discharged at the WWTF and has not since 2016.

Bel Brands loading averages approximately 1,450 lb/day for BOD and a maximum month of 1,960 lb/day BOD as shown in Table 4.4.

Table 4.4 Bel Brands Flows and Loads (April through January 2015)

FLOW, gpd	5,582	3,153
BOD, lb/d	1,446	1,961
TSS, lb/d	1,453	1,785
TKN, lb/d	102	140
O&G, lb/d	761	697

Septage Flow

Septage from septic systems in the greater Sioux Falls area is transported to the WRF Equalization Facilities on Chambers and Cliff Avenue or to the septage dump station at the WRF. Over the past year, an estimated average of 88,200 gallons of septage per day is accepted with a reported yearly high of 23.9 MG in 2015. Refer to Table 4.5. The facilities receive approximately 35 loads per day, based on 5 days of operation 52 weeks per year. The flows for septage and wastes discharged at the Equalization Facilities will not affect the average or peak flows into WRF, as the waste discharged at that location is blended into the Outfall sewer to the Brandon Road Pump Station and is included in the influent flow monitoring and sampling values at the WRF.

The waste dumped at the dump station is pumped to the aerated grit basins, which is after the influent flow monitoring and sampling, and therefore is not monitored with the influent. The flow volume for that portion is 0.13% of the monitored plant flow based on the number of loads presented in Table 4.5 and the average daily influent flow of 15.9 MGD from Table 4.1. The current desire of the WRF is to limit discharging septage at the WRF, taking most if not all septage to the Equalization Facilities.

Table 4.5 Septage Flow and Number and Loads on a Per Day Basis

Source	EQ flows, gallons per day	Loads, Per Day	Average Load Size, gallons
EQ Haulers	65,041	22	2,984
Dump Station Haulers	21,163	13	1,646
High Strength Haulers	2,018	0.7	2,791
Total (Per Day)	**88,200**	**35**	**2,474**

Note: Assumes operation is 5 days per week at 52 weeks per year.

WRF Maximum Month Flows and Loadings

As shown in Table 4.6, maximum month flow to the WRF was 23.7 MGD with maximum month loadings for BOD at 37,000 pounds per day (lb/d), TSS at 39,800 lb/day, ammonia at 5,400 lb/day and TKN at 8,200 lb/d.

Table 4.6 Maximum Month Flows and Loads (January, 2014 through May 23, 2016)

Area	Population	Flow	BOD	TSS	NH3-N	TKN
		MGD	*lb/day*	*lb/day*	*lb/day*	*lb/day*
Sioux Falls - Central, SRS, Northeast, Foundation Park	144,788	21	29,393	32,275	4,178	6,052
Sioux Falls - Westside	8,137	1.09	1,532	1,683	218	316
Sioux Falls - Eastside	13,542	1.67	2,346	2,576	333	483
Sioux Falls WRF - Areas Total	**166,467**	23.7	33,272	36,534	4,730	6,850
Peaking Factor (Max. Month/Ave. Day)		**1.47**	**1.11**	**1.24**	**1.16**	**1.14**

Assessment

The projected peak month flow is in line previous master planning projections at approximately 3% higher than projected. There were no projected maximum monthly organic loadings in the previous master plan. The maximum month flow peaking factor was 1.11, which is in the typical range. Maximum month flow and loadings impact WRF sizing as maximum month loadings drive the size of WRF biological processes.

WRF Maximum Day Flows and Loadings

As shown in Table 4.7, maximum day flow to the WRF was 40.5 MGD with maximum day loadings for BOD at 45,830 pounds per day (lb/d), TSS at 55,127 lb/day, ammonia at 6,850 lb/day and TKN at

8,320 lb/d. The maximum day flow occurred during the June 2014 record storm event during wet conditions, which exceeded the 100-year rainfall event in portions of the City.

Table 4.7 Maximum Day Flows and Loads (January, 2014 through May 23, 2016)

Area	Population	Flow	BOD	TSS	NH3-N	TKN
		MGD	*lb/day*	*lb/day*	*lb/day*	*lb/day*
Sioux Falls - Central, SRS, Northeast, Foundation Park	144,788	36	40,488	48,701	6,052	7,348
Sioux Falls - Westside	8,137	1.87	2,111	2,539	316	383
Sioux Falls - Eastside	13,542	2.86	3,231	3,887	483	586
Sioux Falls Areas Total	**166,467**	**40.5**	**45,830**	**55,127**	**6,850**	**8,318**
Peaking Factor (Max. Day/Ave. Day)		**2.52**	**1.54**	**1.88**	**1.68**	**1.38**

Assessment

The maximum day flow is in excess of what would be assumed in the design of a similar facility. A typical maximum day peaking factor for flow is approximately 1.5 - 2.0. In comparison, the maximum day peaking factor for the 2014 storm event, which was in excess of a 100-year event, was 2.55. In addition, the Recommended Standards for Wastewater Facilities (commonly referred to as Ten States Standards) a primary standard for the design of wastewater facilities, would project a peak hour peaking factor of 2 or less.

4.4 Wastewater Flow and Load Projections

Wastewater projections were distributed by Central, Westside and Eastside contribution areas to accommodate planning needs for potential future treatment facilities. These areas were evaluated separately to determine feasibility of treating flows and loads separately from the existing WRF. The four (4) options for WRF improvements, new Westside and Eastside WRF facilities are as follows:

- Option 1: Expand Existing WRF
- Option 2: Expand Existing WRF and New Eastside WRF
- Option 3: Expand Existing WRF and New Westside WRF
- Option 4: Expand Existing WRF and New Eastside and Westside WRF

Within each of these options, a three-phase approach was used to incorporate potential regional customers' flows and loads as outlined in Table 4.8.

Table 4.8 Regional Customers Phasing

Phase 1 – 2021
City of Brandon and Corson (Current Customer)
City of Harrisburg (Current Customer)
City of Tea
Phase 2 -2031
City of Baltic
City of Crooks
City of Valley Springs
City of Hartford
Wall Lake Sanitary District
City of Canton
Phase 3 -2036
City of Garretson
City of Rowena
City of Lennox
City of Worthing

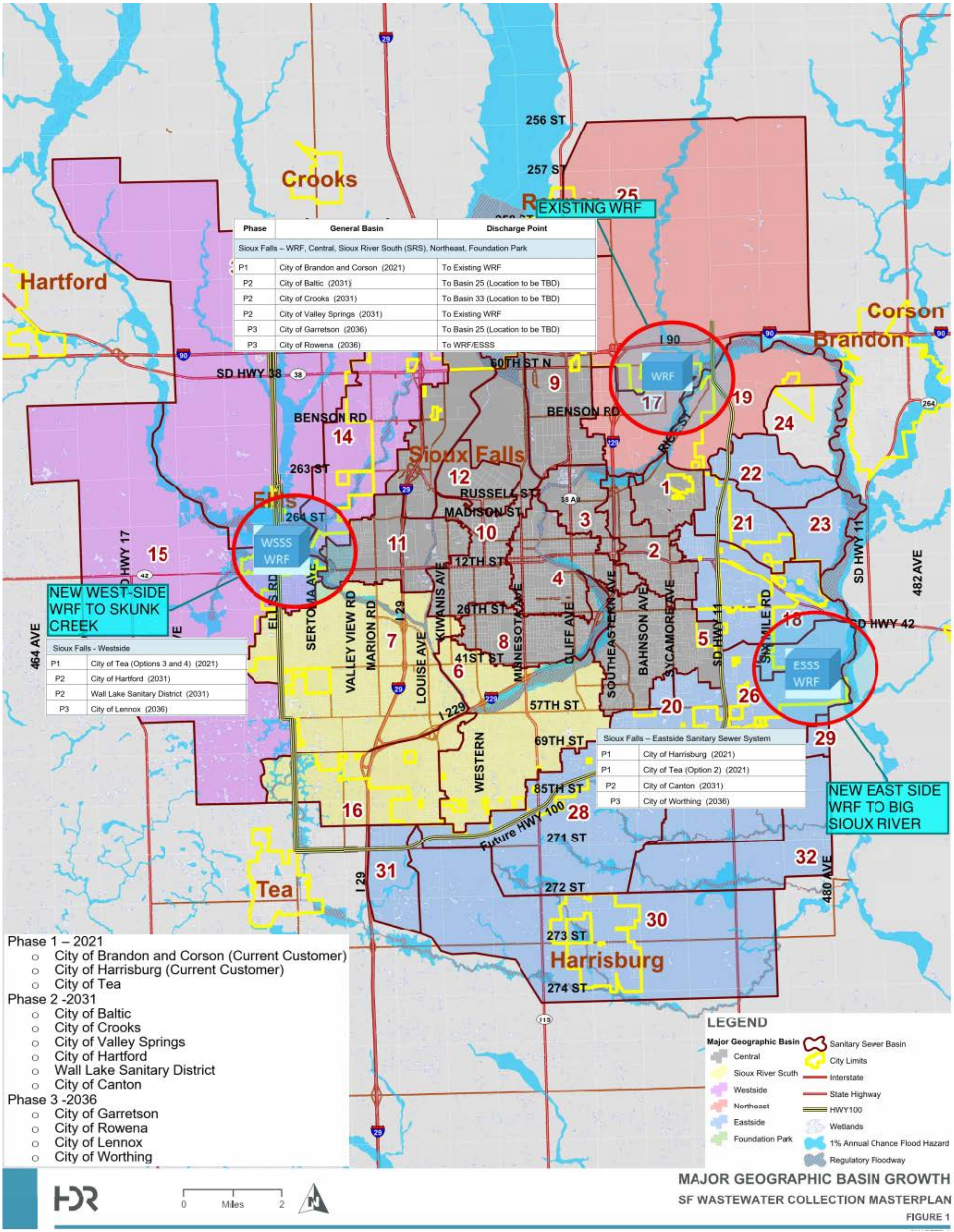
The associated phased year, discharge area and specific discharge points are outlined in Table 4.9.

Table 4.9 Discharge Area for Phased Regional Customers

Phase	Area	Discharge Point
Sioux Falls – WRF, Central, Sioux River South (SRS), Northeast, Foundation Park		
P1	City of Brandon and Corson (2021)	To Existing WRF
P2	City of Baltic (2031)	To Basin 25 (Location to be TBD)
P2	City of Crooks (2031)	To Basin 33 (Location to be TBD)
P2	City of Valley Springs (2031)	To Existing WRF
P3	City of Garretson (2036)	To Basin 25 (Location to be TBD)
P3	City of Rowena (2036)	To WRF/ESSS
Sioux Falls - Westside		
P1	City of Tea (Options 3 and 4) (2021)	To Basin 7R
P2	City of Hartford (2031)	To Basin 33
P2	Wall Lake Sanitary District (2031)	To Basin 15
P3	City of Lennox (2036)	To Basin 15 (Potentially via Tea)
Sioux Falls – Eastside Sanitary Sewer System		
P1	City of Harrisburg (2021)	ESSS
P1	City of Tea (Option 2) (2021)	7R
P2	City of Canton (2031)	ESSS
P3	City of Worthing (2036)	ESSS

Figure 4.1 illustrates the general locations for the Regional WRF facilities along with the associated regional communities.

Figure 4.1 Phasing for Regional WRF Facilities



4.4.1 WRF Projections

This section consists of a summary of the projections for the City of Sioux Falls proper, followed by methodology and projections for the regional communities.

Sioux Falls Projections

City of Sioux Falls industrial flows and loads were projected separately from residential flows and loads. The flows and loads were broken into the following three categories:

- Residential
- Light Industrial Users (LIUs)
- Significant Industrial Users (SIUs)
- Septage

Residential

The following Table 4.10 includes assumptions made for projecting the residential flows and loadings.

Table 4.10 Flow and Loading Assumptions for City of Sioux Falls

Parameter	Value	Basis
Flow		
Ave. Flow, gallons per day per Capita	97	City of Sioux Falls
Flow Maximum Month Peaking Factor (PF)	1.47	City of Sioux Falls
Flow Maximum Day PF	2.52	City of Sioux Falls
Loading		
BOD Ave., lb/d/capita	0.18 existing 0.22 new	City of Sioux Falls Ten States Standards
BOD Maximum Month PF	1.11	City of Sioux Falls
BOD Maximum Day PF	1.54	City of Sioux Falls
TSS Ave., lb/d/capita	0.18 existing 0.25 new	City of Sioux Falls Ten States Standards
TSS Maximum Month PF	1.24	City of Sioux Falls
TSS Maximum Day PF	1.88	City of Sioux Falls
Ammonia Ave, lb/d/capita	0.024 existing 0.020 new	City of Sioux Falls Metcalf and Eddy, 4th Edition
Ammonia Maximum Month PF	1.16	City of Sioux Falls
Ammonia Maximum Day PF	1.68	City of Sioux Falls
TKN Ave, lb/d/capita	0.036 existing 0.040 new	City of Sioux Falls Metcalf and Eddy, 4th Edition
TKN Maximum Month PF	1.14	City of Sioux Falls
TKN Maximum Day PF	1.38	City of Sioux Falls

The projected residential flows and loads are tabulated in Table 4.11.

Table 4.11 Projected Residential Flows and Loads

Parameter	3-year Ave.	2021	2026	2031	2036
WW Service Population	163,096	186,690	203,542	220,395	237,247
Influent Flow	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**
Annual Average Day	16.1	18.18	19.83	21.47	23.11
Maximum Month	23.7	28.3	30.9	33.4	36.0
Maximum Day	40.5	48.5	52.9	57.3	61.7
Biochemical Oxygen Demand	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**
Annual Average Day	29,847	35,037	38,745	42,452	46,160
Maximum Month	33,272	39,170	43,383	47,596	51,809
Maximum Day	45,830	53,852	59,582	65,312	71,041
Total Suspended Solids					
Annual Average Day	29,357	35,256	39,469	43,682	47,895
Maximum Month	36,534	43,848	49,072	54,296	59,520
Maximum Day	55,127	66,216	74,136	82,057	89,977
Ammonia					
Annual Average Day	4,077	4,549	4,886	5,223	5,560
Maximum Month	4,730	5,272	5,660	6,048	6,435
Maximum Day	6,850	7,652	8,225	8,798	9,371
TKN					
Annual Average Day	6,035	6,978	7,652	8,327	9,001
Maximum Month	6,850	7,912	8,670	9,428	10,187
Maximum Day	8,318	9,616	10,542	11,469	12,396

Significant (SIU) Projections:

City of Sioux Falls Traffic Analysis Zones (TAZ) data was used to estimate industrial workforce populations projected for the City. Projected average day SIU flows and loads were distributed among the areas of the City proportionately according to the industrial employee population in the area.

Table 4.12 Projected Significant Industrial User (SIU) Flows and Loads

Parameter	3-year Ave.*	2021	2026	2031	2036
Influent Flow		**MGD**	**MGD**	**MGD**	**MGD**
Annual Average Day	0.14	0.4	0.4	0.4	0.5
Maximum Month	0.17	0.5	0.5	0.5	0.6
Biochemical Oxygen Demand	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**
Annual Average Day	549	8,810	8,810	8,810	8,810
Maximum Month	791	9,821	9,821	9,821	9,821
Total Suspended Solids					
Annual Average Day	286	4,188	4,188	4,188	4,188
Maximum Month	472	5,212	5,212	5,212	5,212
Ammonia					
Annual Average Day	34	398	398	398	398
Maximum Month	51	462	462	462	462
TKN					
Annual Average Day	57	694	694	694	694
Maximum Month	87	788	788	788	788

*Note: Excludes Bel Brands as discharges directly to the digester.

As discussed previously, the actual industrial loading is only a fraction of the total permitted maximum month loadings of 9,821 lb/d BOD, 5,212 lb/d TSS and 788 lb/d TKN. Therefore, to provide compliance, maximum month permitted allocations were maintained as part of the projected treatment loading. A recommended action item for the WRF is to adjust the SIU permit limits to closer to actual conditions to free up capacity for new industry.

The following Table 4.13 illustrates the SIU loading as a percentage of Sioux Falls' projected flows and loads as compared to year 2015.

Table 4.13 SIU Loading as Percentage of Projected Maximum Month Flows & Loads

	2015	2036
	%	%
Influent Flow	0.7	1.6
Biochemical Oxygen Demand	2.3	15.8
Total Suspended Solids	1.1	8.0
TKN	1.3	7.1

The following is a description of the planning basis for computing SIU flows and loads:

The projected 2036 SIU maximum month loadings are 15.8% BOD, 8.0% TSS and 7.1% TKN of the total City of Sioux Falls' maximum month.

Light Industrial User (LIU) projections:

LIU Flows and Loads:

The 2013 to 2015 LIU flows and loads are included as part of the residential flows. Future loadings are broken out separately based on the TAZ spatial distribution and the assumption that the strength of the LIU wastewater is the same as the existing domestic wastewater strength. Refer to Table 4.14. The total impact of projected LIU loading is less than 1% of the total projected load.

Projected LIU Average Day:

All projected LIU average day flows are based on estimated per capita industrial employee wastewater flow and estimated industrial employee populations. The 2013 to 2015 dry weather potable water readings for non-wet industries were used for the flow and TAZ information was used to estimate industrial employee populations throughout the City. The 2013 to 2015 average per capita LIU wastewater flow was calculated to be 17.11 gpd/capita.

Projected LIU Maximum Month and Maximum Day:

All projected LIU maximum month and day flows were based on the existing maximum month peaking ratio, which was applied to the projected average day flow for each year.

Table 4.14 Projected Light Industrial User (LIU) Flows and Loads

Parameter	2021	2026	2031	2036	2040	2066
WW TAZ LIU Population Increase	3,839	6,582	9,324	12,067	14,261	31,910
Influent Flow						
Per Capita	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**
Annual Average Day	0.50	0.54	0.59	0.64	0.68	0.98
Maximum Month	0.73	0.80	0.87	0.94	0.99	1.44
Maximum Day	1.25	1.37	1.49	1.61	1.70	2.46
BOD						
	lb/day	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**
Annual Average Day	146	251	356	460	544	1,217
Maximum Month	166	285	404	523	618	1,383
Maximum Day	226	388	550	711	841	1,881
TSS						
Annual Average Day	166	285	404	523	618	1,383
Maximum Month	206	354	501	649	766	1,715
Maximum Day	313	536	760	983	1,162	2,600
Ammonia						
Annual Average Day	13	23	32	42	49	111
Maximum Month	15	26	37	48	57	127
Maximum Day	23	39	55	71	84	188
TKN						
Annual Average Day	27	46	65	84	99	221
Maximum Month	30	51	73	94	111	249
Maximum Day	37	63	89	115	136	304

Septage

Septage flow and loading discharged to the WRF Equalization Facilities is currently included in and sampled at the WRF influent. Septage flow and loading is built-in to the “per capita” City of Sioux Falls loading projections.

Summary of Combined City of Sioux Falls’ Flows and Loads

A summary of the combined residential, LIU, and SIU City of Sioux Falls’ flows and loads is presented in Table 4.15.

Table 4.15 Projected City of Sioux Falls Combined Residential, LIU, SIU Flows and Loads

Sioux Falls - Total Combined		Residential					Light Industrial Users (LIUs)					Significant Industrial Users (SIUs)					Total Combined Flows and Loads				
Parameter		3-year Ave.	2021	2026	2031	2036	3-year Ave.	2021	2026	2031	2036	3-year Ave.	2021	2026	2031	2036	3-year Ave.	2021	2026	2031	2036
WW Service Population		163,096	186,690	203,542	220,395	237,247	25,261	29,101	31,843	34,586	37,328										
Influent Flow			**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**	**MGD**
	Annual Average Day	16.1	18.43	20.09	21.75	23.42	0.4	0.50	0.54	0.59	0.64	0.14	0.4	0.4	0.4	0.5	15.9	19	21	23	25
	Maximum Month	23.7	27.13	29.57	32.02	34.47	0.6	0.73	0.80	0.87	0.94	0.17	0.4	0.5	0.5	0.6	23.3	28	31	33	36
	Maximum Day	40.5	46.39	50.58	54.77	58.96	1.1	1.25	1.37	1.49	1.61	0.3	0.9	1.0	1.0	1.1	40.5	49	53	57	62
Biochemical Oxygen Demand		**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**	**lb/day**
	Annual Average Day	29,847	35,037	38,745	42,452	46,160		146	251	356	460	549	8,810	8,810	8,810	8,810	30,396	43,994	47,806	51,618	55,430
	Maximum Month	33,272	39,170	43,383	47,596	51,809		166	285	404	523	791	9,821	9,821	9,821	9,821	34,063	49,157	53,489	57,821	62,153
	Maximum Day	45,830	53,852	59,582	65,312	71,041		226	388	550	711	1,098	13,528	13,528	13,528	13,528	46,928	67,606	73,498	79,389	85,281
Total Suspended Solids																					
	Annual Average Day	29,357	35,256	39,469	43,682	47,895		166	285	404	523	286	4,188	4,188	4,188	4,188	29,643	39,610	43,942	48,274	52,606
	Maximum Month	36,534	43,848	49,072	54,296	59,520		206	354	501	649	472	5,212	5,212	5,212	5,212	37,006	49,266	54,638	60,009	65,381
	Maximum Day	55,127	66,216	74,136	82,057	89,977		313	536	760	983	572	7,865	7,865	7,865	7,865	55,698	74,393	82,537	90,681	98,825
Ammonia																					
	Annual Average Day	4,077	4,549	4,886	5,223	5,560		13	23	32	42	34	398	398	398	398	4,111	4,961	5,307	5,654	6,000
	Maximum Month	4,730	5,272	5,660	6,048	6,435		15	26	37	48	51	462	462	462	462	4,781	5,750	6,148	6,547	6,945
	Maximum Day	6,850	7,652	8,225	8,798	9,371		23	39	55	71	67	669	669	669	669	6,917	8,344	8,933	9,522	10,111
TKN																					
	Annual Average Day	6,035	6,978	7,652	8,327	9,001		27	46	65	84	57	694	694	694	694	6,092	7,699	8,392	9,085	9,778
	Maximum Month	6,850	7,912	8,670	9,428	10,187		30	51	73	94	87	788	788	788	788	6,937	8,730	9,509	10,289	11,069
	Maximum Day	8,318	9,616	10,542	11,469	12,396		37	63	89	115	87	957	957	957	957	8,405	10,609	11,562	12,515	13,468

Regional Community Projections

Flows and loads for Tea, Worthing and Harrisburg were projected based on the most recent Master Planning for the Communities. These projections also match additional peak month and day information generated in the 2016 Regionalization Study (Banner Associates), to provide for consistency.

Average day flow from the following Cities were generated from the Recommended Ten States Standards flow of 100 gallons per day per capita with industry standard maximum month and maximum day peaking factors of 1.2 and 1.5, respectively.

- City of Baltic
- City of Crooks
- City of Garretson
- City of Rowena
- City of Valley Springs
- City of Hartford
- City of Lennox
- Wall Lake Sanitary District
- City of Canton

The following Table 4.16 includes assumptions made for projecting the flows and loadings.

Peak flows from the communities were assumed to be equalized to peak flow at 1.5 times average day flows. Industrial flows and loads were not projected separately from residential flows and loads for the regional communities and assumed to be primarily domestic.

Table 4.16 Flow and Loading Assumptions for Regional Customers

Parameter	Value	Basis
Flow		
Ave. Flow, gallons per day per Capita	100	Ten States Standards
Flow Maximum Month Peaking Factor (PF)	1.2	Industry Standard
Flow Maximum Day PF	1.5	Industry Standard
Loading		
BOD Ave., lb/d/capita	0.17 existing/0.22 new	Ten States Standards
BOD Maximum Month PF	1.11	City of Sioux Falls
BOD Maximum Day PF	1.54	City of Sioux Falls
TSS Ave., lb/d/capita	0.20	Ten States Standards
TSS Maximum Month PF	1.24	City of Sioux Falls
Ammonia Ave, mg/l	25	Metcalf and Eddy, 4th Edition
Ammonia Maximum Month PF	1.24	City of Sioux Falls
Ammonia Maximum Day PF	1.88	City of Sioux Falls
TKN Ave, mg/l	40	Metcalf and Eddy, 4th Edition
TKN Maximum Month PF	1.14	City of Sioux Falls
TKN Maximum Day PF	1.38	City of Sioux Falls

Peak flows from the communities were assumed to be equalized to peak flow at 1.5 times average day flows. Industrial flows and loads were not projected separately from residential flows and loads for the regional communities.

Regional WRF Flow and Loading Projections

Option 1 Flow and Loading Projections

Flows and loads for Option 1 to expand the existing WRF are summarized in the following Table 4.17. Note that the maximum day flow is the peak un-equalized flow.

Table 4.17 Option 1: Expand Existing WRF 2036 Design Year Flows and Loads

	Flow	BOD	TSS	NH3-N	TKN
	MGD	lb/d	lb/d	lb/d	lb/d
AADF	30.1	66,687	65,172	7,173	11,655
MMF	42.7	74,961	81,591	8,323	13,211
MDF	70.1	103,383	125,150	12,105	16,061
	MGD	mg/L	mg/L	mg/L	mg/L
AADF	30.1	265	259	29	46
MMF	42.7	210	229	23	37
MDF	70.1	177	214	21	27

AADF: Annual Average Day Flow
MMF: Maximum Month Flow
MDF: Maximum Day Flow (un-equalized)

Option 2 Flow and Loading Projections

Flows and loads for Option 2 to expand the existing WRF and construct a New Eastside WRF are summarized in the following Table 4.18.

Table 4.18 Option 2: Expand Existing WRF and New Eastside WRF at 2036 Design Year Flows and Loads

	To Existing WRF					To Eastside WRF				
	Flow	BOD	TSS	NH3-N	TKN	Flow	BOD	TSS	NH3-N	TKN
	MGD	lb/d	lb/d	lb/d	lb/d	MGD	lb/d	lb/d	lb/d	lb/d
AADF	21.3	49,089	45,992	5,325	8,372	8.8	17,598	19,179	1,848	3,283
MMF	30.6	55,147	57,759	6,179	9,496	12.1	19,814	23,832	2,144	3,715
MDF	51.1	76,257	89,080	8,969	11,539	19.0	27,126	36,070	3,135	4,522
	MGD	lb/d	lb/d	lb/d	lb/d	MGD	lb/d	lb/d	lb/d	lb/d
AADF	21.3	276	259	30	47	8.8	239	260	25	45
MMF	30.6	216	226	24	37	12.1	196	236	21	37
MDF	51.1	179	209	21	27	19.0	171	227	20	28

AADF: Annual Average Day Flow
MMF: Maximum Month Flow
MDF: Maximum Day Flow

Assessment

The projected peak month flow is in line previous master planning projections at approximately 5.5% higher than projected. There were no projected maximum monthly organic loadings in the previous master plan. The maximum month flow peaking factor was 1.47, which is higher than typically expected. This impacts plant sizing as maximum month loadings drive the size of WRF biological processes.

Option 3 Flow and Loading Projections

Flows and loads for Option 3 to expand the existing WRF, construct new Westside WRF are summarized in the following Table 4.19.

Table 4.19 Option 3: Expand Existing WRF and New Westside WRF at 2036 Design Year Flows and Loads

	To Existing WRF					To Eastside WRF				
	Flow	BOD	TSS	NH3-N	TKN	Flow	BOD	TSS	NH3-N	TKN
	MGD	lb/d	lb/d	lb/d	lb/d	MGD	lb/d	lb/d	lb/d	lb/d
AADF	25.8	57,806	56,145	6,223	10,041	4.4	8,881	9,027	950	1,614
MMF	36.9	65,007	70,363	7,217	11,380	5.8	9,954	11,228	1,106	1,831
MDF	61.4	89,712	108,171	10,494	13,836	8.8	13,671	16,979	1,611	2,225
	MGD	mg/L	mg/L	mg/L	mg/L	MGD	mg/L	mg/L	mg/L	mg/L
AADF	25.5	272	264	29	47	4.3	248	252	26	45
MMF	36.4	214	232	24	37	5.8	206	232	23	38
MDF	61.4	175	211	20	27	8.8	186	231	22	30

AADF: Annual Average Day Flow
MMF: Maximum Month Flow
MDF: Maximum Day Flow

Option 4 Flow and Loading Projections

Flows and loads for Option 4 to expand the existing WRF, construct new Eastside and Westside WRFs are summarized in the following Table 4.20.

Table 4.20 Option 4: Expand Existing WRF and New Eastside and Westside WRF at 2036 Design Year Flows and Loads

To Existing WRF	Flow	BOD	TSS	NH3-N	TKN
	MGD	**lb/d**	**lb/d**	**lb/d**	**lb/d**
AADF	18.4	42,796	39,364	4,675	7,239
MMF	26.5	48,070	49,522	5,425	8,213
MDF	44.5	66,563	76,618	7,868	9,977
	MGD	**mg/L**	**mg/L**	**mg/L**	**mg/L**
AADF	18.4	279	257	31	47
MMF	26.5	217	224	25	37
MDF	44.5	179	206	21	27

	To Westside WRF					To Eastside WRF				
	Flow	BOD	TSS	NH3-N	TKN	Flow	BOD	TSS	NH3-N	TKN
	MGD	**lb/d**	**lb/d**	**lb/d**	**lb/d**	**MGD**	**lb/d**	**lb/d**	**lb/d**	**lb/d**
AADF	4.4	8,881	9,027	950	1,614	7.4	15,010	16,781	1,548	2,803
MMF	5.8	9,954	11,228	1,106	1,831	10.4	16,937	20,841	1,792	3,167
MDF	8.8	13,671	16,979	1,611	2,225	16.9	23,149	31,553	2,625	3,859
	MGD	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**MGD**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
AADF	4.4	244	248	26	44	7.4	246	272	25	45
MMF	5.8	205	231	23	38	10.4	223	240	21	37
MDF	8.8	187	232	22	30	16.9	175	224	19	27

AADF: Annual Average Day Flow
MMF: Maximum Month Flow
MDF: Maximum Day Flow

Summary of Regional WRF Flow and Load Projections

Existing and projected average day, maximum month, and maximum day flows and loads are summarized in Table 4.21, Table 4.22 and Table 4.23 respectively, in 5-year increments through 2066 for the four options outlined previously.

Table 4.21 Summary of Projected Regional Average Day Flows and Loads

Projected Average Day	*Flows and loading after implementation of Phase 1.*						*Flows and loading after implementation of Phases 1 and 2.*						*Flows and loading after implementation of Phases 1 and 2.*						*Flows and loading after implementation of Phases 1, 2 and 3.*						*Flows and loading after implementation of Phases 1, 2 and 3.*					
	2021 Projected Average Day						2026 Projected Average Day						2031 Projected Average Day						2036 Projected Average Day						2066 Projected Average Day					
Area	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*
Sioux Falls - Central, SRS, Northeast, Foundation Park	149,006	15	36,252	31,609	4,091	6,213	152,521	16	37,180	32,729	4,165	6,361	156,036	16	38,123	33,857	4,239	6,511	159,550	17	39,079	34,990	4,314	6,661	183,909	19	52,553	54,928	5,539	8,917
City of Brandon and Corson (2021)	11,624	0.87	1,976	2,325	182	291	13,107	0.97	2,228	2,621	202	323	14,700	1.07	2,499	2,940	223	357	16,329	1.18	2,776	3,266	245	393	25,837	2.58	4,392	5,167	539	862
City of Baltic (2031)													1,547	0.15	263	309	32	52	1,687	0.17	287	337	35	56	2,527	0.25	430	505	53	84
City of Crooks (2031)													1,830	0.18	311	366	38	61	2,004	0.20	341	401	42	67	3,047	0.30	518	609	64	102
City of Valley Springs (2031)													769	0.08	131	154	16	26	772	0.08	131	154	16	26	788	0.08	134	158	16	26
City of Garretson (2036)																			1,027	0.10	175	205	21	34	1,024	0.10	174	205	21	34
City of Rowena (2036)																			50	0.005	8	10	1	2	66	0.01	11	13	1	2
Sioux Falls - Westside	11,886	1.78	2,697	2,631	293	883	15,011	1.54	3,482	3,469	360	618	18,136	1.86	4,254	4,300	427	751	21,260	2.18	5,016	5,127	494	883	51,941	5.3	12,139	13,518	1,181	2,240
City of Tea (Options 3 and 4) (2021)	6,708	0.81	1,426	1,342	168	269	8,460	1.02	1,811	1,692	212	339	10,228	1.23	2,200	2,046	256	409	11,994	1.44	2,589	2,399	300	480	22,219	2.22	3,777	4,444	463	741
City of Hartford (2031)													4,484	0.45	762	897	93	150	4,886	0.49	831	977	102	163	7,298	0.73	1,241	1,460	152	243
Wall Lake Sanitary District (2031)													85	0.01	15	17	2	3	85	0.01	14	17	2	3	84	0.01	14	17	2	3
City of Lennox (2036)																			2,537	0.25	431	507	53	85	2,713	0.27	461	543	57	91
Sioux Falls - Eastside	25,797	2.60	5,316	5,679	577	1,003	36,011	3.63	7,584	8,244	782	1,414	46,224	4.66	9,849	10,808	987	1,824	56,437	5.69	12,112	13,371	1,192	2,234	103,942	10.5	22,616	25,367	2,155	4,156
City of Harrisburg (2021)	6,230	0.62	1,059	1,246	130	208	7,580	0.76	1,289	1,516	158	253	9,225	0.92	1,568	1,845	192	308	11,234	1.12	1,910	2,247	234	375	20,847	2.08	3,544	4,169	435	695
City of Tea (Option 2) (2021)	6,708	0.81	1,426	1,342	168	269	8,460	1.02	1,811	1,692	212	339	10,228	1.23	2,200	2,046	256	409	11,994	1.44	2,589	2,399	300	480	22,219	2.22	3,777	4,444	463	741
City of Canton (2031)													3,476	0.35	591	695	72	116	3,528	0.35	600	706	74	118	3,840	0.38	653	768	80	128
City of Worthing (2036)																			2,286	0.23	389	457	48	76	4,243	0.42	721	849	88	142
Option 1 - Existing WRF Only																														
Total	***211,252***	***22.2***	***48,726***	***44,831***	***5,440***	***8,866***	***232,689***	***23.8***	***53,573***	***50,271***	***5,879***	***9,307***	***266,739***	***27.2***	***60,566***	***58,234***	***6,580***	***10,567***	***295,664***	***30.1***	***66,687***	***65,172***	***7,173***	***11,655***	***434,324***	***44.6***	***103,379***	***112,720***	***10,847***	***18,466***
Option 2 - Existing WRF and New Eastside WRF																														
Existing WRF	172,516	18.1	40,925	36,565	4,566	7,387	180,639	18.4	42,890	38,819	4,727	7,302	197,587	20.1	46,358	42,840	5,072	7,910	210,185	21.3	49,089	45,992	5,325	8,372	279,233	29.0	72,067	77,123	7,625	12,604
New Eastside WRF (including Tea flow)	38,736	4.0	7,801	8,266	874	1,479	52,050	5.4	10,683	11,452	1,152	2,005	69,152	7.2	14,208	15,394	1,508	2,657	85,478	8.8	17,598	19,179	1,848	3,283	155,091	15.6	31,312	35,597	3,221	5,862
Total	***211,252***	***22.2***	***48,726***	***44,831***	***5,440***	***8,866***	***232,689***	***23.8***	***53,573***	***50,271***	***5,879***	***9,307***	***266,739***	***27.2***	***60,566***	***58,234***	***6,580***	***10,567***	***295,664***	***30.1***	***66,687***	***65,172***	***7,173***	***11,655***	***434,324***	***44.6***	***103,379***	***112,720***	***10,847***	***18,466***
Option 3 - WRF and Westside plant																														
Existing WRF	192,657	19.6	44,603	40,858	4,980	7,714	209,218	21.2	48,280	45,110	5,307	8,350	233,806	23.7	53,335	50,974	5,801	9,254	254,903	25.8	57,806	56,145	6,223	10,041	350,069	36.1	85,746	92,739	8,991	15,148
New Westside WRF (including Tea flow)	18,595	2.6	4,123	3,973	460	1,152	23,471	2.6	5,293	5,161	572	956	32,933	3.5	7,231	7,260	778	1,313	40,761	4.4	8,881	9,027	950	1,614	84,255	8.5	17,632	19,981	1,855	3,318
Total	***211,252***	***22.2***	***48,726***	***44,831***	***5,440***	***8,866***	***232,689***	***23.8***	***53,573***	***50,271***	***5,879***	***9,307***	***266,739***	***27.2***	***60,566***	***58,234***	***6,580***	***10,567***	***295,664***	***30.1***	***66,687***	***65,172***	***7,173***	***11,655***	***434,324***	***44.6***	***103,379***	***112,720***	***10,847***	***18,466***
Option 4 - WRF and New Eastside WRF and New Westside WRF																														
Existing WRF	160,630	16.3	38,228	33,934	4,273	6,503	165,628	16.8	39,408	35,350	4,367	6,684	174,882	17.7	41,327	37,626	4,549	7,006	181,418	18.4	42,796	39,364	4,675	7,239	217,198	22.7	58,212	61,586	6,233	10,027
New Eastside WRF	32,027	3.2	6,375	6,925	707	1,211	43,590	4.4	8,872	9,760	940	1,666	58,924	5.9	12,008	13,348	1,252	2,248	73,485	7.4	15,010	16,781	1,548	2,803	132,872	13.4	27,534	31,153	2,758	5,121
New Westside WRF (including Tea flow)	18,595	2.6	4,123	3,973	460	1,152	23,471	2.6	5,293	5,161	572	956	32,933	3.5	7,231	7,260	778	1,313	40,761	4.4	8,881	9,027	950	1,614	84,255	8.5	17,632	19,981	1,855	3,318
Total	***211,252***	***22.2***	***48,726***	***44,831***	***5,440***	***8,866***	***232,689***	***23.8***	***53,573***	***50,271***	***5,879***	***9,307***	***266,739***	***27.2***	***60,566***	***58,234***	***6,580***	***10,567***	***295,664***	***30.1***	***66,687***	***65,172***	***7,173***	***11,655***	***434,324***	***44.6***	***103,379***	***112,720***	***10,847***	***18,466***
Sioux Falls Areas Total	186,690	19.9	44,265	39,919	4,961	8,099	203,542	21.0	48,246	44,442	5,307	8,392	220,395	22.8	52,226	48,965	5,654	9,085	237,247	24.5	56,207	53,489	6,000	9,778	339,791	35.2	87,308	93,814	8,876	15,312
Phase 1 Regional Communities Total	24,562	2.3	4,461	4,912	479	767	29,146	2.7	5,328	5,829	572	914	34,152	3.2	6,267	6,830	672	1,075	39,556	3.7	7,274	7,911	780	1,248	68,903	6.9	11,714	13,781	1,437	2,299
Phase 2 Regional Communities Total	0	0.0	0	0	0	0	0	0.0	0	0	0	0	12,192	1.2	2,073	2,438	254	407	12,962	1.3	2,204	2,592	270	432	17,584	1.8	2,989	3,517	367	587
Phase 3 Regional Communities Total	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	5,899	0.6	1,003	1,180	123	197	8,046	0.8	1,368	1,609	168	268
Total	***211,252***	***22.2***	***48,726***	***44,831***	***5,440***	***8,866***	***232,689***	***23.8***	***53,573***	***50,271***	***5,879***	***9,307***	***266,739***	***27.2***	***60,566***	***58,234***	***6,580***	***10,567***	***295,664***	***30.1***	***66,687***	***65,172***	***7,173***	***11,655***	***434,324***	***44.6***	***103,379***	***112,720***	***10,847***	***18,466***

Table 4.22 Summary of Projected Regional Maximum Month Flows and Loads

Max Month Flows and Loads	*Flows and loading after implementation of Phase 1.*						*Flows and loading after implementation of Phases 1 and 2.*						*Flows and loading after implementation of Phases 1 and 2.*						*Flows and loading after implementation of Phases 1, 2 and 3.*						*Flows and loading after implementation of Phases 1, 2 and 3.*					
	2021 Projected Max Month						2026 Projected Max Month						2031 Projected Max Month						2036 Projected Max Month						2066 Projected Max Month					
	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*
Sioux Falls - Central, SRS, Northeast, Foundation Park	149,006	23	40,540	39,518	4,745	7,050	152,521	23	41,656	41,026	4,830	7,217	156,036	24	42,790	42,544	4,915	7,385	159,550	24	43,938	44,068	5,001	7,554	183,909	28	61,354	73,052	6,417	10,104
City of Brandon and Corson (2021)	11,624	1.05	2,196	2,899	213	332	13,107	1.05	2,477	3,269	237	369	14,700	1.29	2,778	3,666	262	408	16,329	1.41	3,085	4,072	288	448	25,837	3.10	4,882	6,443	633	984
City of Baltic (2031)													1,547	0.19	292	386	38	59	1,687	0.20	319	421	41	64	2,527	0.30	478	630	62	96
City of Crooks (2031)													1,830	0.22	346	456	45	70	2,004	0.24	379	500	49	76	3,047	0.37	576	760	75	116
City of Valley Springs (2031)													769	0.09	145	192	19	29	772	0.09	146	192	19	29	788	0.09	149	197	19	30
City of Garretson (2036)																			1,027	0.12	194	256	25	39	1,024	0.12	193	255	25	39
City of Rowena (2036)																			50	0.006	9	12	1	2	66	0.01	12	16	2	3
Sioux Falls - Westside	11,886	1.78	3,028	3,270	338	547	15,011	2.26	3,918	4,308	416	698	18,136	2.73	4,794	5,339	493	848	21,260	3.20	5,658	6,365	570	997	51,941	7.8	13,747	16,772	1,361	2,524
City of Tea (Options 3 and 4) (2021)	6,708	0.97	1,585	1,673	197	307	8,460	1.22	2,013	2,110	249	387	10,228	1.47	2,445	2,551	301	467	11,994	1.73	2,877	2,991	352	548	22,219	2.67	4,199	5,541	544	846
City of Hartford (2031)													4,484	0.54	847	1,118	110	171	4,886	0.59	923	1,219	120	186	7,298	0.88	1,379	1,820	179	278
Wall Lake Sanitary District (2031)													85	0.01	16	21	2	3	85	0.01	16	21	2	3	84	0.01	16	21	2	3
City of Lennox (2036)																			2,537	0.30	479	633	62	97	2,713	0.33	513	677	66	103
Sioux Falls - Eastside	25,797	3.81	5,994	7,051	666	1,133	36,011	5.33	10,232	10,232	902	1,595	46,224	6.84	11,144	13,411	1,138	2,056	56,437	8.35	13,716	16,590	1,374	2,518	103,942	15.4	25,652	31,465	2,481	4,680
City of Harrisburg (2021)	6,230	0.75	1,177	1,554	153	237	7,580	0.91	1,432	1,890	186	289	9,225	1.11	1,743	2,301	226	351	11,234	1.35	2,123	2,802	275	428	20,847	2.50	3,939	5,199	510	794
City of Tea (Option 2) (2021)	6,708	0.97	1,585	1,673	197	307	8,460	1.22	2,013	2,110	249	387	10,228	1.47	2,445	2,551	301	467	11,994	1.73	2,877	2,991	352	548	22,219	2.67	4,199	5,541	544	846
City of Canton (2031)													3,476	0.42	657	867	85	132	3,528	0.42	667	880	86	134	3,840	0.46	726	958	94	146
City of Worthing (2036)																			2,286	0.27	432	570	56	87	4,243	0.51	802	1,058	104	162
Option 1 - Existing WRF Only																														
Total	***211,252***	***31.1***	***54,520***	***55,964***	***6,313***	***9,605***	***232,689***	***34.0***	***61,729***	***62,835***	***6,819***	***10,553***	***266,739***	***38.7***	***67,999***	***72,852***	***7,634***	***11,980***	***295,664***	***42.7***	***74,961***	***81,591***	***8,323***	***13,211***	***434,324***	***63.0***	***118,615***	***144,865***	***12,574***	***20,907***
Option 2 - Existing WRF and New Eastside WRF																														
Existing WRF	172,516	25.5	45,765	45,687	5,297	7,929	180,639	26.6	48,051	48,603	5,483	8,283	197,587	28.9	52,009	53,723	5,884	8,973	210,185	30.6	55,147	57,759	6,179	9,496	279,233	41.5	83,298	100,644	8,840	14,280
New Eastside WRF (including Tea flow)	38,736	5.5	8,756	10,277	1,016	1,677	52,050	7.5	13,677	14,232	1,336	2,270	69,152	9.8	15,990	19,129	1,750	3,007	85,478	12.1	19,814	23,832	2,144	3,715	155,091	21.5	35,317	44,221	3,733	6,627
Total	***211,252***	***31.1***	***54,520***	***55,964***	***6,313***	***9,605***	***232,689***	***34.0***	***61,729***	***62,835***	***6,819***	***10,553***	***266,739***	***38.7***	***67,999***	***72,852***	***7,634***	***11,980***	***295,664***	***42.7***	***74,961***	***81,591***	***8,323***	***13,211***	***434,324***	***63.0***	***118,615***	***144,865***	***12,574***	***20,907***
Option 3 - WRF and Westside plant																														
Existing WRF	192,657	28.3	49,907	51,022	5,777	8,752	209,218	30.6	55,797	56,417	6,154	9,468	233,806	34.0	59,896	63,822	6,728	10,491	254,903	36.9	65,007	70,363	7,217	11,380	350,069	51.3	98,762	120,034	10,421	17,153
New Westside WRF (including Tea flow)	18,595	2.7	4,613	4,943	536	854	23,471	3.5	5,932	6,418	665	1,085	32,933	4.7	8,103	9,030	906	1,489	40,761	5.8	9,954	11,228	1,106	1,831	84,255	11.7	19,853	24,831	2,153	3,755
Total	***211,252***	***31.1***	***54,520***	***55,964***	***6,313***	***9,605***	***232,689***	***34.0***	***61,729***	***62,835***	***6,819***	***10,553***	***266,739***	***38.7***	***67,999***	***72,852***	***7,634***	***11,980***	***295,664***	***42.7***	***74,961***	***81,591***	***8,323***	***13,211***	***434,324***	***63.0***	***118,615***	***144,865***	***12,574***	***20,907***
Option 4 - WRF and New Eastside WRF and New Westside WRF																														
Existing WRF	160,630	23.8	42,736	42,417	4,958	7,382	165,628	24.3	44,133	44,295	5,067	7,585	174,882	25.6	46,351	47,244	5,279	7,951	181,418	26.5	48,070	49,522	5,425	8,213	217,198	32.5	67,644	81,354	7,232	11,371
New Eastside WRF	32,027	4.6	7,171	8,604	819	1,370	43,590	6.2	11,664	12,122	1,088	1,883	58,924	8.4	13,544	16,579	1,449	2,540	73,485	10.4	16,937	20,841	1,792	3,167	132,872	18.8	31,118	38,680	3,189	5,781
New Westside WRF (including Tea flow)	18,595	2.7	4,613	4,943	536	854	23,471	3.5	5,932	6,418	665	1,085	32,933	4.7	8,103	9,030	906	1,489	40,761	5.8	9,954	11,228	1,106	1,831	84,255	11.7	19,853	24,831	2,153	3,755
Total	***211,252***	***31.1***	***54,520***	***55,964***	***6,313***	***9,605***	***232,689***	***34.0***	***61,729***	***62,835***	***6,819***	***10,553***	***266,739***	***38.7***	***67,999***	***72,852***	***7,634***	***11,980***	***295,664***	***42.7***	***74,961***	***81,591***	***8,323***	***13,211***	***434,324***	***63.0***	***118,615***	***144,865***	***12,574***	***20,907***
Sioux Falls areas total	186,690	28.3	49,562	49,839	5,750	8,730	203,542	30.9	55,807	55,567	6,148	9,509	220,395	33.4	58,729	61,295	6,547	10,289	237,247	36.0	63,312	67,022	6,945	11,069	339,791	51.6	100,752	121,289	10,259	17,308
Phase 1 regional communities total	24,562	2.8	4,959	6,125	563	876	29,146	3.2	5,922	7,269	671	1,044	34,152	3.9	6,966	8,517	789	1,227	39,556	4.5	8,085	9,865	916	1,424	68,903	8.3	13,020	17,184	1,687	2,624
Phase 2 regional communities total	0	0.0	0	0	0	0	0	0.0	0	0	0	0	12,192	1.5	2,304	3,040	299	464	12,962	1.6	2,449	3,233	317	494	17,584	2.1	3,323	4,385	431	670
Phase 3 regional communities total	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	5,899	0.7	1,115	1,471	144	225	8,046	1.0	1,520	2,007	197	306
Total	***211,252***	***31.1***	***54,520***	***55,964***	***6,313***	***9,605***	***232,689***	***34.0***	***61,729***	***62,835***	***6,819***	***10,553***	***266,739***	***38.7***	***67,999***	***72,852***	***7,634***	***11,980***	***295,664***	***42.7***	***74,961***	***81,591***	***8,323***	***13,211***	***434,324***	***63.0***	***118,615***	***144,865***	***12,574***	***20,907***

Table 4.23 Summary of Projected Regional Maximum Day Flows and Loads

Projected Peak Day	*Flows and loading after implementation of Phase 1.*						*Flows and loading after implementation of Phases 1 and 2.*						*Flows and loading after implementation of Phases 1 and 2.*						*Flows and loading after implementation of Phases 1, 2 and 3.*						*Flows and loading after implementation of Phases 1, 2 and 3.*					
	2021 Projected Peak Day						2026 Projected Peak Day						2031 Projected Peak Day						2036 Projected Peak Day						2066 Projected Peak Day					
	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*	Population	Flow *MGD*	BOD *lb/day*	TSS *lb/day*	NH3-N *lb/day*	TKN *lb/day*
Sioux Falls - Central, SRS, Northeast, Foundation Park	149,006	39	55,958	60,286	6,876	8,563	152,521	40	57,567	62,972	7,001	8,766	156,036	41	59,200	65,672	7,128	8,972	159,550	42	60,851	68,383	7,255	9,179	183,909	49	87,844	126,476	9,324	12,285
City of Brandon and Corson (2021)	11,624	1.31	3,036	4,377	309	402	13,107	0.21	3,423	4,936	343	446	14,700	1.61	3,840	5,536	380	494	16,329	1.77	4,265	6,149	417	543	25,837	3.88	6,749	9,730	916	1,191
City of Baltic (2031)													1,547	0.23	404	582	55	71	1,687	0.25	441	635	60	78	2,527	0.38	660	952	90	116
City of Crooks (2031)													1,830	0.27	478	689	65	84	2,004	0.30	523	755	71	92	3,047	0.46	796	1,147	108	140
City of Valley Springs (2031)													769	0.12	201	290	27	35	772	0.12	202	291	27	36	788	0.12	206	297	28	36
City of Garretson (2036)																			1,027	0.15	268	387	36	47	1,024	0.15	267	386	36	47
City of Rowena (2036)																			50	0.007	13	19	2	2	66	0.01	17	25	2	3
Sioux Falls - Westside	11,886	3.06	4,152	4,943	493	666	15,011	3.87	5,364	6,518	608	850	18,136	4.68	6,556	8,081	722	1,034	21,260	5.48	7,733	9,635	835	1,216	51,941	13.3	18,738	25,409	2,003	3,081
City of Tea (Options 3 and 4) (2021)	6,708	1.21	2,191	2,526	285	371	8,460	1.52	2,783	3,186	360	468	10,228	1.84	3,380	3,852	435	566	11,994	2.16	3,977	4,517	510	663	22,219	3.33	5,804	8,367	787	1,024
City of Hartford (2031)													4,484	0.67	1,171	1,689	159	207	4,886	0.73	1,276	1,840	173	225	7,298	1.09	1,906	2,748	259	336
Wall Lake Sanitary District (2031)													85	0.01	22	32	3	4	85	0.01	22	32	3	4	84	0.01	22	32	3	4
City of Lennox (2036)																			2,537	0.38	663	955	90	117	2,713	0.41	709	1,022	96	125
Sioux Falls - Eastside	25,797	6.54	8,194	10,671	974	1,381	36,011	9.13	8,194	15,494	1,324	1,945	46,224	11.72	15,199	20,315	1,672	2,509	56,437	14.31	18,696	25,133	2,021	3,073	103,942	26.4	34,930	47,685	3,657	5,716
City of Harrisburg (2021)	6,230	0.93	1,627	2,346	221	287	7,580	1.14	1,980	2,854	269	349	9,225	1.38	2,409	3,474	327	425	11,234	1.69	2,934	4,230	398	518	20,847	3.13	5,445	7,851	739	961
City of Tea (Option 2) (2021)	6,708	1.21	2,191	2,526	285	371	8,460	1.52	2,783	3,186	360	468	10,228	1.84	3,380	3,852	435	566	11,994	2.16	3,977	4,517	510	663	22,219	3.33	5,804	8,367	787	1,024
City of Canton (2031)													3,476	0.52	908	1,309	123	160	3,528	0.53	922	1,329	125	163	3,840	0.58	1,003	1,446	136	177
City of Worthing (2036)																			2,286	0.34	597	861	81	105	4,243	0.64	1,108	1,598	150	196
Option 1 - Existing WRF Only																														
Total	***211,252***	***52.0***	***75,158***	***85,150***	***9,158***	***11,669***	***232,689***	***55.8***	***79,310***	***95,960***	***9,904***	***12,825***	***266,739***	***64.0***	***93,769***	***111,520***	***11,095***	***14,562***	***295,664***	***70.1***	***103,383***	***125,150***	***12,105***	***16,061***	***434,324***	***102.7***	***166,204***	***235,170***	***18,334***	***25,439***
Option 2 - Existing WRF and New Eastside WRF																														
Existing WRF	172,516	43.3	63,146	69,607	7,678	9,630	180,639	44.0	66,354	74,426	7,952	10,063	197,587	48.5	71,872	82,571	8,538	10,901	210,185	51.1	76,257	89,080	8,969	11,539	279,233	68.7	117,914	168,223	12,864	17,366
New Eastside WRF (including Tea flow)	38,736	8.7	12,012	15,544	1,480	2,039	52,050	11.8	12,956	21,534	1,952	2,762	69,152	15.5	21,897	28,949	2,557	3,660	85,478	19.0	27,126	36,070	3,135	4,522	155,091	34.0	48,290	66,948	5,470	8,073
Total	***211,252***	***52.0***	***75,158***	***85,150***	***9,158***	***11,669***	***232,689***	***55.8***	***79,310***	***95,960***	***9,904***	***12,825***	***266,739***	***64.0***	***93,769***	***111,520***	***11,095***	***14,562***	***295,664***	***70.1***	***103,383***	***125,150***	***12,105***	***16,061***	***434,324***	***102.7***	***166,204***	***235,170***	***18,334***	***25,439***
Option 3 - WRF and Westside plant																														
Existing WRF	192,657	47.7	68,815	77,681	8,380	10,632	209,218	50.4	71,164	86,256	8,936	11,507	233,806	56.8	82,639	97,867	9,777	12,752	254,903	61.4	89,712	108,171	10,494	13,836	350,069	84.5	139,026	197,593	15,186	20,868
New Westside WRF (including Tea flow)	18,595	4.3	6,343	7,470	779	1,037	23,471	5.4	8,147	9,704	968	1,318	32,933	7.2	11,130	13,654	1,319	1,810	40,761	8.8	13,671	16,979	1,611	2,225	84,255	18.2	27,179	37,578	3,148	4,571
Total	***211,252***	***52.0***	***75,158***	***85,150***	***9,158***	***11,669***	***232,689***	***55.8***	***79,310***	***95,960***	***9,904***	***12,825***	***266,739***	***64.0***	***93,769***	***111,520***	***11,095***	***14,562***	***295,664***	***70.1***	***103,383***	***125,150***	***12,105***	***16,061***	***434,324***	***102.7***	***166,204***	***235,170***	***18,334***	***25,439***
Option 4 - WRF and New Eastside WRF and New Westside WRF																														
Existing WRF	160,630	40.2	58,995	64,663	7,185	8,964	165,628	40.1	60,990	67,908	7,344	9,213	174,882	43.1	64,122	72,769	7,654	9,657	181,418	44.5	66,563	76,618	7,868	9,977	217,198	53.8	96,539	139,012	10,504	13,819
New Eastside WRF	32,027	7.5	9,821	13,017	1,195	1,668	43,590	10.3	10,173	18,349	1,592	2,294	58,924	13.6	18,516	25,097	2,122	3,095	73,485	16.9	23,149	31,553	2,625	3,859	132,872	30.7	42,487	58,580	4,682	7,049
New Westside WRF (including Tea flow)	18,595	4.3	6,343	7,470	779	1,037	23,471	5.4	8,147	9,704	968	1,318	32,933	7.2	11,130	13,654	1,319	1,810	40,761	8.8	13,671	16,979	1,611	2,225	84,255	18.2	27,179	37,578	3,148	4,571
Total	***211,252***	***52.0***	***75,158***	***85,150***	***9,158***	***11,669***	***232,689***	***55.8***	***79,310***	***95,960***	***9,904***	***12,825***	***266,739***	***64.0***	***93,769***	***111,520***	***11,095***	***14,562***	***295,664***	***70.1***	***103,383***	***125,150***	***12,105***	***16,061***	***434,324***	***102.7***	***166,204***	***235,170***	***18,334***	***25,439***
Sioux Falls areas total	186,690	48.5	68,304	75,900	8,344	10,609	203,542	52.9	71,124	84,984	8,933	11,562	220,395	57.3	80,955	94,068	9,522	12,515	237,247	61.7	87,280	103,151	10,111	13,468	339,791	88.5	141,512	199,570	14,984	21,082
Phase 1 regional communities total	24,562	3.4	6,854	9,250	815	1,060	29,146	2.9	8,186	10,976	971	1,263	34,152	4.8	9,629	12,861	1,142	1,485	39,556	5.6	11,177	14,896	1,325	1,724	68,903	10.3	17,997	25,948	2,442	3,176
Phase 2 regional communities total	0	0.0	0	0	0	0	0	0.0	0	0	0	0	12,192	1.8	3,184	4,591	432	562	12,962	1.9	3,386	4,881	459	597	17,584	2.6	4,593	6,622	623	810
Phase 3 regional communities total	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	5,899	0.9	1,541	2,221	209	272	8,046	1.2	2,102	3,030	285	371
Total	***211,252***	***52.0***	***75,158***	***85,150***	***9,158***	***11,669***	***232,689***	***55.8***	***79,310***	***95,960***	***9,904***	***12,825***	***266,739***	***64.0***	***93,769***	***111,520***	***11,095***	***14,562***	***295,664***	***70.1***	***103,383***	***125,150***	***12,105***	***16,061***	***434,324***	***102.7***	***166,204***	***235,170***	***18,334***	***25,439***

Future Industry Planning Basis Considerations

The following industrial wastewater studies provide direction and recommendations for incorporating growth of industry in the City.

- Foundation Park Industrial Wastewater Services Study, SEH, September 30, 2015.
- Industrial Customer Guidance Plan, SEH, September 30, 2015.

The Foundation Park Industrial Wastewater Services Study stated intent was to identify the infrastructure to maximize benefits and reduce risks to attract world-class companies to Foundation Park.

The Industrial Customer Guidance Plan (Plan), dated September 30, 2015, was prepared by SEH in conjunction with the Foundation Park Industrial Wastewater Services Study. It provides direction on best practices to serve new and expanding industrial customers with an emphasis on high strength industries.

4.4.3 Foundation Park Industrial Wastewater Services Study

The Foundation Park Industrial Wastewater Services Study (Study), dated September 30, 2015 was prepared by SEH to plan wastewater services for development of the Foundation Park industrial area. Refer to Figure 4.2. Foundation Park is located at the intersection of Interstates 90 and 29 and has rail as well as highway access. The Study considered the capacity and condition of existing wastewater facilities, improvements to handle phased implementation of different types of industrial wastewater discharges, siting of new industries, capacity allocation, capital funding, and rates. The stated intent was to identify the infrastructure to maximize benefits and reduce risks to attract world-class companies to Foundation Park.

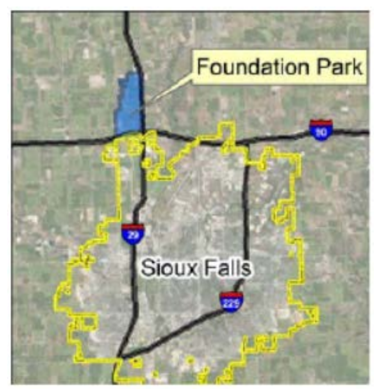


Figure 4.2 Foundation Park Overview

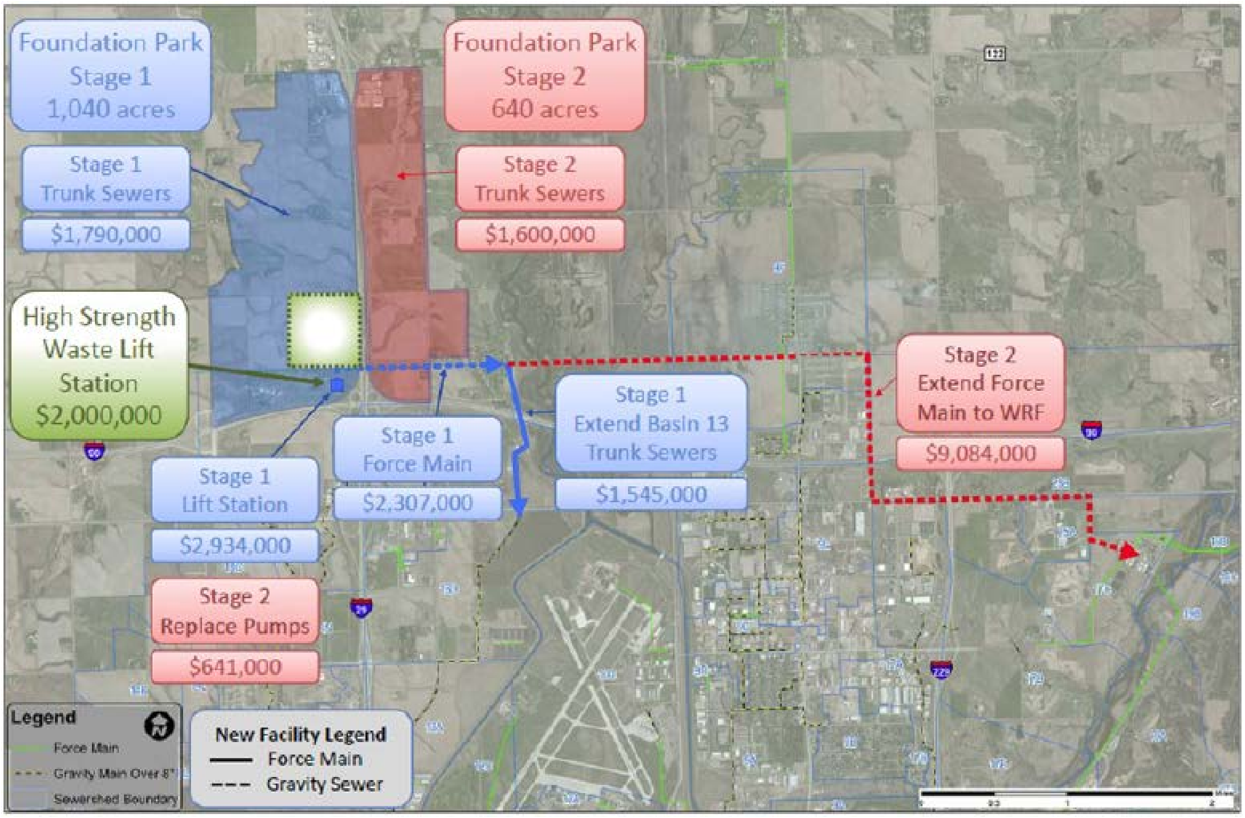
The Executive Summary notes the following.
"This Study provides supporting information to assist in making decisions on wastewater service infrastructure needs to serve Foundation Park and other industrial development in the region. The assumptions in this study can be updated to accommodate the various growth scenarios presented to the City with new business and industry proposals, as well as a longer-term growth plan for the City. The City will integrate planning for area industrial growth with its master planning activities for wastewater conveyance and treatment facilities, regionalization planning with customer communities, and other public works projects."

The Study recommended Development Plan C shown below. The recommended plan assumes mostly domestic strength industrial wastewater, but reserves an area for higher strength wastewater.

Plan C assumes 0.7 million gallons per day (mgd) of average daily industrial wastewater flow in Stage 1 with a peak flow of 2.4 mgd. Stage 1 wastewater will be pumped to an extended Basin 13 sanitary sewer southeast of the park. Plan C also assumes 1.2 mgd of average daily industrial wastewater flow in Stage 2 with a peak flow of 4.2 mgd. Following Stage 2, wastewater flow will be pumped directly to the City of Sioux Falls Water Reclamation Facility (WRF).

Required facilities are shown in Figure 4.3 and tabulated below. The associated timing is dependent on industrial growth and the Executive Summary indicates that the $8.576 million capital for Stage 1 could be as early as 2016 and the $11.325 million capital for Stage 2 could be as early as 2020. These costs would be recaptured through cost recovery at an estimated at $11,528 per acre.

Figure 4.3 Recommended Development Plan: Mixed Industry (Plan C)



Additional expenditures would be required to separately convey and treat high strength industrial waste streams. Refer to Table 4.24. Preferred alternatives were dissolved air flotation (DAF) thickening onsite with solids hauled to the WRF and separate conveyance for up-flow anaerobic sludge blanket (UASB) treatment at the WRF. The additional costs were assumed to be recaptured through a proportionate share of newly established high strength rates.

Table 4.24 Capital Costs[a] for Recommended Development Plan C

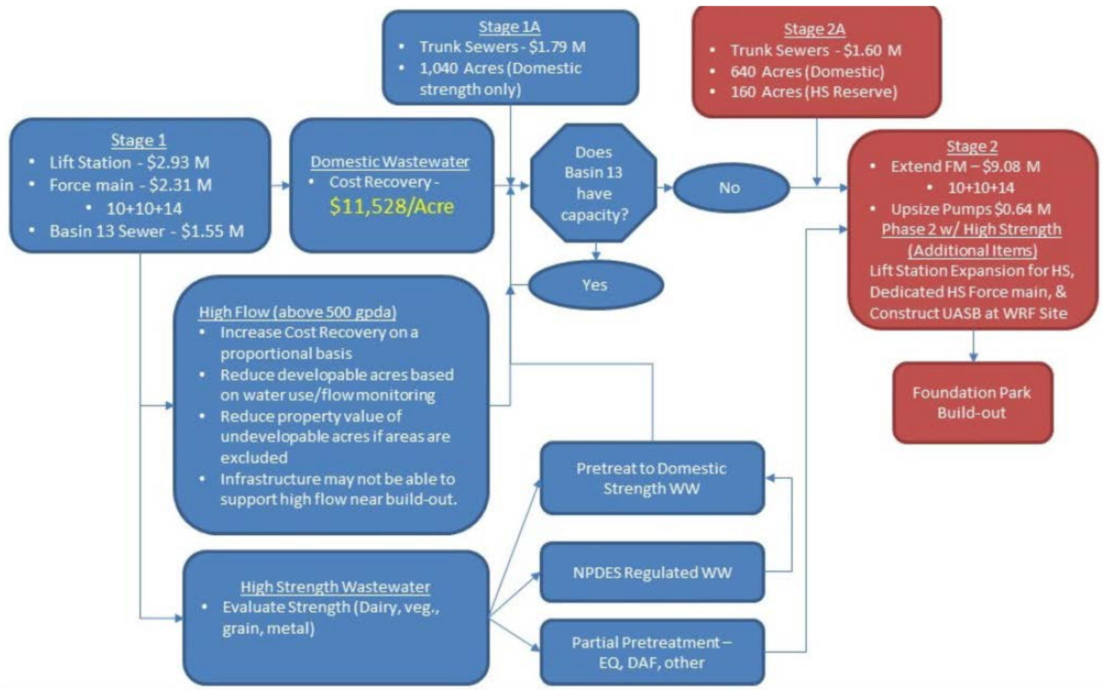
Stage 1	Stage 1 1040 acres	Stage 2 640 acres	High Strength Waste
Trunk Sewers	$1.790	$1.602	
High Strength Trunk Sewers			$0.798
Lift Station	$2.934		
Pump Replacement		$0.641	
Force Main	$2.307		
High Strength Force Main			$1.171
Extend Force Main to WRF		$9.084	
Extend Basin 13 Trunk Sewers	$1.545[b]		
High Strength Lift Station			$2.000
Total	$8.576[b]	$11.327	$3.969

[a] Includes construction with contingency of 25 percent for undeveloped design details at planning level stage plus, engineering, legal, and administrative costs of 25 percent of construction. Costs are December 2014 dollars (ENDR CCI 9936.44).

[b] $0.536 million of this total is applied to Basin 13 cost recovery.

A flow chart for determining the actual staging for Stage 1, Stage 2, and high strength facilities is included in Figure 4.4 below.

Figure 4.4 Basis for Facility Staging for Mixed Industry Development (Plan C –Figure 5)



Alternative Plan D provides a less expensive concept to locate industries with high strength wastewater just west of the WRF. That location provides good highway access to Interstate 229 and Benson Road, but does not provide rail access. Both capital and O&M costs would be lower because of proximity to WRF.

Plan A was the original intent, but financial analysis drove consideration of other more cost-effective plans with a lower "carrying cost." Carrying cost was calculated as the difference between new industry allocated revenue requirements and total revenue requirements including new and future industry.

Considering carrying costs, Plan C was determined to be most cost-effective scenario with the initial phase being infrastructure for domestic strength waste and additional future infrastructure for high strength waste in subsequent phases.

Foundation Park Study Considerations

- Industries with high strength wastewater discharges need to be fully vetted on a case-by-case basis and duly considered in support of economic goals and other community interests.
- The associated capital costs for industrial development with mostly domestic strength wastewater discharges in the Foundation Park area will be included.
- The Study indicates that the capital and O&M cost of service for high strength wastewater is quite a bit higher than the capital and O&M cost of service for domestic strength wastewater. On this basis, industries with higher strength wastewater are incented to locate nearer to the WRF unless rail access as well as interstate access is required. The study assumed parallel

but separate trunk sewers, pump station, force main, and treatment for high strength wastewater.

- The study was based on characteristics typical of high strength wastewater from dairy and other agricultural based processing, with the intent of treating the waste stream separately with anaerobic technology.
- The trickling train can be repurposed for industry as appropriate after the nutrient improvements are in place. However, this is not projected to be complete until 2029.

4.4.4 Industrial Customer Guidance Plan

The Industrial Customer Guidance Plan (Plan), dated September 30, 2015, was prepared by SEH in conjunction with the Foundation Park Industrial Wastewater Services Study. It provides direction on best practices to serve new and expanding industrial customers with an emphasis on high strength industries. The Plan is presented in a format that can be updated periodically with the most current information from comprehensive planning, wastewater master planning, and capital improvements. The Plan also serves as a resource for the City and industrial customers to complement the Industrial Pretreatment Program.

Approach

The Plan identifies and elaborates on the following six-step process with a new industry or when an existing industry proposes changes. The six steps are intended to guide the City through the decision process to accommodate future industrial dischargers. Refer to Figure 4.5.

Figure 4.5 Industrial Wastewater Discharge Review Approach (Figure 1)

To clarify, Step 5 identifies the related costs and nonmonetary factors to consider with the proposed improvements. Likewise, Step 6 includes a financial analysis to identify financing options, associated City carrying costs, and potential fees to be charged to industries and developers. Carrying costs represent the difference between debt service on City investment and revenue produced as industry and developers use the associated facilities.

Other Information

The Plan notes that high strength industries specifically targeted for growth by the state and Sioux Falls region are agricultural based industries, specifically dairy related industries. At the same time, the Plan reinforces interest in attracting other types of industries and maintaining existing industrial customers that are not high strength industries.

Local limits for the WRF headworks are identified for metals and traditional parameters as follows.

Table 4.25 WRF Headworks Local Limits

Pollutant	Daily Maximum (mg/L)	Instantaneous Maximum (mg/L)
Arsenic	0.19	0.38
Cadmium	0.024	0.048
Copper	2.79	5.58
Lead	1.06	2.12
Nickel	1.52	3.04
Selenium	0.19	0.38
Silver	3.04	6.08
Zinc	11.57	23.14

Pollutant	Maximum Allowable Industrial Loading (MAIL)	Unit of Measure	Unit of Limit
BOD	20,692	lbs/day	30-day average
Molybdenum	6.17	lbs/day	Daily
TKN	3,527	lbs/day	30-day average
TSS	15,095	lbs/day	30-day average

The Plan presents and describes both monetary and nonmonetary criteria for use in evaluating alternatives as follows. Refer to Table 4.26 for general criteria and Table 4.27 Monetary Criteria for Evaluating Alternatives for monetary criteria.

Table 4.26 Criteria for Evaluating Alternatives

Planning	Monetary	Technical Performance	Environmental	Social
• Planning Period	• Capital Cost • O&M Cost • Payback Period • Incentives	• Operability • Maintainability • Implementation • Flexibility • Reliability • Staffing Impacts	• Water Quality Impact • Air Quality Impact • Soils Quality Impact • Sustainability	• Odors • Noise • Traffic • Aesthetics • Economic Development • Safety Impacts • Jobs

Table 4.27 Monetary Criteria for Evaluating Alternatives

Description	Units	2015 Value
Planning Period	years	20
Discount Rate		4%
Electricity		
Current Rate	$/kwh	$0.072
Escalation Rate	per year	5%
Labor		
Current Rate	$/hr.	$50
Escalation Rate	per year	3%
Maintenance/Materials Escalation Rate	per year	3%

The Plan defines and describes a Risk Register to identify potential risks associated with treatment of a potential future industrial wastewater, starting with conveyance and treatment facility ownership. Other categories of Risks to be considered are included as follows and defined in the Plan. The associated Risk Register is included in Appendix H of the Plan.

- Unutilized Capacity (treatment, conveyance, or only one industry builds)

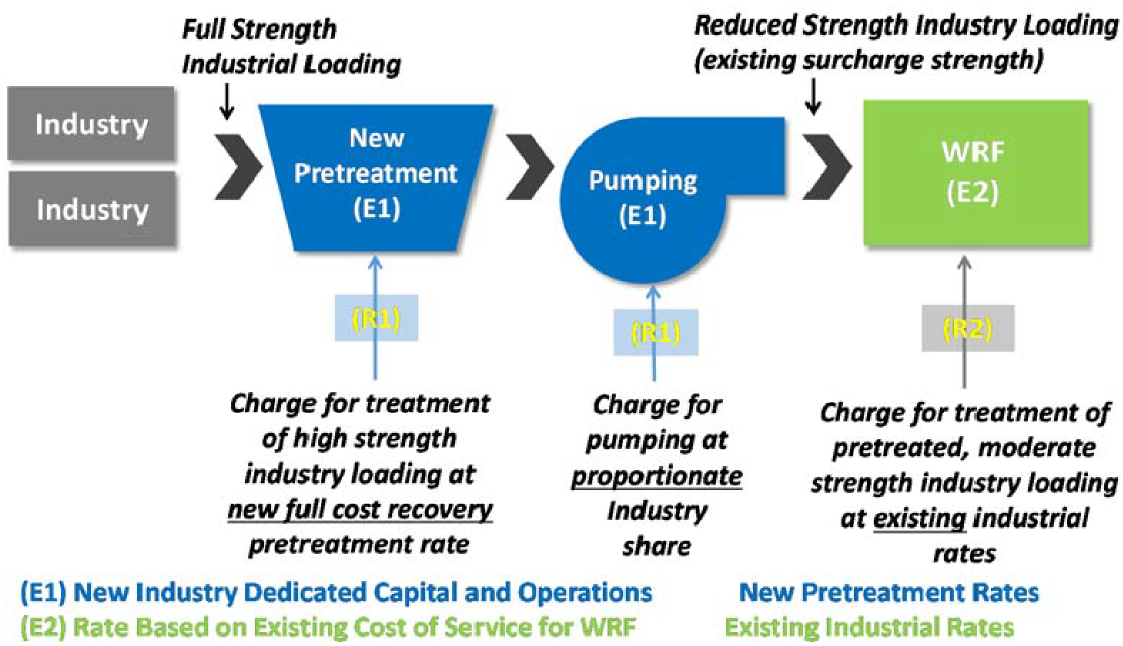
- Safety Concerns
- WRF Non-Compliance
- Loss of Pretreatment Process
- O, M, & R Costs Increase
- Capital Costs Increase from Engineering Estimates

Likewise, the Plan identifies and describes benefits associated with potential future industrial wastewater as follows:

- Job Creation.
- Economic growth and increased industrial base for tax and utility revenue.
- High strength wastes could reduce future requirements for a costly chemical supplement at the WRF.
- Potential for recycled water use, which could reduce demands for potable water and help the City or industry achieve sustainability goals.
- Potential for increased energy recovery, which could lower electricity costs at the WRF.

Finally, the Plan presents an approach for financial analysis to implement a fair and equitable annual charge for cost associated with future industrial wastewater. The approach is shown schematically in Figure 4.6.

Figure 4.6 Financial Analysis Approach (Figure 2)



Industrial Customer Guidance Plan Planning Considerations

The following considerations are recommended for planning for industry based on the Industrial Customer Guidance Plan.

1. There is a need to attempt to provide wastewater service to industries, including those with high strength wastewater discharges, in support of economic goals and other community interests.

2. Separate conveyance, pumping, and treatment (anaerobic) is more appropriate for the right high strength industrial wastewater from an industry located at the site just west of the WRF. Separate conveyance, pumping, and treatment may not be as appropriate for high strength wastewater from the Foundation Park area. This should be considered on a case-by-case basis.
3. The Industrial Customer Guidance Plan provides:
    a. Monetary and nonmonetary evaluation criteria summarized above.
    b. Risks and benefits summarized above.
4. Follow Industrial Guidance Plan prescribed practices for conveyance of high strength wastewater.

4.5 Summary of Requirements

The purpose of this section is to summarize the requirements to provide service to WRF customers for the 10-year, 20-year, and 50-year planning periods. The existing capacities for the facilities are summarized and compared with future capacity requirements. The existing capacities for collection and treatment control the immediate ability to serve existing system requirements and set the baseline ability for expanding the system in the future. The future capacity requirements provide the basis for evaluating the need for expanding treatment and the approximate phasing of recommended expansions.

The future capacity requirements were compared to the 2009 Master Plans requirements to note any significant differences to focus on during subsequent collection and treatment system analyses.

The treatment capacity of the WRF is currently rated at 21 MGD average day and 35 MGD peak. More detail about their respective treatment capacities is provided in Chapter 8. The treatment capacities for the WRF were evaluated for re-rating treatment capacity; this analysis is included in Chapter 8.

The WRFs are generally sized to treat MMF and loads. However, some treatment components of the WRFs are sized to handle the MDF and PHF. The wastewater collection system must be sized to handle the PHF to the juncture with equalization facilities.

Table 4.28, Table 4.29 and Table 4.30 summarize ADF, MMF, and MDF for the various planning periods. Note that the 2013 to 2015 average column in these three tables show no flow from Phase 1 regional communities. While the existing regional customers of Brandon and Harrisburg are identified as Phase 1 regional communities, their historical flows for this period were monitored in the influent to the WRF. Future flows from those communities are accounted for as a regional customer. Chapters 7 and 8 present the evaluation of the adequacy of the existing WRFs for meeting the projected flows at to each WRF.

Table 4.28 Projected Average Day Flows

Area	2013 to 2015 Ave	2021	2026	2031	2036	2066
	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*
Option 1 - Existing WRF Only						
Total	***16.1***	***22.2***	***23.8***	***27.2***	***30.1***	***44.6***
Option 2 - Existing WRF and New Eastside WRF						
Existing WRF	15.0	18.1	18.4	20.1	21.3	29.0
New Eastside WRF (including Tea flow)	1.1	4.0	5.4	7.2	8.8	15.6
Total	**16.1**	**22.2**	**23.8**	**27.2**	**30.1**	**44.6**
Option 3 - WRF and Westside plant						
Existing WRF	15.4	19.6	21.2	23.7	25.8	36.1
New Westside WRF (including Tea flow)	0.7	2.6	2.6	3.5	4.4	8.5
Total	**16.1**	**22.2**	**23.8**	**27.2**	**30.1**	**44.6**
Option 4 - WRF and New Eastside WRF and New Westside WRF						
Existing WRF	14.2	16.3	16.8	17.7	18.4	22.7
New Eastside WRF	1.1	3.2	4.4	5.9	7.4	13.4
New Westside WRF (including Tea flow)	0.7	2.6	2.6	3.5	4.4	8.5
Total	16.1	22.2	23.8	27.2	30.1	44.6
Sioux Falls Areas total	**16.1**	**19.9**	**21.0**	**22.8**	**24.5**	**35.2**
Phase 1 Regional Communities total	**0.0**	**2.3**	**2.7**	**3.2**	**3.7**	**6.9**
Phase 2 Regional Communities total	**0.0**	**0.0**	**0.0**	**1.2**	**1.3**	**1.8**
Phase 3 Regional Communities total	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**	**0.8**
Total	***16.1***	***22.2***	**23.8**	**27.2**	**30.1**	**44.6**

Table 4.29 Projected Maximum Month Flow

Area	2013 to 2015	2021	2026	2031	2036	2066
	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*
Option 1 - Existing WRF Only						
Total	***23.7***	***31.1***	***34.0***	***38.7***	***42.7***	***63.0***
Option 2 - Existing WRF and New Eastside WRF						
Existing WRF	22.0	25.5	26.6	28.9	30.6	41.5
New Eastside WRF (including Tea flow)	1.7	5.5	7.5	9.8	12.1	21.5
Total	**23.7**	**31.1**	**34.0**	**38.7**	**42.7**	**63.0**
Option 3 - WRF and Westside plant						
Existing WRF	22.6	28.3	30.6	34.0	36.9	51.3
New Westside WRF (including Tea flow)	1.1	2.7	3.5	4.7	5.8	11.7
Total	**23.7**	**31.1**	**34.0**	**38.7**	**42.7**	**63.0**
Option 4 - WRF and New Eastside WRF and New Westside WRF						
Existing WRF	20.9	23.8	24.3	25.6	26.5	32.5
New Eastside WRF	1.7	4.6	6.2	8.4	10.4	18.8
New Westside WRF (including Tea flow)	1.1	2.7	3.5	4.7	5.8	11.7
Total	**23.7**	**31.1**	**34.0**	**38.7**	**42.7**	**63.0**
Sioux Falls Areas total	**23.7**	**28.3**	**30.9**	**33.4**	**36.0**	**51.6**
Phase 1 Regional Communities total	**0.0**	**2.8**	**3.2**	**3.9**	**4.5**	**8.3**
Phase 2 Regional Communities total	**0.0**	**0.0**	**0.0**	**1.5**	**1.6**	**2.1**
Phase 3 Regional Communities total	**0.0**	**0.0**	**0.0**	**0.0**	**0.7**	**1.0**
Total	**23.7**	**31.1**	**34.0**	**38.7**	**42.7**	**63.0**

Table 4.30 Projected Maximum Day Flows

Area	2013 to 2015	2021	2026	2031	2036	2066
	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*
Option 1 - Existing WRF Only						
Total	***40.5***	***52.0***	***55.8***	***64.0***	***70.1***	***102.7***
Option 2 - Existing WRF and New Eastside WRF						
Existing WRF	37.7	43.3	44.0	48.5	51.1	68.7
New Eastside WRF (including Tea flow)	2.9	8.7	11.8	15.5	19.0	34.0
Total	***40.5***	***52.0***	***55.8***	***64.0***	***70.1***	***102.7***
Option 3 - WRF and Westside plant						
Existing WRF	38.6	47.7	50.4	56.8	61.4	84.5
New Westside WRF (including Tea flow)	1.9	4.3	5.4	7.2	8.8	18.2
Total	***40.5***	***52.0***	***55.8***	***64.0***	***70.1***	***102.7***
Option 4 - WRF and New Eastside WRF and New Westside WRF						
Existing WRF	35.8	40.3	40.1	43.2	44.5	53.8
New Eastside WRF	2.9	7.5	10.3	13.6	16.9	30.7
New Westside WRF (including Tea flow)	1.9	4.3	5.4	7.2	8.8	18.2
Total	***40.5***	***52.0***	***55.8***	***64.0***	***70.1***	***102.7***
Sioux Falls Areas total	40.5	48.5	52.9	57.3	61.7	88.5
Phase 1 Regional Communities total	0.0	3.4	2.9	4.8	5.6	10.3
Phase 2 Regional Communities total	0.0	0.0	0.0	1.8	1.9	2.6
Phase 3 Regional Communities total	0.0	0.0	0.0	0.0	0.9	1.2
Total (Equalized to Maximum of 57 mgd)	***40.5***	***52.0***	***55.8***	***57***	***57***	***57***

Since the 2009 Master Plan does not split projected wastewater flows by service basin, the sum of the WRFs' projections for average and maximum day are used for comparison purposes. Comparing the 2009 and 2016 master plans, the wastewater flow requirements are higher in the 2016 master plan. Refer to Table 4.31. This is mainly due to including the potential for BSF contributions from large commercial and industrial customers.

Table 4.31 Comparison of Projected Flows to 2009 Master Plan

	2013 to 2015 Ave	2021	2026	2031	2036	2066
	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*	Flow *MGD*
Average Day						
2016 Master Plan	16.1	22.2	23.8	27.2	30.1	*44.6*
2009 Master Plan	*16.5*	*18.4*	*19.9*	*21.5*		
Maximum Month						
2016 Master Plan	23.7	31.1	34.0	38.7	42.7	63.0
2009 Master Plan	*22.0*	*22.4*	*24.3*	*26.1*	*28.1*	

Chapter 5 – Collection System Model Development and Calibration

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Table of Contents

Tables

Figures

Appendices

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Chapter 5 Collection System Model Development and Calibration

5.1 Introduction

This chapter summarizes the City of Sioux Falls' (City) existing and future sanitary collection system model development to support the 2016 Wastewater Treatment and Collection System Master Plan (WTCSMP). This chapter generally discusses hydraulic modeling history of the collection system and how the current model was updated to support the current WTCSMP. Water meter-based base wastewater production (BWP), dry-weather infiltration (DWI), rainfall derived infiltration and inflow (RDII) flow development, and future flow allocations as well as model calibration are detailed in this chapter. Chapter 2, Population and Land Use Planning, discussed future population and flow projections and subsequent Chapter 9, Collection System Analysis and Improvement Alternatives, and Chapter 11, Collection System Improvement Recommendations discuss model results under existing conditions as well future conditions modeling and capital improvement program (CIP) project recommendations.

5.1.1 Related Chapters

Related Chapters for population and flows, hydraulic modeling, and capacity analysis related to the City's wastewater collection system facilities include:

- Population and Land Use Planning (Chapter 2)
- Existing Wastewater System Facilities (Chapter 3)
- Wastewater Flows and Loads (Chapter 4)
- Collection System Analysis and Improvement Alternatives (Chapter 9)
- Summary of Collection System Capital Improvements (Chapter 11)

5.2 Hydraulic Model History and Software Selection

Modeling for the City is being done using the Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) hydraulic engine via XPSWMM. SWMM is a fully dynamic hydraulic simulation engine that can be use for single event or continuous simulation. The hydraulic model is a mathematical representation of the sewer system depicted by a series of nodes and links. Nodes represent manholes, storage basins, wet wells, junction boxes, and outfalls. Links represent any hydraulic structure, typically gravity or force mains, connecting two nodes. However, pumps, weirs, and gates are all represented by links as well in a model.

Dynamic hydraulic head conditions are computed at the nodes and flows through the links, conserving mass and momentum. These hydraulic calculations enable evaluation of hydraulic grades at nodes and flows and velocities in links to determine capacity within the collection system under various hydraulic and hydrologic scenarios including for both existing and future conditions. Hydraulic scenarios may include flow diversions, parallel pipes (relief sewers), replacement pipes, storage basins, and other operational changes. Hydrologic scenarios include different analysis storm events, antecedent moisture conditions, and sewer infiltration and inflow responses.

SWMM contains a flexible set of hydraulic modeling capabilities used to route dry-weather loads and wet-weather inflows through the drainage system network of pipes, storage and pumping elements, and diversion structures. These include the ability to:

- Simulate drainage networks of virtually unlimited size.
- Use a wide variety of standard closed and open conduit shapes.
- Model special elements such as storage/treatment units, flow dividers, pumps, weirs, and orifices.
- Apply external flows and water quality inputs from surface runoff, groundwater interflow, rainfall-dependent infiltration/inflow, dry-weather sanitary flow, and user-defined inflows.
- Use the fully dynamic wave flow routing methods (complete Saint-Venant flow equations).
- Model various flow regimes, such as backwater, surcharging, reverse flow, and surface ponding.
- Apply user-defined dynamic control rules to simulate the operation of pumps, orifice openings, and weir crest levels.

Since 2008, models have been developed within the GIS environment with a direct relationship to the City's ArcGIS geodatabase joined to their Hanson Asset Management system. The model geometry is created by exporting the City's GIS and into a new modeling geodatabase that supports EPA SWMM modeling.

Sanitary sewer pipes and manholes are validated within the modeling geodatabase to fill in data gaps, ensure reasonableness of the pipe/manhole geometry, check for potential data anomalies or datum issues, and locate any potentially incorrect information within the database that could negatively and incorrectly influence model results. Once the sewer pipe network is validated, the model is imported into SWMM-based modeling software.

Modeling since 2008 has been performed on the entire collection system for which data is available including trunk and local gravity sewer pipes and the pump stations and forcemains that serve them.

5.2.1 Previous Modeling

This section describes the collection system model history beginning with the 2002 Facilities Plan model up until the end of 2015 prior the beginning of this WTCSMP. Along with the model history, a summary of previous modeling approach and software is provided.

Model History

The Central Main Model was first developed to support the *Sanitary Sewer Collection System Facilities Plan* (Black & Veatch, 2002) and included the trunk sewers for the City-wide sanitary sewer collection system plus future growth plans through 2025. At that time, XPSWMM was used for modeling the City's collection system. The geometry and flow input information for the 2002 Facilities Plan model was contained within a FoxPro database and exported to an xpx file to import into the XPSWMM model. The xpx file was a method to interact with the model based on previous generations of the software package. The model was further limited to pipe diameters larger than 12-

inches, which resulted in large pipeshed areas. The 2002 Facilities Plan selected the 25-year, 24-hour rainfall depth under a United States Department of Agriculture (USDA) Soil Conservation Service (SCS) Type II distribution as the capacity analysis storm to evaluate system performance. Modifications to this model were completed from 2002 to 2008. These modeling efforts used the SCS curve number method for hydrologic determination and applied an inflow factor to reduce contributing sewershed area.

Beginning in 2008, the model was recreated by directly incorporating the City's GIS and Hanson databases into a GIS modeling geodatabase described in Section 5.3.1. This approach allowed the GIS data to be directly imported into the XPSWMM model and allowed for extensive data tracking. This effort used the EPA SWMM runoff method for hydrologic flow estimates. This change in method allowed for a more straight forward approach of assigning an inflow factor directly to the hydrologic inflow and modeling actual rainfall events that are not 24 hours in duration or in a SCS distribution. This model was the first 'all pipes' model meaning that all local, collector, and trunk sewer pipes containing data were included in the modeling effort.

Another major model update occurred in 2011 based on updated invert data, addition of new sewer lines associated with new developments, and construction modifications to the existing system. As with the 2008 modeling effort, the assumptions, data modifications, and data changes were tracked. The 2011 model was the last major model update prior to this 2016 WTCMP. The model was updated during this study to incorporate new GIS data from February 2016 and information on diversion structures, lift stations, and construction on the Sioux River South trunk sewer.

Previous Modeling Approach

Previous modeling incorporated a land use based approach to estimate existing BWP. Land use was divided into 65 separate land use categories, with residential parcels assigned an estimated area density (units/acre), an estimated unity density (people/unit), and an estimated loading of 55 gallons per day per person for the central main and 100 gallons per day per person for the ESSS. Other land use types such as commercial, industrial, institutions, public assembly, public service, etc. were assigned loadings based on a gallons per day per acre (gpd/acre) value depending upon their development density or type. Diurnal patterns were developed from available flow monitoring data and assigned to these BWP loads.

Infiltration was assigned a value of 100 gallons per day per acre of sanitary sewer basin based on standard planning values in absence of more detailed flow monitoring data.

Inflow was developed by modeling runoff from the hydrologic watersheds using the SCS curve number method prior to 2008 and the EPA SWMM runoff method after 2008. A 0.4 percent inflow factor was assigned to the runoff hydrographs for the majority of analyses. Modeling also incorporated a 0.8 percent inflow factor when system capacity in areas of known high inflow was examined in more detail.

XPSWMM

XP Solution's XPSWMM software was used for modeling the City's collection system from the *Sanitary Sewer Collection System Facilities Plan* (Black & Veatch, 2002) until the start of the 2016 WTCSMP. XPSWMM uses the EPA SWMM hydraulic modeling engine and fully supports sanitary sewer collection system modeling. XPSWMM allowed for direct model import from the modeling geodatabase and generally produced good, stable results. The XPSWMM software is based in a stand alone interface that interfaces with GIS data. However, given the complex flow scenarios required for this 2016 WTCSMP and the GIS-driven nature of the master planning process, it was decided to use another SWMM-based modeling platform.

5.2.2 InfoSWMM Conversion

Modeling for this 2016 WTCSMP is performed using Innovyze's InfoSWMM software Version 14, Service Pack 1, Update #8. InfoSWMM also uses the EPA SWMM hydraulic modeling engine, a fully dynamic platform for evaluating sewer hydraulics and capacity. Reasons for converting the City's collection system model to InfoSWMM include the following:

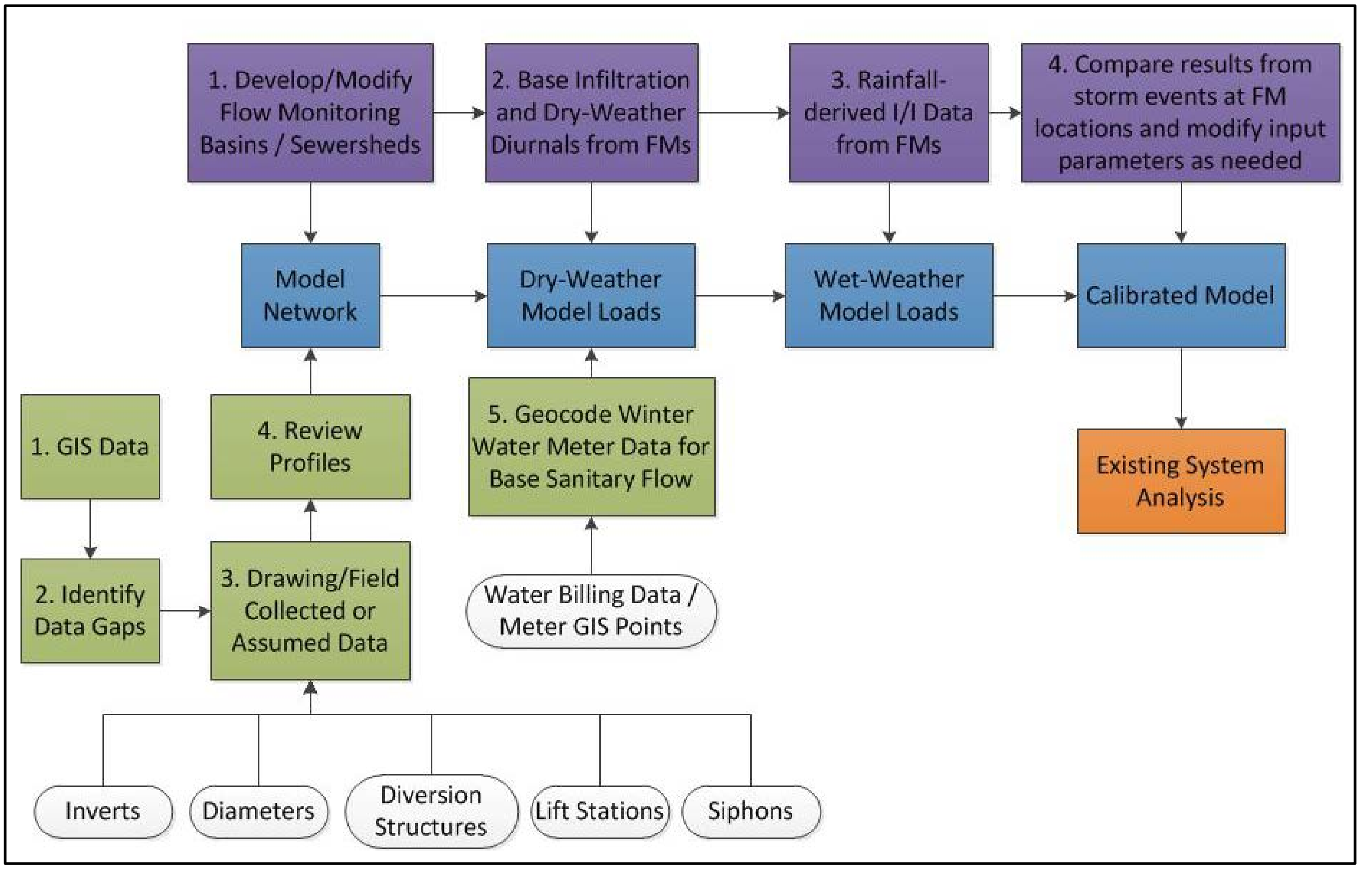
- InfoSWMM is executed through a graphical user interface directly within ArcMap by Esri as an extension, allowing straightforward interaction with GIS-based data and backgrounds.
- InfoSWMM has a built-in feature for processing RTK values for modeling wet-weather responses.
- InfoSWMM allows for direct importing of the modeling geodatabase.
- InfoSWMM is more efficient at modeling large systems and managing large amounts of data.
- Updating flow loads is quicker and more efficient. Values can be universally copy and pasted into InfoSWMM easily, whereas in XPSWMM, given the size of the network, this is problematic and would thus require importing.

5.3 Collection System Modeling Approach and Updates

The collection system modeling approach with sewer network, flow monitoring, dry-weather load and wet-weather response allocation, and calibration steps is summarized in this chapter and depicted in Figure 5.1. Sewer basins and subbasins are a major component of the hydraulic model and loading approach. The City has 25 basins and 168 subbasins that sanitary sewer service is currently provided or partially provided to. Through the 100-year planning period, an additional 9 basins and 59 subbasins are currently identified for a total of 34 basins and 227 subbasins. The currently served area consists of 58,008 acres while the 100-year proposed served area is estimated at 137,181 acres.

The previous 2011 modeling geodatabase and the City's GIS geodatabase (current to February 6, 2016) were used as the foundation for the 2016 WTCSMP. Given the extensive effort involved with validating, correcting, and interpolating geometry data for an 'all pipes' model, the model update effort focused on areas of development and sanitary sewer construction that occurred after 2011. GIS pre-processing work was completed first to provide a network that was continuous and hydraulically representative of the existing system. This section summarizes the hydraulic modeling components and network inputs. Appendix 5-A contains a map of the existing collection system modeled as part of the 2016 WTCSMP.

Figure 5.1 2016 WTCSMP Modeling Workflow



5.3.1 Basis of Model Inputs

The current modeling effort used the 2011 modeling geodatabase as the foundation updated with the recent 2016 GIS data. A full sized map of the modeled existing collection system is provided in Appendix 5-A. The objective is to create as close to 1:1 relationship between the City's sewer collection system GIS and the model as possible. The 2011 modeling effort extracted elevation data from the City's GIS as provided at that time. Elevation invert data for the pipes and manholes were developed based on the following (in order of prioritized use):

1. Available survey or construction plan data
2. Available GIS invert data assigned to the pipes
3. Available GIS invert depths assigned to the pipes minus GIS rim elevations
4. Available GIS invert depths assigned to the pipes minus rim elevations estimated from contours
5. Available GIS invert elevations assigned to the manholes and placed on the pipes lacking invert data
6. Available GIS invert depths assigned to the manholes minus GIS rim elevations and placed on the pipes lacking invert data
7. Available GIS invert depths assigned to the manholes minus rim elevations estimated from contours and placed on the pipes lacking invert data

If none of the above information was available or if the above information created an invalid network by having back pitched pipes, perched pipes, etc., pipe invert data was estimated from surrounding information. In cases where an entire portion of the network did not contain invert data on either the pipes or manholes, that network was excluded from the model.

Pipes missing diameters were inferred from the upstream and downstream diameter(s) where necessary. Certain newer subdivisions, such as Westwood, were not in the provided GIS database from February 2016. Where sewer mains were not contiguous from manhole to manhole, they were merged into one segment for modeling purposes. Stub-outs or services were not included in the model. Any sewer main and manhole GIS features classified with a future status were not included in the model.

As stated above, the model geometry was constructed by importing the City's 2016 GIS database into the modeling geodatabase for areas of new construction that have occurred since 2011. The City's feature classes used for creation of the modeling geodatabase are summarized in Table 5.1.

All elevations are United States Geological Survey (USGS) North American Vertical Datum of 1988 (NAVD 88) where the data was possible to confirm or convert them into this datum. For datum conversion from National Geodetic Vertical Datum of 1929 (NAVD 29) to NAVD 88, the shift is approximately +0.909 feet at City Hall (224 W 9th Street) in Sioux Falls.

Roughness Coefficients

The collection system model uses Manning's formula (Equation 5-1) to represent pipe roughness for open channel flow.

Equation 5-1

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} \sqrt{S}$$

where:

Q = Flow, cfs
n = Manning's roughness coefficient
A = Area, sq ft
R = Hydraulic radius, ft
S = Slope, ft/ft

Manning's roughness coefficient increases with increasing pipe roughness. All sewer main was assigned a Manning's roughness number of 0.013, a widely used standard pipe roughness for open channel flow. Changes in roughness occur with differences in material, age, condition, and root infiltration. However, there is insufficient individual pipe segment-specific data to accurately estimate changes in pipe roughness and the standard n value was applied. During future evaluations of capacity and improvements, the Manning's roughness coefficient can be varied in local areas to represent different existing and future pipe conditions based on pipe lining, root presence/removal, and newer pipe materials, as needed, to better understand the sensitivity of this coefficient with respect to capacity in improvement areas. Forcemain roughness was assigned with Hazen-Williams roughness coefficients (C value) of 120, a widely used standard pipe roughness for pressurized flow.

Table 5.1 GIS Data Inventory

Feature Class Name	Feature Class Type	Use for Collection System Modeling	Feature Class Name in Modeling Geodatabase/Feature Class Name in InfoSWMM
ssGravityMain	Complex Edge Line	Contains all known gravity sewer mains within the City's collection system. This file was basis for adding new gravity mains to the model. This dataset was the primary source of upstream and downstream invert elevations, pipe diameters, pipe materials, etc.	Single Links / Conduit
ssManhole	Simple Junction Point	Contains all known within the City's collection system. This file was the basis for manhole naming and junction rim elevations. This file was also used to supplement invert elevation when they were absent from the ssGravityMain feature class.	Nodes / Junction, Outfall
ssNetworkStructure	Simple Junction Point	Contains all known network structures within the City's collection system. The primary structure extracted from this feature class were pump/lift stations	Pumps / Pump, Storage
ssSepticSystems	Simple Point	Contains all known septic systems within the City's collection system. This data was used to verify the exclusion of water meter data not contained within a sanitary sewer basin.	N/A
ssPressurizedMain	Complex Edge Line	Contains all known force mains within the City's collection system.	Single Links / Conduit
ssMainAbandon	Simple Line	Contains all known abandoned sewers. This file was used to help remove and replace sewer mains in the previous modeled geodatabase.	N/A
ssBasin	Simple Polygon	Contains the City generated and named sanitary sewer basins delineated based on areas served within the collection system.	Pipesheds

Source: City of Sioux Falls GIS Geodatabase, February, 2016

The City provided supplemental GIS files, such as topographical data, streets, and land use, which provided further supporting information for analysis and figure reference.

5.3.2 Sewer Mains

A full discussion of the City's sewer mains is provided in Chapter 3. A total of 846 miles of existing gravity mains ranging from 4 to 66 inches in diameter and 24.2 miles of existing force mains ranging from 4 to 36 inches in diameter were included in the model. Of the 14,091 modeled sewer mains, 25 had diameters that were ultimately assumed, 3,464 had upstream inverts (or upstream manhole inverts) that had to be either assumed or adjusted, and 3,059 had downstream inverts (or downstream manhole inverts) that had to be either assumed or adjusted to coincide with the surrounding gravity sewer network.

Pipe invert data was first assigned to the new pipes based on inverts contained within the ssGravityMain feature class. When invert data was absent from this file, the manhole depth minus the rim elevation from the ssManhole feature class was used, if available. If pipe invert and manhole depth was both missing from the dataset, that portion of the network was either removed from the model if was in an upstream sewer location or interpolated based on surrounding known information. Sources of invert data are tracked within the modeling geodatabase.

5.3.3 Sewer Manholes

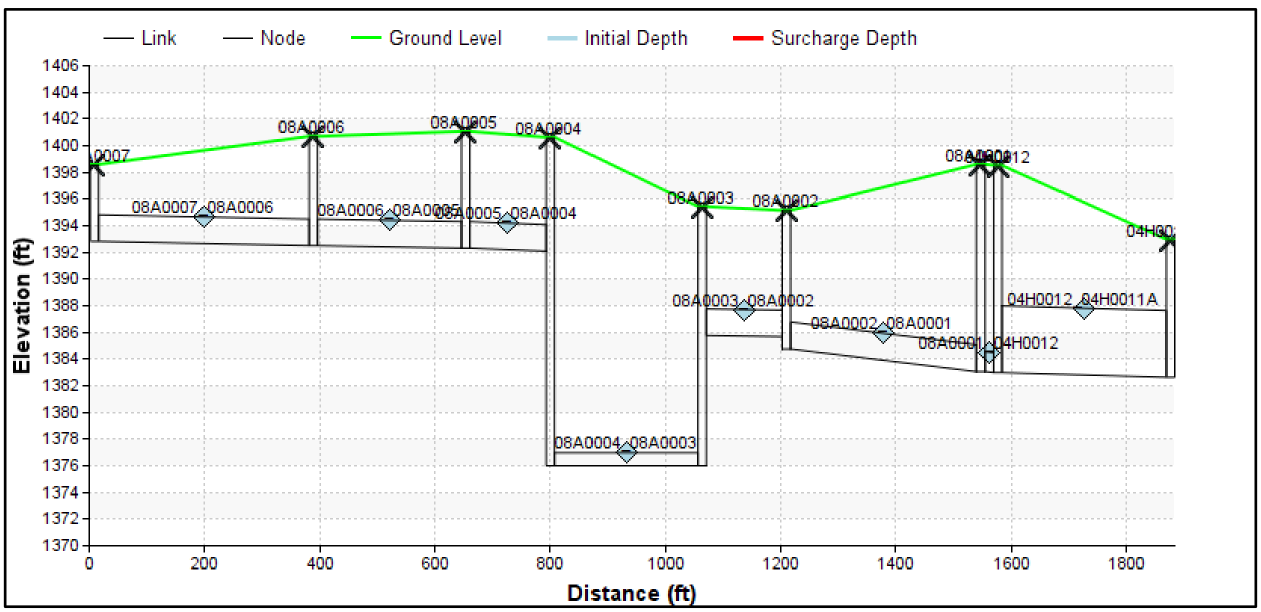
A full discussion of the City's sewer manholes is provided in Chapter 3. A total of 15,686 existing manholes were included in the current model. Of these manholes, over 3,500 had inverts that needed to be calculated, interpolated, or adjusted in coordination with the gravity sewer main invert adjustments.

Invert values for the manholes was assigned based on the lowest elevation between inlet pipes, outlet pipes, and manhole depth minus manhole rim. Sources of invert data are tracked within the modeling geodatabase.

5.3.4 Inverted Siphons

There are seven known inverted siphons in the city and they are summarized in Chapter 3. These siphons are reflected to various degrees in the current modeling. The Outfall Trunk siphon, the Basin 17 Siphon, and the Yankton Trail Park Siphon are modeled based on their designed configuration. The remaining siphons are modeled as dropped pipes (see Figure 5.2 for an illustration of a siphon modeled as a dropped pipe for the Cherry Rock Siphon). Either representation of the siphons within the hydraulic model is sufficient for the purposes of master planning-level evaluation; however the dropped pipes approach typically results in more stable model simulations than including short steep sewer main segments.

Figure 5.2 Example of a Siphon Modeled as a Dropped Pipe (Cherry Rock Siphon)



5.3.5 Lift Stations and Force Mains

There are a total of 29 city-owned and 40 privately-owned lift stations as discussed in Chapter 3. The current modeling effort includes 24 of these lift stations and their respective force mains. For the current modeling effort, the flow rating, the manufacturer's actual approximated flow, and pump flow testing data from 2013 and 2009 were gathered and organized. Lift station operation curves from the previous modeling efforts were compared to this data and adjusted as necessary. Lift stations within the City's collection system are modeled as dynamic pumps, meaning that their operation is based on the difference between upstream and downstream hydraulic head. Pump curves were extracted from the *Sanitary Sewer Collection System Facilities Plan* (Black & Veatch, 2002) model and adjusted based on the information reflected in Chapter 3.

The lift station definitions in the model include the pump curves, pump on/off control settings, wet well dimensions, and downstream force mains. Wet well dimensions were estimated based on aerial photography and estimated depths. For the flows storm events evaluated in this WTCSMP, wet well volumes are small enough that the impact on modeled peak flows and total volumes are minimal, but they do aid in model stability.

Default values for missing data include:

- Number of pumps = 1
- Wet well area: estimated from aerial
- Wet well depth = 20 feet
- Pump 1 on depth = influent invert elevation or 3 feet from the wet well bottom
- Pump 2 on depth = 1 foot above pump 1 on elevation
- Pump 1 and 2 off depth = 1 foot above wet well bottom elevation
- Flow/head design point: estimated to pump general peak flow

Permanent flow meters are available at several major lift stations which flow data was provided for use in developing and calibrating the hydraulic model. Table 5.2 summarizes the existing permanent SCADA-enabled flow meters at lift stations. Flow meters should be installed and calibrated regularly for all lift stations pumping over 350 gpm (0.5 mgd) under peak wet-weather flow conditions.

Table 5.2 SCADA-Enabled Modeled Lift Stations

Station Number	Station Name	Station Address
BRPS	Brandon Road Pump Station	3300 E. Rice Street
202	Air Terminal	South End of Costello Terminal
203	Cherokee & "C"	Cherokee and C Avenue
204	Modern Press	806 N. West Avenue
205	6th & Hawthorne	6th & Hawthorne, 300 Blk. N.
206	Burnside	1800 Burnside
213	23rd & Kiwanis	1421 S. Kiwanis
215	Sioux River North	3301 W. 12th St.
218	Tuthill Park	3500 S. Blauvelt
220	Rock Island, Riverside Park	1260 S. Blauvelt
221	Madison & Vail	1116 N. Sycamore
224	50^{th} Street North	50^{th} Street North
225	40^{th} Street North	210 E. 40^{th} Street North
227	Highway 38A	201 Powderhouse Road
233	Renner #1	N. of 72nd Street
234	Renner #2	N. of 72nd St.
235	Renner #3	47492 Berry Ln.
236	Renner #4	25775 Lindburg Ave.
237	Renner #5	47419 258th St.
240	ESSS	9400 E 57^{th} Street

5.3.6 Flow Equalization Facility

There is a Flow Equalization (EQ) Basin that is located upstream of the Brandon Road Pumping Station (BRPS) with a storage capacity of about 12 million gallons (MG) which is used to handle peak flows in excess of the BRPS capacity. This facility was modeled as a storage node in the InfoSWMM model. The equalization facility is discussed in further detail in Chapter 3.

Flows are directed to and from the facility by gravity flow, which is based on valve adjustments at a manhole outside the facility. The complex flow splitter geometry was incorporated into the model to generate the proper hydraulic grade lines, as well as the flow rates going into the BRPS. Based on conversations with the City, the EQ Basin is manually operated for wet-weather flows. The flow splitter governing protocol was therefore modeled by setting the flow bypass threshold to the estimated (modeled) maximum daily dry-weather summer flow of about 22,000 gpm. Flows in excess of this bypass threshold are diverted to the EQ Basin. The EQ basin is modeled with a 12-inch drain pipe and a maximum capacity of 12 million gallons. When the EQ Basin is full, all remaining flow is diverted back into the outfall trunk.

The EQ Basin is operated based on flow rates measured upstream of the BRPS. The flow into the EQ Basin from the flow control weir is allowed when the measured flow rate approaches flow set-points for the following conditions:

1. Equalize at the maximum pumping capacity of a single operating pump in the pumping station to minimize the cycling of the pumps, and maintain optimum pump operation rates.
2. Equalize to three pumps operating to avoid back-ups at the WRF. The WRF has a re-rated capacity of 35 mgd peak, but is able to pass in the neighborhood of 43 mgd.

The complex flow splitter geometry was incorporated into the InfoSWMM model to generate the proper hydraulic grade lines, as well as the flow rates going into the BRPS. The flow splitter governing protocol was modeled by matching the elevations at a reference manhole to flow rates and setting flow rate thresholds into the EQ Basin from the flow splitter.

5.3.7 Diversion Structures

There are numerous apex manholes and inter-basin flow splits within the City's collections system; however, there are only eight major diversions that direct substantial volumes of flow to other basins. These major diversion structures are discussed in Chapter 3 and are modeled accordingly. During a dynamic analysis, InfoSWMM determines the flow split between the sewers based on head differentials in each downstream direction.

5.3.8 Water Reclamation Facility

The Water Reclamation Facility (WRF) located on the north side of the Big Sioux River, east of Sycamore Street and south of East 60th Street, serves as the final outfall to the City's collection system model. The BRPS, Pump Station 240, and other connections such as the City of Brandon's flows all connect at the WRF. The WRF influent is the final outfall in the collection system model. Equalization at the WRF is not included in the model. The most current re-rating of the facility is 21 MGD average day flow and 35 MGD peak equalized flow.

5.3.9 Network Validation

Sanitary sewer pipes and manholes were validated within the modeling geodatabase, with checks performed that evaluate negative pipe slopes, pipes whose elevations do not tie into the surrounding profiles; upstream and downstream manhole references; manhole rim and invert elevations; and pipe diameters. Pipes that were missing invert elevation data were assigned the manhole inverts. When neither pipe nor manhole inverts exist, invert data was either interpolated or approximated. If an entire portion of the network was missing invert data and there are no other sewer pipes tying into it, then the network was removed from the modeling geodatabase. All adjustments, assumptions, and other notes are tracked within the modeling geodatabase.

- Pipe slopes that were negative or excessively positive (greater than 15 percent) were identified and the pipe inverts were adjusted to correct the slope if they were found to be erroneous.
- Manhole rim elevations were checked for irregularities, such as elevations causing excessively deep or negative pipe cover at manholes, and fixed as necessary.

- Pipe cover was checked for shallow pipes with less than 3 feet of cover at manholes as well as pipe in and pipe out invert elevations plus pipe size are below ground elevations (pipes cannot be out of the ground in the pipe profile) and adjusted as necessary.
- Manhole outlets being generally below manhole inlets were checked and adjusted as necessary so that artificial backups wouldn't be shown.
- Interceptor profiles within the model environment were checked for irregularities, such as negative slopes, and corrected as necessary.

5.3.10 Supplemental Survey and Drawings

Based on the results of the initial model validation and existing capacity analysis, several areas were identified where invert and diameter data was present but did not result in expected model results and flow profile conditions including unsubstantiated surcharging and sanitary sewer overflows (SSOs). These areas were examined further and determined likely to have invalid network data for the hydraulic model including adverse slopes and inconsistent diameters. Upon invert and diameter survey and model input updates, several of the areas no longer had modeled capacity limitations. The supplemental survey completed during the 2016 WTCSMP included the following areas:

- Central Main, McClellan Street to Riverside Avenue
- Walnut and Main
- West Madison Street to North 1st Avenue
- North 4th Avenue south of Hermosa Drive
- Thornwood & Richmond Estates east of Bahnson Avenue
- 41st Street between Grange Avenue and Walts Avenue
- South Pam Road/Lincoln High School
- Segment 07MC010/07MC009
- Segment 02F0001/02C0010

The following projects were under design during the 2016 WTCSMP and were included in the baseline model network:

- 72-inch Outfall Sewer Improvements
- Brandon Road Pump Station Upgrades and 42-inch Force Main
- Big Sioux River Siphon Improvements
- Basin 17 Trunk Sewer

5.4 Flow and Rainfall Monitoring Program

The City conducts a flow and rainfall monitoring program annually to collect dry- and wet-weather flow data to characterize base flows and wet-weather responses throughout the collection system. The flow data is collected using Hach FloDar flow monitor units owned and operated by City. Each Flo-Dar unit measures open channel flow based on pulsed doppler profiling sensors for flow depth and velocity combined with the pipe diameter and slope to calculate flow. Depth and velocity data is sent from the sensors to the base monitor unit through a communication cable. The monitor records the depth, velocity, and calculated flow data on a 15-min interval and downloaded periodically by City staff using a laptop computer. The monitor units are powered by battery and occasionally lose data due to equipment malfunction, sensor fouling, or power loss. These flow monitors are generally accepted to have a ±10 percent flow accuracy. The flow data provided was reviewed to select the most representative days for use in developing the dry- and wet-weather flow parameters from the data through use of the RDII Analyst extension to InfoSWMM.

Sioux Falls staff is responsible for installation, maintenance and calibration of the flow monitoring equipment. Therefore, the accuracy of the flow monitor data depended on the calibration of the equipment during the periods of flow data used during this study; however, for the most part, the data appeared to be suitable for model development and calibration. Typically, this data is used by the City to prioritize infiltration and inflow reduction within targeted areas of the collection system. Data in fifteen minute increments from this program was provided by the City at twenty-one permanent and temporary sanitary sewer flow monitors for use in updating and calibrating the hydraulic model for the period from January 2013 to December 2015. In addition, flow data recorded at 20 permanent meters at lift stations and the WRF was provided. The flow meters at the equalization basin were not considered reliable enough by the City to use in this study.

The data from the City's flow monitoring program was used to fully define the following flow components, as depicted in Figure 5.3, for each metered basin:

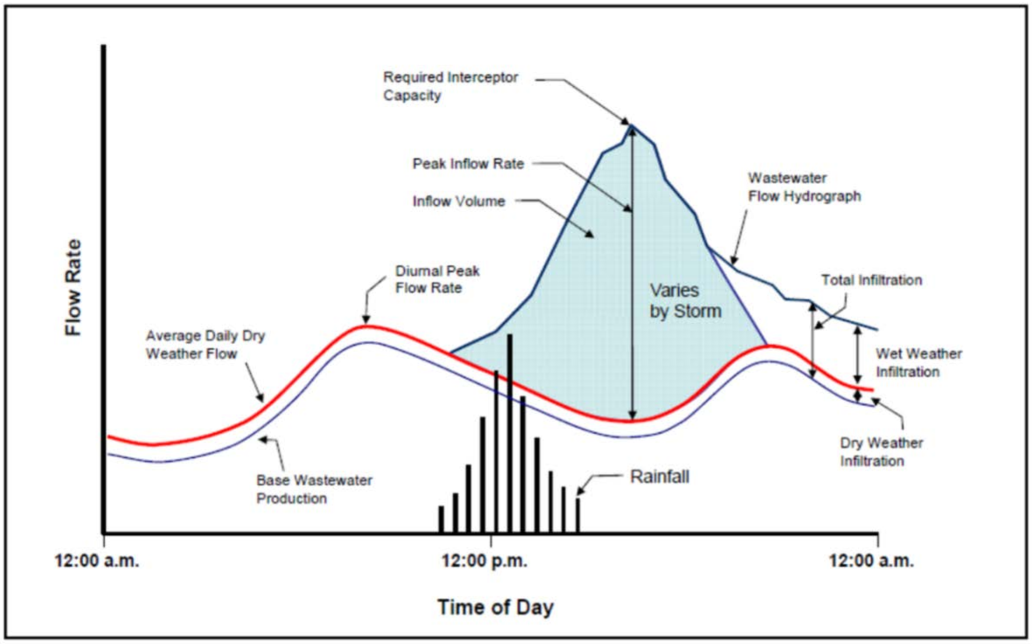
- Base Wastewater Production (BWP) – December 2014 to February 2015
- Dry-Weather (Groundwater) Infiltration (DWI) - December 2014 to February 2015
- Rainfall Derived Infiltration and Inflow (RDII) - June 14, 2014 to June 18, 2014

Hach FloDar Flow Monitoring Equipment similar to that used by City and applied to this Study

Twenty-one flow monitors along with the associated flow monitoring basins, labeled in red, are shown on Figure 5.4, and listed in Table 5.3. The flow monitors record flow in the pipes upstream of the designated manhole. These flow monitors are generally located to correspond to the outlets of the City's sanitary sewer basins (defined with the bold black outlines and labels on Figure 5.4. Several of the flow monitors represent flow from several sanitary sewer basins and similarly several of the flow monitors split one sanitary sewer basin. The sanitary sewer basins were combined or separated as needed to match up with corresponding flow monitors and resulted in the flow monitoring basins mapped in Figure 5.4.

There area several areas within the City that were not served by a flow monitor during the time frame used to evaluate average and peak flows for 2016 WTCSMP. Some of these areas are significant and include the Western Interceptor, the airport, the majority of the Eastside Sanitary Sewer (ESSS), and Basin 17. These basins without flow monitoring data were assigned flow characteristics, including dry-weather diurnal patterns and infiltration and wet-weather responses, from basins of similar proximity, land use, and sewer collection system age. To development flow allocations for areas both with and without flow monitoring data, flow allocation basins were developed. These flow allocation basins are mapped in Figure 5.5.

Figure 5.3 Typical Collection System Flow Components



The existing conditions breakdown of land use identified in each flow allocation basin is summarized in Table 5.4. Figure 5.6 schematically illustrates Sioux Fall's sanitary sewer collection system comprised of flow monitors, metered trunk lines, rain gauges, lift stations, and major diversion structures. This schematic represents the flow balance performed to establish contributing flow from each flow monitoring basin and allows for characterization of basin-by-basin BSF, DWI and RDII.

Table 5.3 Collection System Flow Monitors Applied to WTCSMP

Flow Monitor	Location	Manhole ID	Sewer Size (inches)
FM_01A0001	Basin 1, Brandon Rd Pump Station	01A0001	15
FM_02AA004	Archery Range Front Gate	02AA004	18
FM_03C0003	Sioux Nation back lot, Cliff	03C0003	36
FM_04A0004	Central Main, N Falls Park	04A0004	48
FM_04AD001	Downtown, Falls Park	04AD001	37
FM_05A0002	Central Main, Cherry Rock Park	05A0002	60
FM_05D0010	Southwestern Ave.	05D0010	24
FM_06A0004	SRSI Tuthill PS, upstream	06A0004	54
FM_06CA001	Tomar Park	06CA001	15
FM_06DA006	3324 S Duluth Ave	06DA006	24
FM_06HA004	5108 S Swift Park Dr	06HA004	15
FM_06J0020	Black Rock Cir & Western	06J0020	18
FM_07A0014	43rd Street, E of West Port	07A0014	36
FM_07J0003	Silver Valley Trunk	07J0003	24
FM_07R0005	Westview Channel	07R0005	21
FM_07S0001	4501 W Hornefield Dr.	07S0001	30
FM_09A0005	Basin 9, North Dr. & Elm St	09A0005	24
FM_11E0016	SRNI, Edmonds Ave	11E0016	42
FM_13F0001A	PS 215, Incoming North Line	13F0001A	42
FM_14A0001	W 12th St & Skunk Creek	14A0001	24
FM_15A0001	12th St. & Sertoma, Legacy Park	15A0001	18
FM_26C0002	Basin 26, 57th St. and Dubuque	26C0002	21

Source: City of Sioux Falls GIS

Figure 5.4 Flow Monitoring Basins

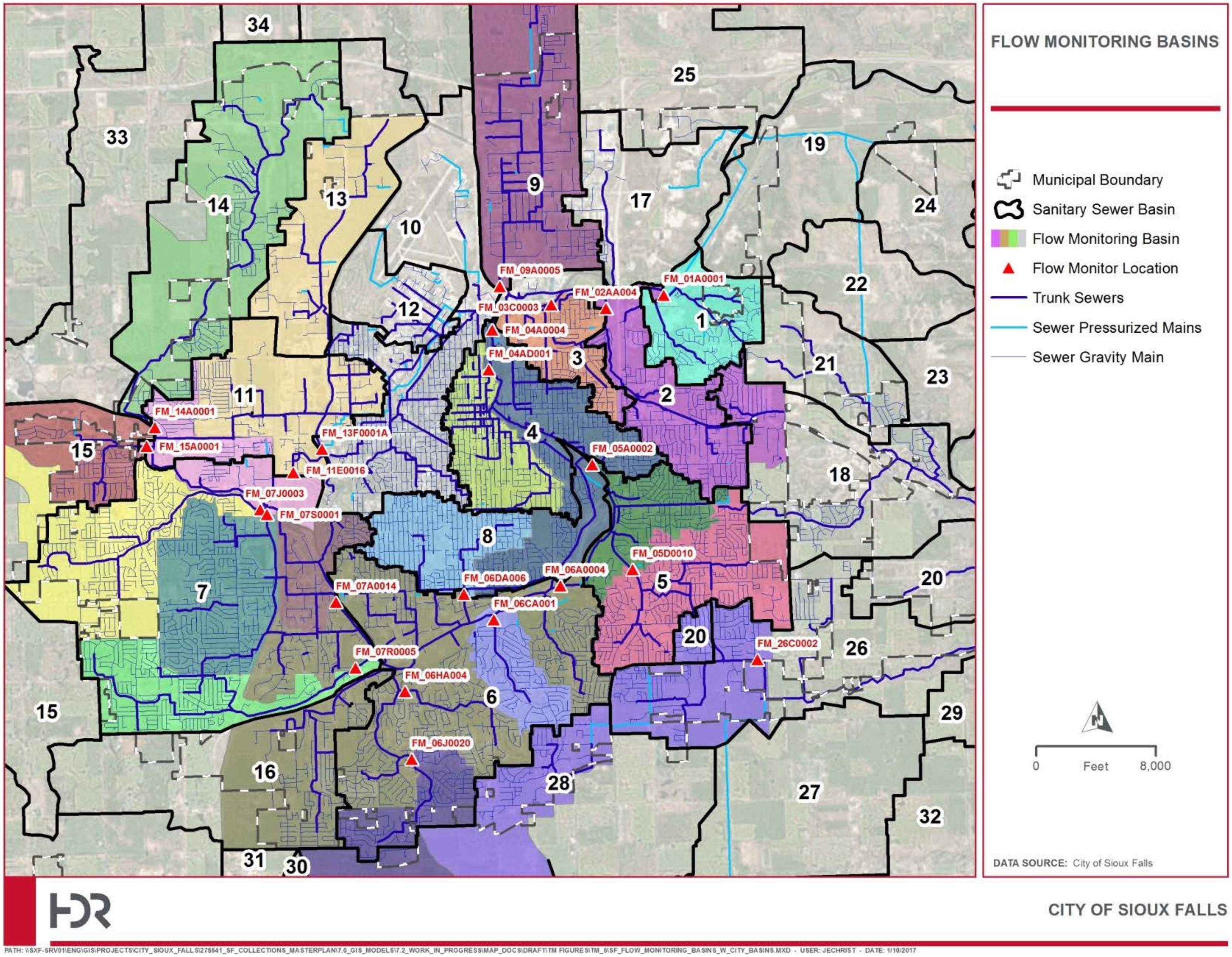


Figure 5.5 Flow Allocation Basins Used for Diurnal, DWI, and RDII Assignment

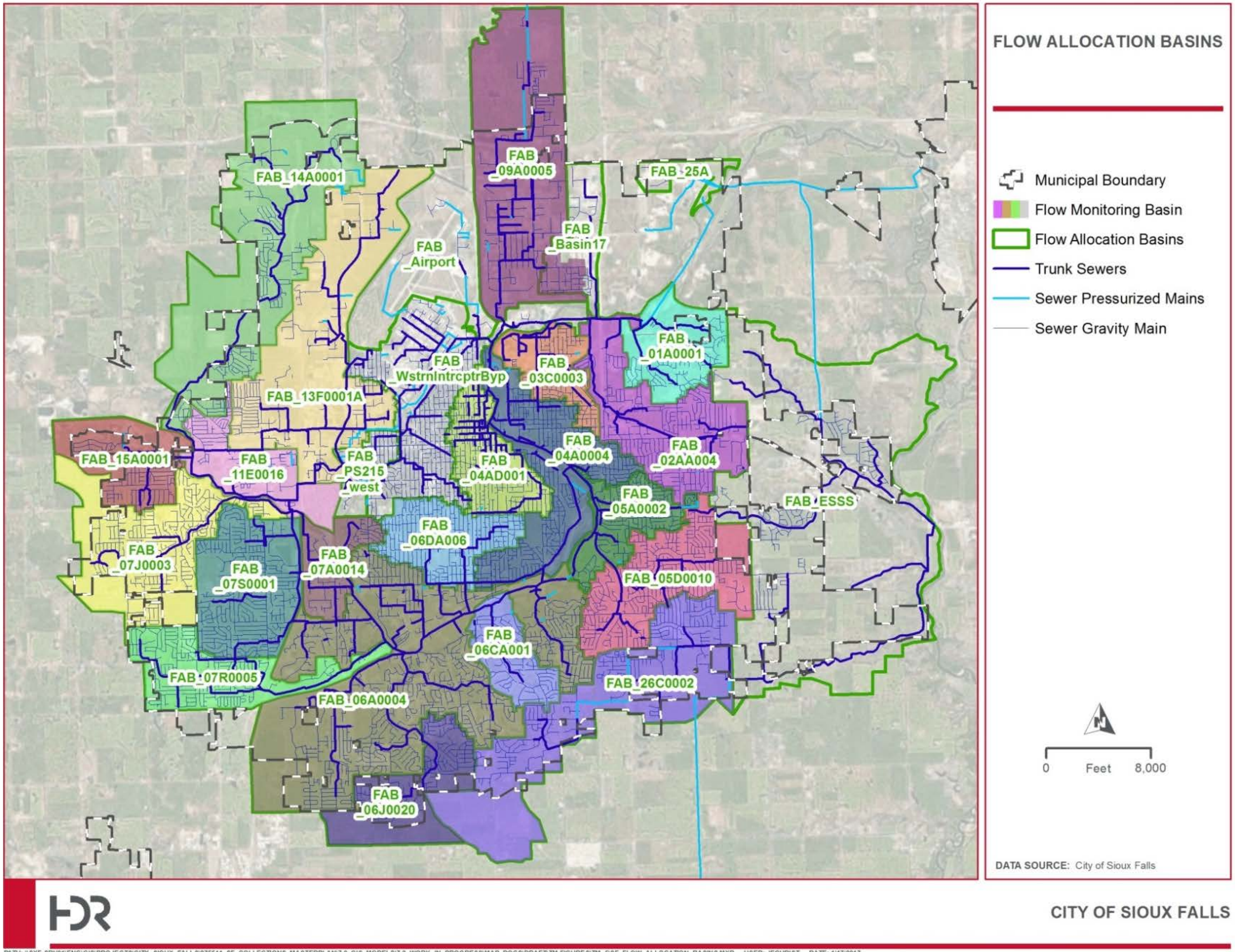


Table 5.4 Flow Allocation Assignments and Existing Land Use Composition

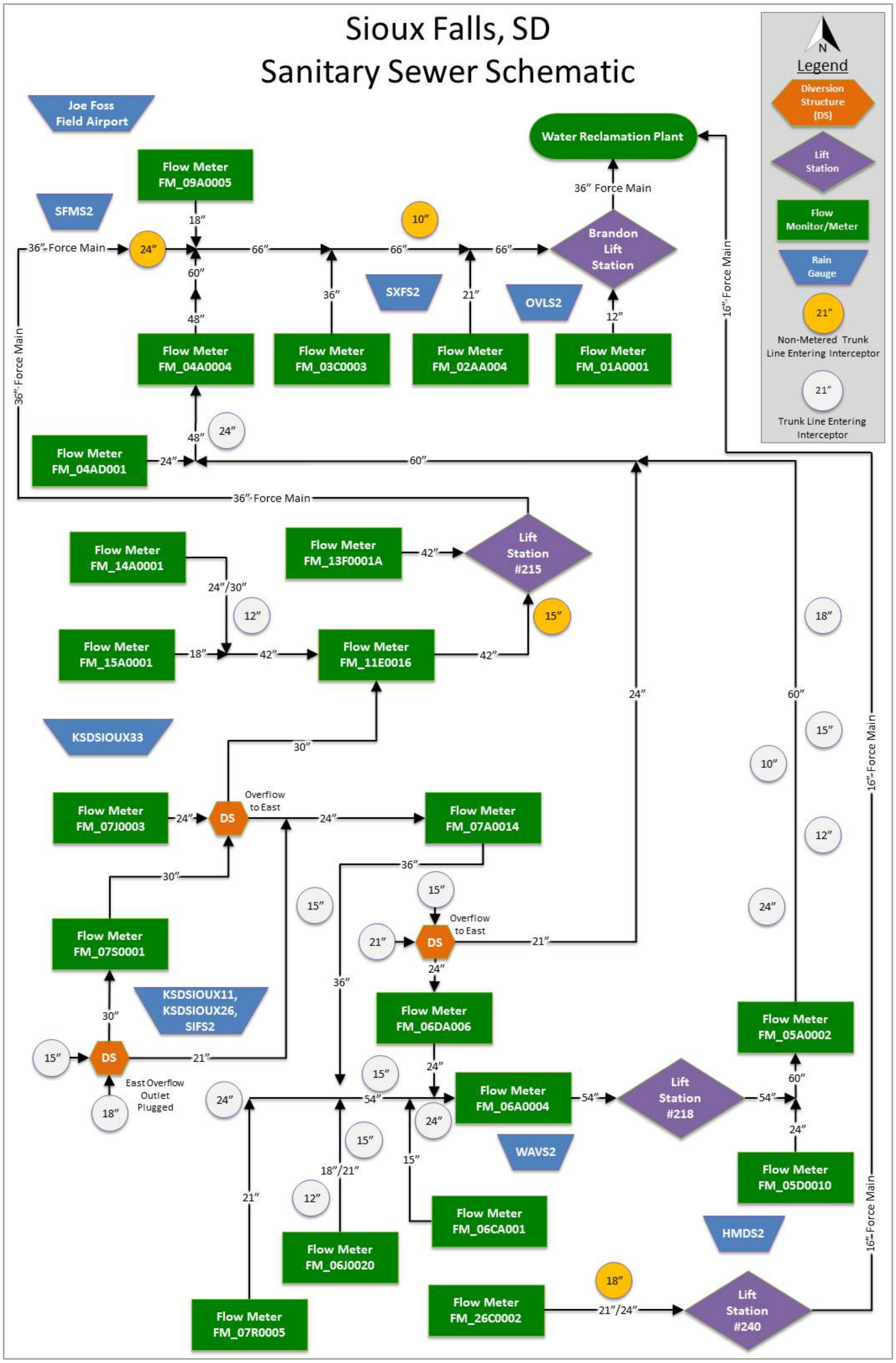
Flow Allocation Basin	Associated Flow Monitor Basin for Diurnal, DWI, and RDII Assignment	Commercial	Industrial	Institutions/ Education / Public Assembly	Office and Public Service	Open Spaces-Agriculture	Open Spaces-Recreation and Natural Resources	Residential	Roads, Rail, Right-of-Way, Parking Lots
FAB_01A0001	FM_01A0001	3%	-	5%	2%	4%	14%	71%	0%
FAB_02AA004	FM_04AD001	8%	8%	13%	12%	3%	4%	47%	5%
FAB_03C0003	FM_03C0003	1%	-	6%	1%	6%	19%	66%	0%
FAB_04A0004	FM_04A0004	7%	5%	7%	3%	3%	27%	48%	1%
FAB_04AD001	FM_04AD001	4%	6%	1%	3%	66%	6%	13%	0%
FAB_05A0002	FM_05A0002	7%	2%	5%	8%	20%	17%	40%	1%
FAB_05D0010	FM_05D0010	7%	0%	2%	1%	0%	59%	31%	0%
FAB_06A0004	FM_06A0004	54%	1%	0%	1%	2%	25%	16%	0%
FAB_06CA001	FM_06CA001	0%	0%	2%	3%	4%	27%	64%	0%
FAB_06DA006	FM_06DA006	17%	35%	1%	9%	18%	9%	11%	1%
FAB_06J0020	FM_06J0020	8%	0%	23%	2%	1%	3%	63%	0%
FAB_07A0014	FM_07A0014	12%	4%	4%	2%	14%	14%	50%	0%
FAB_07J0003	FM_07J0003	2%	0%	9%	1%	20%	10%	58%	0%
FAB_07R0005	FM_07R0005	4%	-	10%	2%	10%	9%	65%	0%
FAB_07S0001	FM_07S0001	2%	1%	2%	3%	16%	12%	64%	-
FAB_09A0005	FM_09A0005	0%	29%	8%	4%	20%	4%	33%	2%
FAB_11E0016	FM_11E0016	5%	23%	10%	7%	7%	12%	35%	1%
FAB_13F0001A	FM_13F0001A	0%	0%	5%	1%	56%	9%	29%	1%
FAB_14A0001	FM_13F0001A	3%	30%	-	28%	13%	3%	23%	1%
FAB_15A0001	FM_15A0001	0%		2%	0%	84%	7%	6%	0%
FAB_25A	FM_09A0005	1%	28%	-		71%	-	-	-
FAB_26C0002	FM_26C0002	-	-	11%	1%	23%	11%	52%	2%

Table 5.4 Flow Allocation Assignments and Existing Land Use Composition

Flow Allocation Basin	Associated Flow Monitor Basin for Diurnal, DWI, and RDII Assignment	Commercial	Industrial	Institutions/ Education / Public Assembly	Office and Public Service	Open Spaces-Agriculture	Open Spaces-Recreation and Natural Resources	Residential	Roads, Rail, Right-of-Way, Parking Lots
FAB_Airport	FM_13F0001A	-	67%	-	3%	6%	23%	0%	1%
FAB_Basin17	FM_01A0001	7%	6%	-	0%	6%	36%	44%	1%
FAB_ESSS	ESSS	6%	21%	3%	1%	16%	7%	44%	3%
FAB_PS215_west	FM_04AD001	-	12%	0%	0%	33%	12%	44%	-
FAB_WstrnIntrcptrByp	FM_04AD001	7%	30%	12%	2%	31%	6%	10%	1%

Note: 0% indicates that less than 0.5 percent of that land use is contained within that flow allocation basin and a '-' indicates an absence of that land use within that flow allocation basin

Figure 5.6 Sioux Falls Sanitary Sewer Schematic



Rainfall data sources from National Oceanic and Atmospheric Administration (NOAA)'s covering two significant historical storm events, June 14-18, 2014 and August 27-28, 2015, were accessed by HDR for use during the study from:

- National Climatic Data Center (NCDC) from three rain gauges in the vicinity of Sioux Falls
- Historical Hydrometeorologic Automated Data System (HADS) from eight rain gauges in the vicinity of Sioux Falls
- Next Generation Radar (NEXTRAD) Level III from Aberdeen, SD

5.5 Existing Conditions Load Allocation

Dry and wet-weather flows were loaded into the hydraulic model based on winter water consumption, flow monitor, significant industrial users, and other data provided by the City. A spatial allocation approach was used based on water meter points, flow monitoring locations and the sewer basins. Generating the sewer flow components and allocating them spatially to the sewer model network is a key step to prepare the hydraulic model for calibration.

This section discusses the development and allocation of existing conditions dry- and wet-weather model loads including BWP, DWI, and RDII.

5.5.1 Dry-Weather

Dry-weather flow represents the flow in the sanitary sewer system outside of the influence of individual rainfall events. Average daily dry-weather flow (ADWF) is the flow that it is in a sanitary sewer system on a normal dry day and represents the daily loading to the WRF averaged over a year. ADWF is comprised of BWP and DWI. This section documents the development and model allocation of BWP and DWI loads.

BWP is the sanitary loading mostly from homes and businesses and DWI is mostly groundwater that seeps into a collection system through defective pipes, pipe joints, and manhole structures. BWP can be based on ADDF during low ground water conditions or winter water consumption. For the purposes of this study, the basis for BWP allocation is winter water meter use for reasons mentioned in the next section. The rate of DWI depends on the presence of groundwater, depth of groundwater above the defects, the size of the defects, and the percentage of the collection system that is submerged. Variation in groundwater levels and the associated infiltration is both seasonal and weather dependent. Low groundwater and dry-weather infiltration is infiltration that occurs year-round is defined as DWI. The high ground and wet-weather infiltration is the additional infiltration that occurs following storm events that is included in the RDII allocation.

ADWF is the expected wastewater flow on a day with no precipitation events and no residual influence of previous precipitation events. Rainfall data collected from the Joe Foss Field (Airport) location was used to process the flow monitoring data for developing timeframes for ADWF conditions within the collection system. ADWF can vary seasonally as groundwater levels change and cause fluctuations in the DWI. Daily fluctuations in ADWF are mostly attributed to variations in BWP, such as domestic, industrial, and commercial wastewater contributions and how these contributions vary throughout a day and from customer to customer, but is generally highest system-wide between 7 and 11am. These daily fluctuations in wastewater flows are represented by diurnal patterns, which are discussed later in this section.

Base Wastewater Production

Existing potable water consumption data from winter periods, significant industrial user (SIU) data, and regional customer information were used to allocate 2015 BWP to the model. Using winter water meter data for BWP generation is generally accepted within the industry for its increased data accuracy, spatial detail, and reliability over other methods, such as TAZ polygons or land use-based allocations.

Winter Water Meter Data

Winter water meter data is characteristically equal to BWP because outdoor water use is minimal and the majority of potable water use is discharged to the sanitary sewer system. During the winter there is also limited infiltration due to the absence of increased groundwater levels from irrigation ditches and high stream flows. The City provided monthly potable water meter data and the spatial location of these meters. This water meter data was filtered to remove duplicate monthly values and further filtered to the months of December, January, and February. The flow data from December 2015 through February of 2016 was wetter than normal and was not considered to be a true representation of dry-weather flows. Because of this, the potable water use records from December 1, 2014 through February 28, 2015 are considered a more accurate spatial representation of existing BWP contributions to use for this current 2016 WTCSMP.

Monthly metered water use volumes were converted to a monthly average rate of consumption. The monthly flow rates, converted to gallons per minute (gpm), were averaged over the three months for each meter. Some meters used in the analysis did not have records for each of the three months, and this was accounted for by including only the months with data in the average. Reasons there may be winter months without water use consumption include unoccupied rentals, offices or dwellings, extended vacation, and residents who migrate south for the winter (snowbirds). The non-calibrated, unadjusted total flows resulting from this analysis are presented in Section 5.6.1 with the required calibration adjustments to represent DWF along with DWI.

BWP Allocation

This section describes the process of how BWP loads were allocated spatially to the model. The City's sanitary sewer basins and subbasins were used as the starting point for both the dry- and wet-weather flow components and were not altered from the City's 2016 GIS file. For BWP allocation, the sanitary sewer basins and subbasins serve as spatial boundaries for analysis.

The water meter data was joined to the GIS water meter spatial locations. Thiessen polygons for the modeled manholes were generated within each of the adjusted sanitary sewer basins and subbasins and joined spatially to the GIS meter locations. The calculated monthly water meter data flow rates, representing BWP, were summed within each Thiessen polygon for each modeled manhole (the majority of Thiessen polygons contain multiple water meters) and assigned as BWP to that respective modeled manhole (first row in the model under dry-weather loading). If a Thiessen polygon for a model node did not contain a water meter, then that model node was not assigned a BWP load. Figure 5.7 illustrates an example of this BWP load allocation using Thiessen polygons.

The allocation method assumes a return to sewer ratio (ratio of the amount of water use to the amount of sewage returned to the collection system) of 100 percent. These values are adjusted based on calibration, which is described in Section 5.6.1 under dry-weather calibration.

Significant Industrial Users

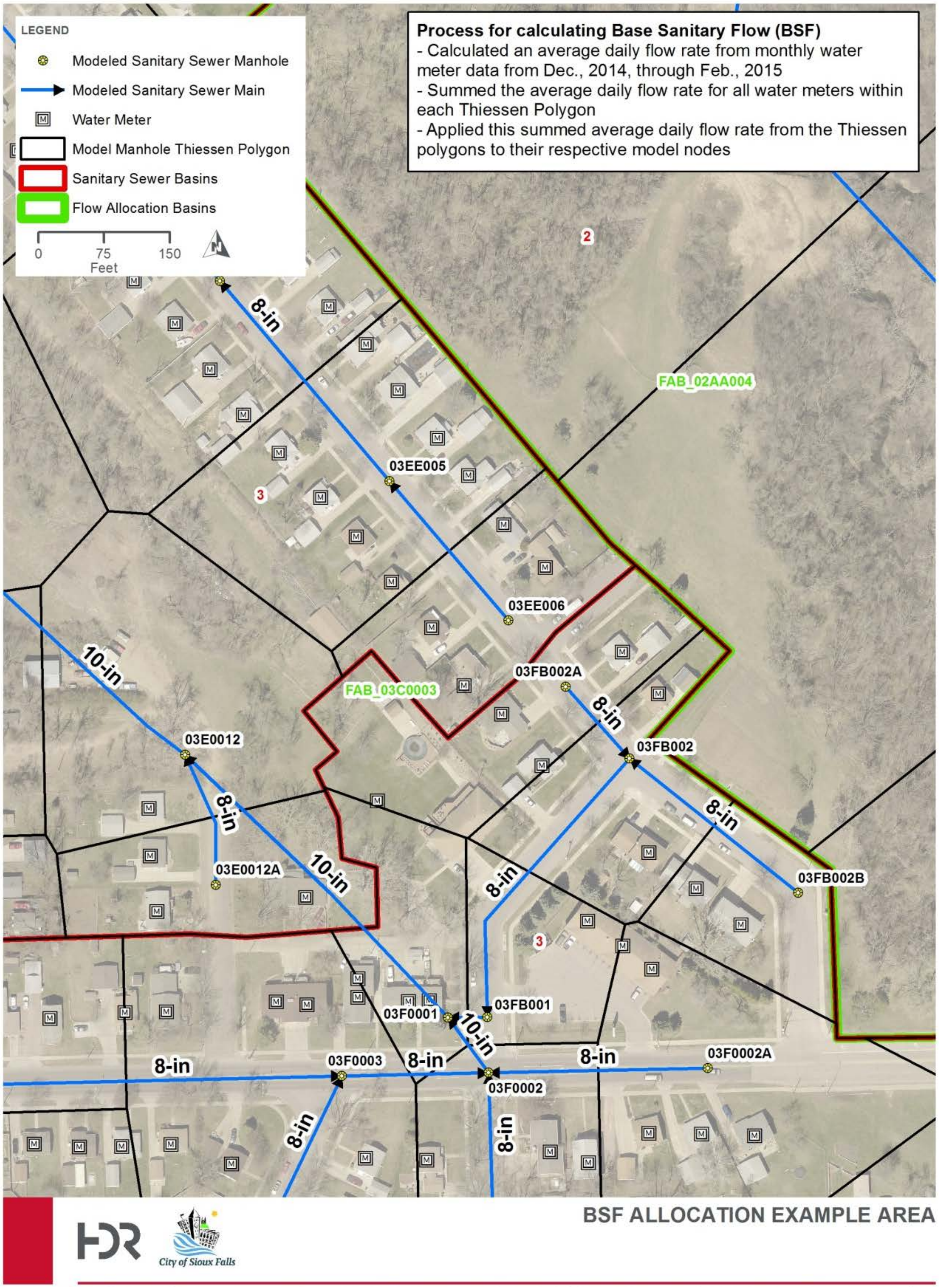
Significant industrial users (SIU) are owners who contribute high sanitary loadings and are accounted for independently in the sanitary flow allocation. For this current 2016 WTCSMP, SIUs are contained within the water meter data. The identified SIUs are presented in Table 5.5. An SIU of note is the John Morrell and Company meat packing, who currently treats their own sewage but has a permit to discharge into the City's collection system. The John Morrell flows are removed from the existing conditions and calibration scenarios but are included in the future flow scenarios.

Table 5.5 Significant Industrial Users

SIU	Model Manhole	Flow Rate (gpm)	Comment
Concrete Materials	13BD006D, 13BF005, 13F0021	17.5	Contained in water meter data.
John Morrell & Co.	03B0012	-1,551 (Subtracted as it is not discharged to sewer.)	They treat their own sewage but are allowed to discharge. For calibration, this value needs to be removed from analysis. For planning, this value needs to be included under future condition scenarios. The industrial discharge permit allows for 400,000 gpd which is added as a point load for future scenarios.
ADP	14CH014	34.8	Contained in water meter data.

Source: City of Sioux Falls, water meter billing records

Figure 5.7 BWP Allocation Example Using Thiessen Polygons



Regional Customers and Sanitary Districts

Sioux Falls currently has one regional customer, the City of Harrisburg, and two sanitary districts, Renner and Prairie Meadows, contributing flow to the collection system. These BWP loads were added as point flows to the model (second row in the model under dry-weather loading) and are summarized in Table 5.6. Included in this table are the diurnal patterns given to these point flow loads. Calibrated diurnal patterns are contained in Appendix 5B.

Table 5.6 Regional Customers and Sanitary Districts Contributing to the Collection System.

Customer	Type	Model Manhole	Flow Rate (gpm)	Diurnal Pattern
City of Harrisburg	Regional Customer	HARRISBURG	340	Constant flow rate since it is equalized to an average daily flow
Prairie Meadows	Sanitary District	07LB003	13.9	Calibrated pattern associated with the downstream flow monitoring basin FM_07J0003
Renner	Sanitary District	09GB003	34.7	Calibrated pattern associated with the downstream flow monitoring basin FM_05A0002

Source: City of Sioux Falls, 2016

Diurnal Patterns

A diurnal pattern, or cycle, is a pattern that occurs daily. For sanitary sewer flows, this is the daily pattern of sanitary flow with peak sanitary flows occurring at different times during the day depending upon land use. This daily pattern typically varies between weekday and weekend flow. Instead of using peaking factors typically associated with steady state flow analysis, diurnal patterns are used to more dynamically assess the system hydraulics across the simulation timeframe. Using diurnal patterns allows for capturing flow contribution change across a 24-hour time period for both weekdays and weekends and provides unique peaking characteristics that simulate actual flow contribution. These patterns generally have two peaks, the first peak occurring in the morning hours and the second in the evening.

For this analysis, weekday and weekend diurnal patterns were developed from the flow monitoring data from December 1, 2014 through February 28, 2015 averaged across weekdays and weekends. Normalized diurnal patterns are developed within each flow monitoring basin from these winter averages using the InfoSWMM extension RDII Analyst and assigned to the corresponding loads for each manhole within the basin. Diurnal patterns are not assigned to non-sewered areas since these areas will have zero flow contribution. For portions of the collection system not within a flow monitoring basin, diurnal patterns were assigned based on an adjacent flow monitoring basin with similar characteristics.

For the current modeling effort, a total of 38 separate diurnal patterns were developed and applied, two (weekday and weekend) for each of the 19 flow monitoring basins. The range of daily dry-weather peaking factors ranged from 1.4 to 2.8 and 1.4 to 2.2 across the weekday and weekend diurnals, respectively. The system-wide average daily peaking factor is 1.8 and 1.7 for weekdays and weekends, respectively. These diurnals were then calibrated for peak flows and timing (shape) as described in the Section 5.6.1., dry-weather calibration. As model inputs, these diurnal patterns dynamically generate the daily flows for average BWP loads in the model. Appendix 5-B contains the calibrated diurnal patterns for each of the flow monitoring basins.

Dry-Weather Infiltration

DWI was assigned to the model based on the flow monitoring data from December 1, 2014 through February 28, 2015 and averaged separately for both weekdays and weekends. BWP plus DWI corresponds to the ADWF red line on Figure 5.3.

DWI was allocated to the sanitary collection system by taking the sum of total DWI based on Stevens-Schutzbach method for each flow monitor basin and applying it to the manholes by weighting them based on the sewer main diameters times their lengths of the immediately upstream connecting pipes. For portions of the collection system not contained within a flow monitor basin, DWI characteristics were assigned based on an adjacent flow monitoring basin with similar characteristics.

The Stevens-Schutzbach method using the following equations to estimate DWI uses the following equation:

Equation 5-2

$$\boldsymbol{DWI = \frac{0.4\,(MDF)}{1-0.6\,(\frac{MDF}{ADF})\hat{}\,ADF^{0.7}}}$$

where:

DWI = dry-weather infiltration

MDF = maximum daily flow

ADF = average daily flow

Figure 5.8 incrementally illustrates the percent DWI for each basin by color.

Dry-Weather Flow Summary

ADWF and DWI is based on the dry-weather average flow summary, from December 1, 2014 through February 28, 2015, and is presented in Table 5.7 corresponding with a total WRF flow of 14.2 mgd. Flows were accounted for so that City-only dry-weather flows of 13.7 mgd were used in the calculations to represent only the ADWF and DWI from monitored flow areas and ESSS. Dry-weather flow monitor basin metrics are summarized in Table 5.8 with the following features:

- Flow Monitor ID – Basin and Manhole
- Basin Area
- Basin Population (2013)
- Predominate Land Use Type
- Winter Water Meter Use (2014/2015)
- Uncalibrated Base Wastewater Production (same as winter water use)

- Average ADWF (as recorded at the flow monitor)
- Average ADWF Gain (upstream flow monitor flow contributions removed when applicable)
- ADWF per Acre and Capita

Figure 5.8 Flow Monitoring Basins – Percent Dry-Weather Groundwater Infiltration

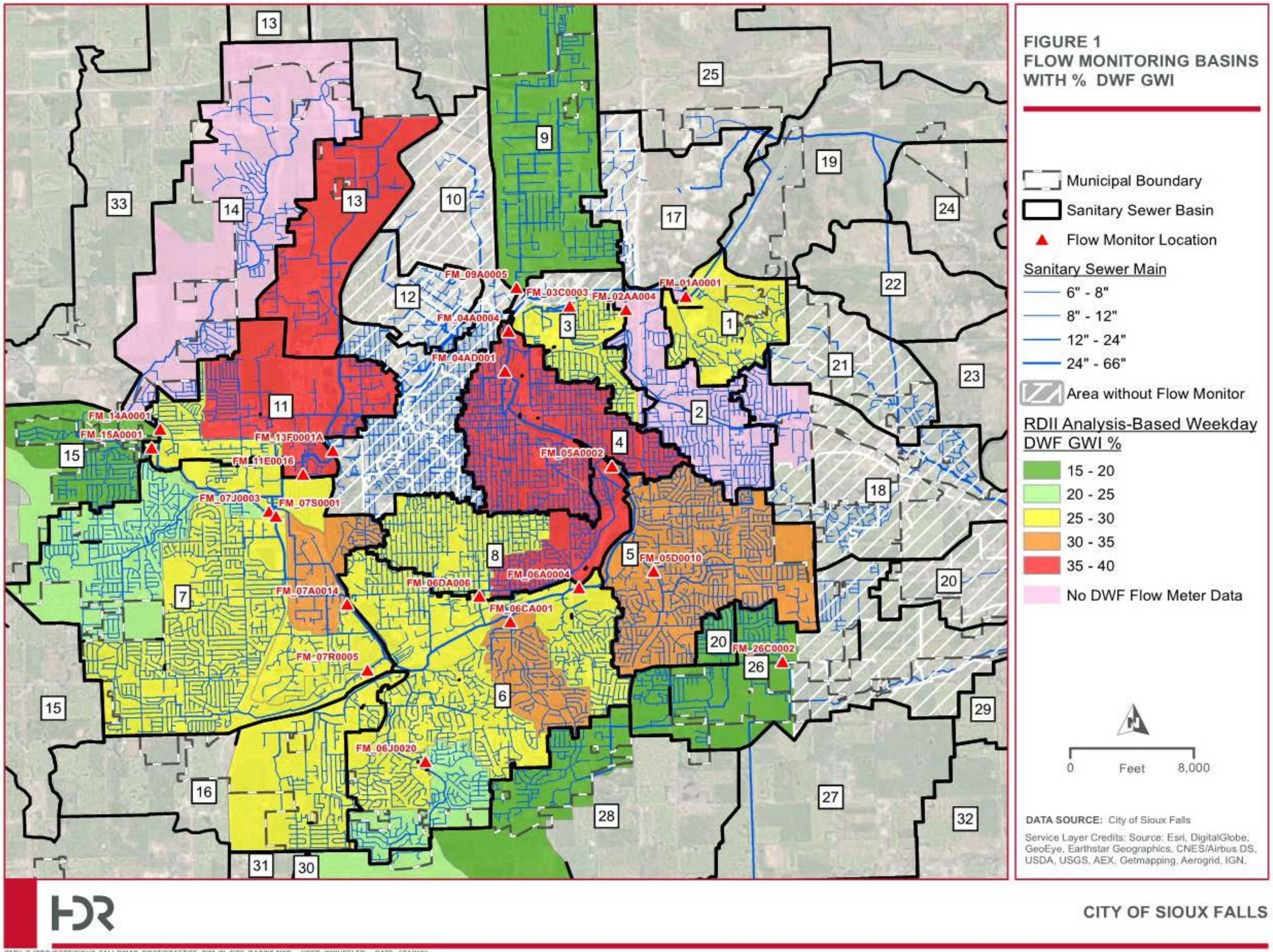


Table 5.7 Existing Condition Dry-Weather Flow Totals

WRF (mgd)	Harrisburg (mgd)	Renner (mgd)	Prairie Meadows (mgd)	Brandon (mgd)	Adjusted Total City Flow to the WRF (mgd)
14.22	0.74	0.05	0.02	1.06	13.65

Table 5.8 Uncalibrated Dry-Weather Flow Monitor Basin Metrics (Winter of 2014/2015)

Flow Meter and Flow Monitoring Basin ID	Basin Acre (acre)	Basin Pop. (2013)	Predominate Land Use Type(s)	Winter (Dec. 2014 – Feb. 2015) Water Meter Consumption (gpm)	Uncalibrated Wastewater Production (gpm)	Average monitored ADWF (gpm)	Average monitored ADWF Gain (gpm)	Average ADWF per Acre (gpd/acre)	Average DWF per capita (gpd/cap)	Uncalibrated DWI Estimate (ADWF – Wastewater Production) (gpm)	Uncalibrated DWI Estimate (Stevens-Schutzbach DWI Calculation) (gpm)
FM_01A0001	1,114	3,030	Residential	104	104	128	128	165	61	24	19
FM_02AA004	2,032	11,539	Residential	506	506	--	--	--	--	--	--
FM_03C003	810	3,858	Residential	165*	165	137	137	137	244	-28	23
FM_04A004	2102	11,070	Residential/ Commercial	472	472	4,110	821	821	562	349	138
FM_04AD001	1079	8,378	Residential	625	638	443	443	443	592	-181	72
FM_05A0002	949	6,168	Residential/ Commercial	298	298	2,846	398	398	605	100	55
FM_05D0010	1,956	10,668	Residential	423	423	471	471	471	347	49	78
FM_06A0004	6,252	19,560	Residential/ Commercial	1,086	1,086	1,997	827	827	190	-259	103
FM_06CA001	781	2,894	Residential	127	127	137	137	137	252	9	24
FM_06DA006	1,124	7,088	Residential	369	369	467	467	467	599	98	59
FM_06J0020	1,380	2,742	Residential	101	101	64	64	64	67	-37	8

Table 5.8 Uncalibrated Dry-Weather Flow Monitor Basin Metrics (Winter of 2014/2015)

Flow Meter and Flow Monitoring Basin ID	Basin Acre (acre)	Basin Pop. (2013)	Predominate Land Use Type(s)	Winter (Dec. 2014 – Feb. 2015) Water Meter Consumption (gpm)	Uncalibrated Wastewater Production (gpm)	Average monitored ADWF (gpm)	Average monitored ADWF Gain (gpm)	Average ADWF per Acre (gpd/acre)	Average DWF per capita (gpd/cap)	Uncalibrated DWI Estimate (ADWF – Wastewater Production) (gpm)	Uncalibrated DWI Estimate (Stevens-Schutzbach DWI Calculation) (gpm)
FM_07A0014	739	1,250	Commercial	224	224	260	260	260	506	35	50
FM_07J0003	2,379	9,207	Residential	340	340	394	394	394	239	55	44
FM_07R0005	1,426	8,543	Residential	304	304	221	221	221	224	-83	31
FM_07S0001	1,851	12,116	Residential	545	545	422	422	422	328	-123	51
FM_09A0005	3,606	2,988	Industrial	204	204	182	182	182	73	-20	16
FM_11E0016	1,122	5,588	Residential	287	287	1,100	248	248	318	-39	32
FM_13F0001A	3,718	3,616	Agriculture/ Transition	355	355	390	390	390	151	35	70
FM_14A0001	4,219	4,514	Agriculture/ Transition	204	204	--	--	--	--	--	--
FM_15A0001	1,173	2,664	Residential	92	92	37	37	37	45	-57	4
FM_26C0002	3,408	6,655	Agriculture/ Transition	232	232	128	128	128	54	-106	10

* Value has John Morrell flows removed

5.5.2 Wet-Weather

This section discusses the development of existing conditions rainfall and sanitary sewer wet-weather response for allocation to the model. RDII is infiltration and inflow that is caused by storm events from due to elevated groundwater levels and water on the ground surface that finds its way into the sewers. Wet-weather infiltration is responsive over longer periods of time as groundwater levels respond to rainfall. Inflow is rain that enters the collection system from sewer laterals, downspouts, foundation drains, sump pumps, yard and area drains, manholes lids including the corbel and chimney, defective piping and even cross-connections with storm drains. Wet-weather inflow is responsive over shorter periods of time as rainfall immediately enters into sanitary sewer system. Although prohibited for any new construction, in older areas of the City, there are locations where downspouts, foundation drains, and sump pumps which are connected to the sanitary sewer system. Customers that had sump pumps and are only allowed to discharge during the wintertime; however, it is suspected that there is a number of customers which discharge during the higher flow periods during the summer as well.

Level of Service and Recurrence Intervals

To assess the capacity of the existing collection system and to develop a target for the design of new and future collection system infrastructure, an evaluation metric must be used to estimate a level of service associated with wet-weather event impacts. For the City, this metric is the 25-year storm event, consistent with the 2002 and 1990 Facilities Plans. A 25-year storm event has a 96 percent chance of not being exceeded in one year, 82 percent in 5 years, 66 percent in 10 years, 44 percent in 20 years, 13 percent in 50 years, and 2 percent in 100 years. This recurrence interval is considered appropriate for sanitary sewer collection system planning with many Midwest communities planning around 5 to 25 year recurrence intervals with 10 years the most common interval.

Since the calibration event is 96 hours (4 days) in duration with two separate rainfall peaks, the analysis for this master plan is also a 96-hour storm with multiple peaks. This specific storm event represents two primary waves of rainfall where the first wave saturates the soils and with those antecedent soil moisture conditions, the second wave causes peak wet-weather responses in the collection system. The 25-year, 96-hour frequency storm event with the calibration rainfall pattern is therefore considered the Evaluation Storm for this master plan and defines the level of service that the City strives to achieve in the collection system.

In addition, the objective is maintaining peak flows below 75 to 80 percent of the sewer main's capacity, particularly for new sewers. Existing sewers in areas that do not impact customer service laterals may be allowed to surcharge for short durations of time but SSOs are not permitted in the sewer system and improvements have been developed for any modeled overflow occurrences.

June 2014 Rainfall

June 2014 saw record rainfall across the upper Midwest, with the City receiving about 13.7 inches of rain in June 2014[1]. This exceeded the old monthly record of 9.42 inches in May 1898 by 45 percent, and the June 1984 record of 8.43 inches by 62 percent. The storm that occurred starting on June

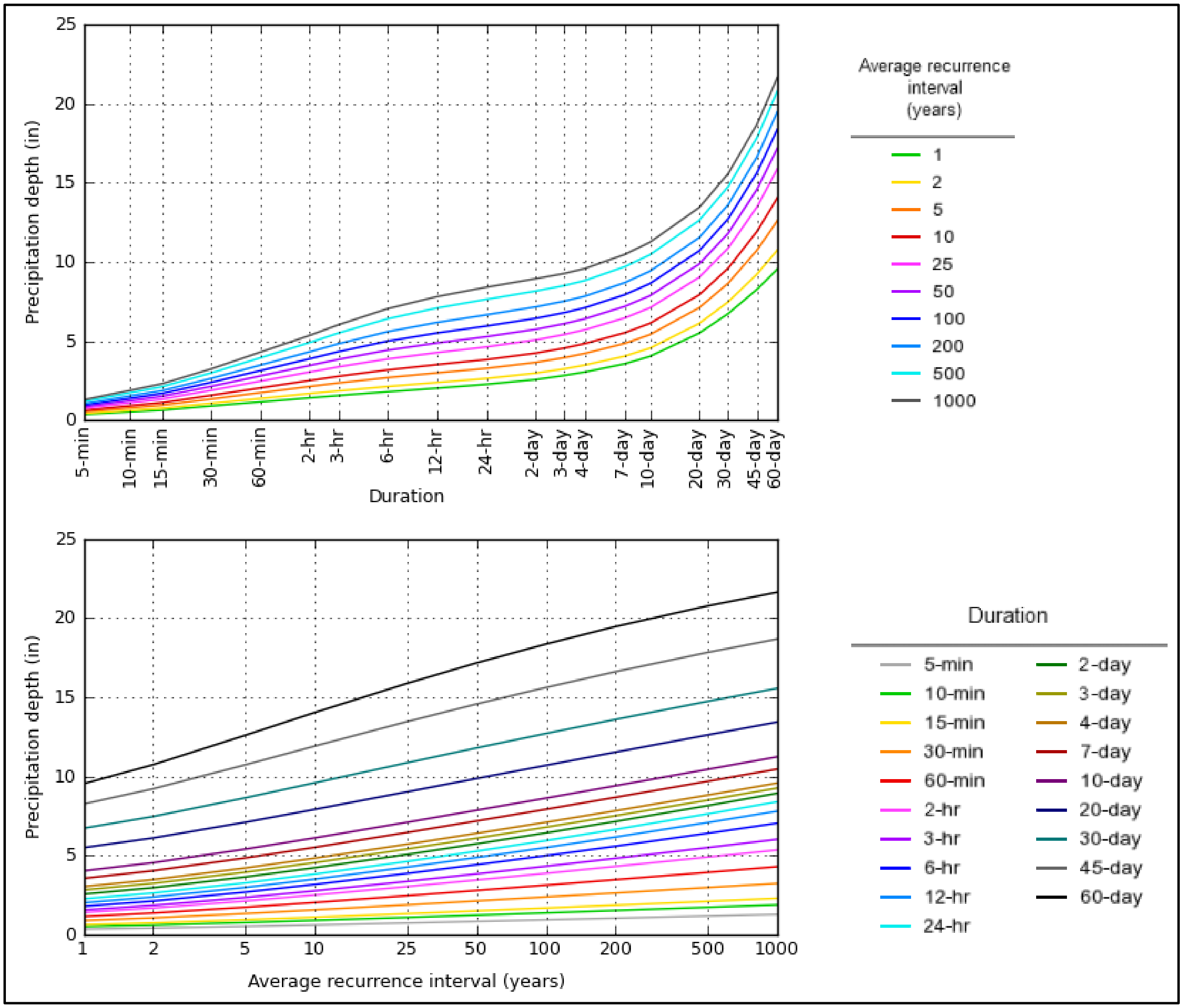
[1] https://weather.com/news/news/extreme-weather-june-tornadoes-record-rain-20140701#/1

14th and ending on June 18th, 2015 produced a minimum of over 5 inches of rainfall depth across the City, with an average total rainfall depth of about 7.2 inches and a maximum depth of over 11 inches in some locations. June 14th and 15th each saw daily rainfall records[2]. Coupled with already saturated soils from previous large events that occurred earlier in that month, this 96-hour storm caused significant flooding and resulted in the governor declaring a state of emergency for the City. Depending on area of the system and the corresponding rainfall observed, June 2014 storm was a 25- to 1000-year plus event.

Based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2 (NOAA, 2013), the 25-year, 4-day rainfall depth is 5.69 inches (refer to Figure 5.9). Despite the large volume of rainfall, high rainfall intensities, and extensive flooding, the City's collection system did not experience any observed SSOs. Because of the relatively uniform rainfall, the large rainfall depths, reoccurrence interval exceeding the 25-year level of service, and the available flow monitoring data, the June 2014 storm was chosen as the calibration event for developing wet-weather flow parameters for the model update and improvement planning.

[2] https://www.wunderground.com/blog/weatherhistorian/record-rainfall-in-sioux-falls-south-dakota

Figure 5.9 Depth-Duration-Frequency (DDF) Curves for Sioux Falls, SD



Source: NOAA Atlas 14, Volume 8, Version 2

June 2014 Rainfall Data Analysis

Gauge-adjusted radar rainfall (GARR) for the storm of June 2014 was used, as shown on Figure 5.12 as the total event rainfall, to calibrate the InfoSWMM model to coincident flow monitoring data. The advantage of using the GARR process is to provide a spatial distribution of rainfall beyond the traditional rain gauge network's discrete points while using their accuracy to calibrate the radar rainfall data. The result is ground rainfall gauge-adjusted radar rainfall coverage across the entire collection system for input into the model. The 1 kilometer blocks are translated into unique temporal rainfall distributions across the system within each flow allocation basin to better represent the spatial variation of the calibration event.

Getting an accurate representation of the spatial distribution, pattern, and total depth of rainfall is a key component in analyzing the sanitary collection system's response to wet-weather. Rainfall patterns and depths were developed for each sanitary sewer subbasin within the City. The gridded rainfall per subbasin was then compiled into area weighted average depths across flow monitor basins in 15 minute time increments. 15 minute time increments were used to correlate to the flow monitor time increments. GARR data was only used for major portions of the storm event. For the days leading up to the event, the days following the event, and a couple of time increments during the event the rain gauge data at the airport was used and assumed consistent across the City.

Figure 5.10 presents the average rainfall depth across the City produced by the June 2014 rainfall event and Figure 5.11 presents the corresponding mass curve. Rainfall depths are produced as 15 minute totals and input into the model. As can be seen from these figures, this storm came in multiple blocks over a 4 day (96-hour) period, with over a day separating the two major waves of the storm. This type of multi-peaked event is common in the City, reflective of flood-producing events, and has a major impact on wet-weather response in the collection system.

Figure 5.10 June 2014 City Average Rainfall Depth in 15 Minute Increments

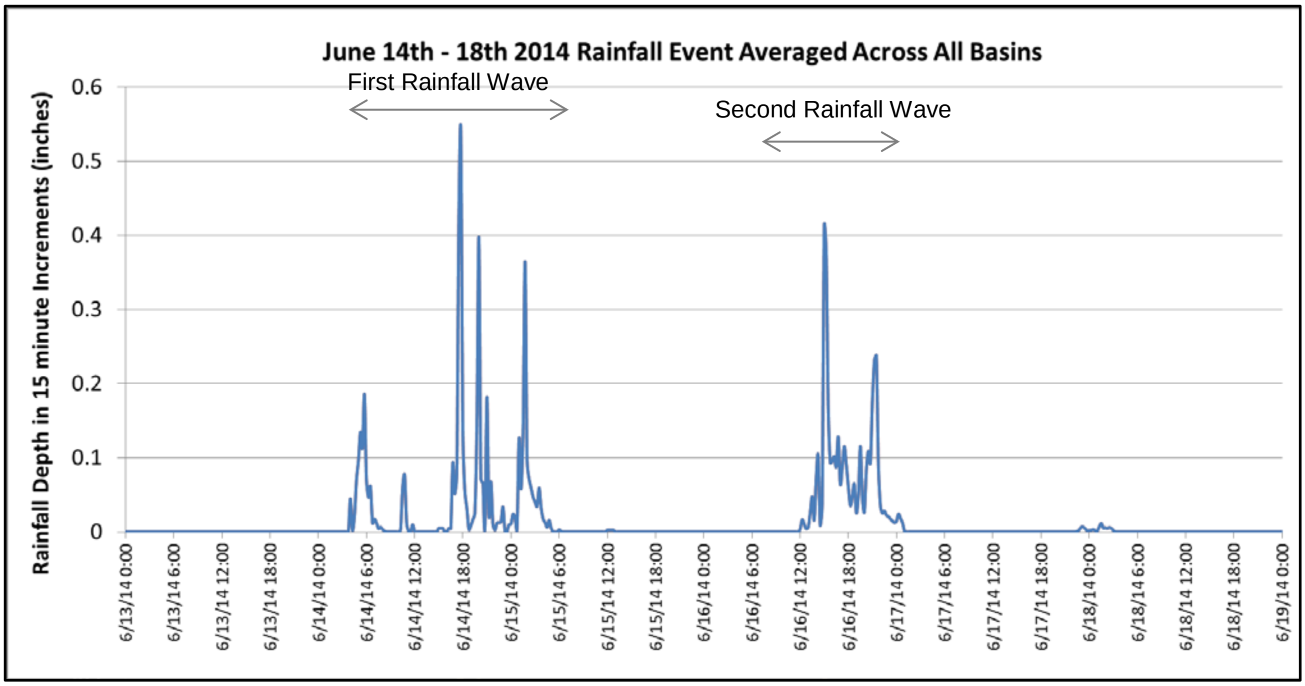


Figure 5.11 June 2014 City Average Rainfall Mass Curve

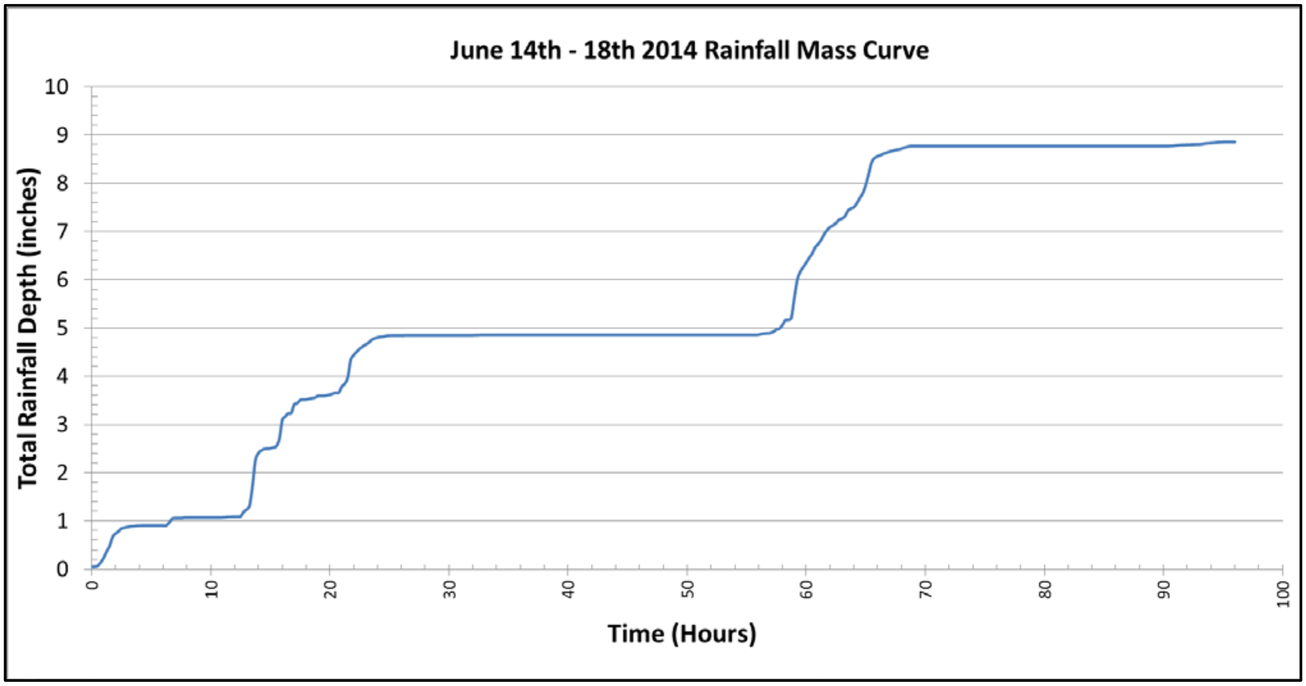
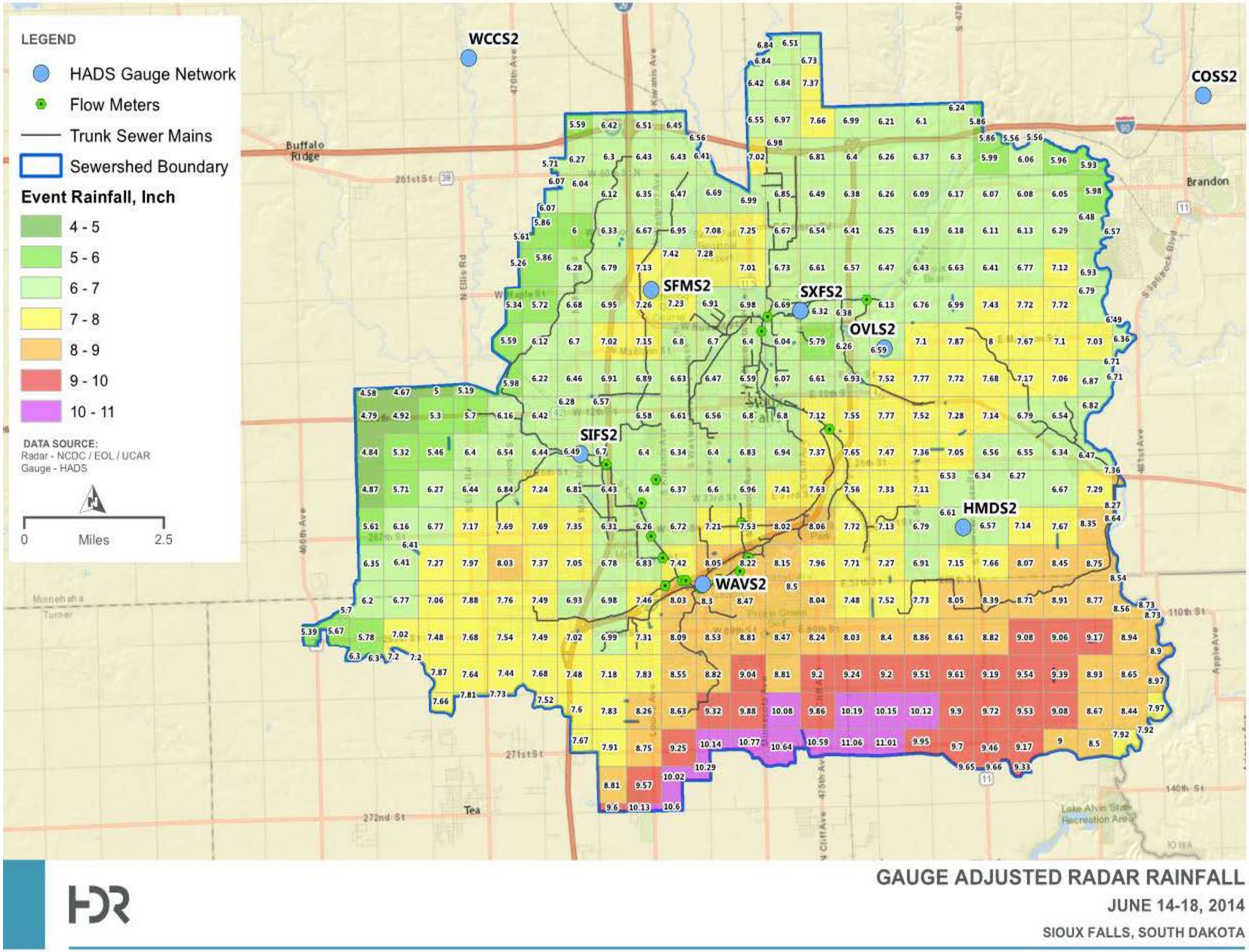


Figure 5.12 Gauge Adjusted Radar Rainfall for June 2014 Event



Wet-Weather Flow Development and Allocation

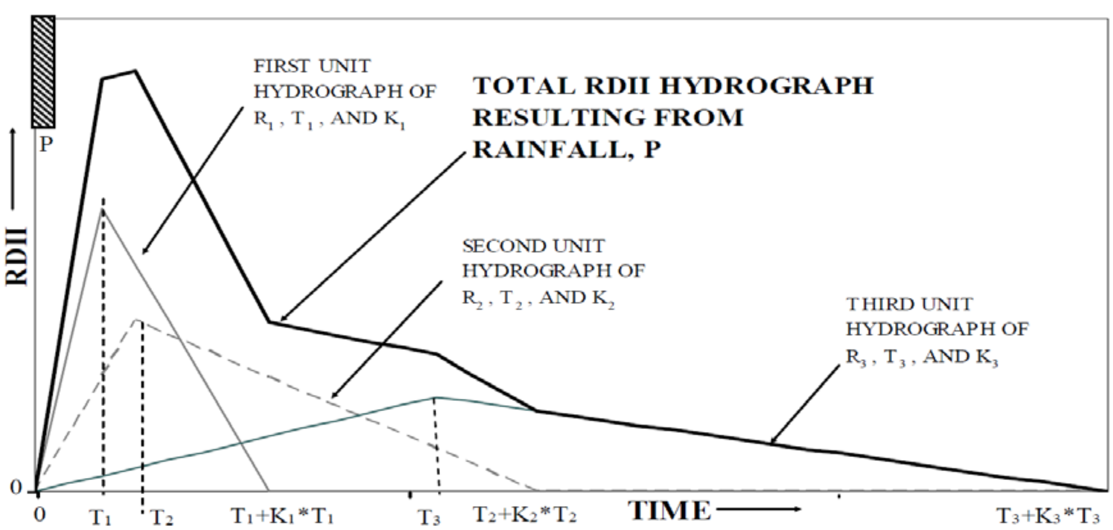
The Unit Hydrograph method using RTKs was applied to characterize and model the City's collection system RDII response to the June 2014 rainfall event and under the Evaluation Storm under existing and future conditions. RTK values are defined by the following:

- R = fraction of rainfall volume entering the collection system as RDII
- T = time from the onset of rainfall to the peak of the Unit Hydrograph
- K = ratio of time to recession of the Unit Hydrograph to T

In InfoSWMM, three RTK Unit Hydrographs are used to define collection system response to rainfall events, with one each for the short-term, mid-term, and long-term responses. Figure 5.13 provides an illustration of how the three RTK triangular Unit Hydrographs define and build the overall RDII Unit Hydrograph used for wet-weather analysis. These RTK values are wet-weather calibration parameters. In addition, initial abstraction (initial RDII losses to soil and groundwater) parameters are associated with the RTK response. For each of the RTK Unit Hydrographs, initial abstraction is defined by a maximum infiltration depth (maximum depth that infiltration will allow), a recovery rate of infiltration (rate of which infiltration is depleted), and an initial depth of stored infiltration (amount of water already in the ground). These infiltration values determine how much rainfall is lost to interception and depression storage before excess rainfall is generated and transformed into RDII flow by a Unit Hydrograph. These three initial abstraction values are also calibration parameters.

The RDII volumes of three unit hydrographs are designated as R1 (short-term response), R2 (mid-term response), and R3 (long-term response) with similar designations for T and K values. A high R1 value indicates that the RDII is primarily inflow driven. If more of the total R value is allocated to R2 and R3, this will indicate that the RDII is primarily infiltration driven. For each RDII hydrograph, there are three sets of R, T, and K parameters as well as three sets of infiltration parameters, making a total of eighteen variables that need to be defined for each RDII response and used as inputs to calibrate the model to wet-weather flows.

Figure 5.13 RTK Unit Hydrograph



RDII is also developed based on the area contributing to the loading point. For the 2016 WTCSMP, RDII is developed and assigned to the manholes on the local and trunk sewer mains. Allocation of flows to the sewershed area is based on existing and future developed area with no contributions from open space and other non-developed areas. For existing conditions, the Thiessen polygons for each manhole based on the City's sewer subbasin boundaries were filtered and clipped to include only parcels indicating a developed state. This step was completed because RDII inflow is going to be much greater in locations with more service connections and higher manhole densities than in areas that are open space, parkland, or other non-developed areas. These filtered Thiessen polygons were then used as sewersheds in InfoSWMM to load RDII.

RDII Analyst, an add-on program to InfoSWMM, was used to develop the initial sets of RDII parameters for each of the nineteen flow monitors and associated flow monitor basins that recorded flow during the June 2014 storm event. These initial RTKs require adjustment as part of the model calibration process, which is discussed in detail in Section 5.6.2.

5.6 Model Calibration

Model calibration is necessary for developing a valid representation of the City's existing sanitary collection system under both dry- and wet-weather conditions. This process to increase confidence in the results generated by the hydraulic model is completed through comparing model results to field flow data under comparable conditions. Model calibration consists of adjusting model parameters so that the predicted flows from the model match those observed at the same locations in the collection system. Adjusted model parameters include BWP, DWI, weekday diurnal patterns, weekend diurnal patterns, and RDII inputs as well as reflect updates to interceptor connectivity, pumping rates, and major flow diversions. Once the parameters have been adjusted within reasonable levels given the possible ranges of input values, the difference between predicted and observed flows is determined. The closer the agreement is between predicted and observed flows, the better the calibration and representation of the collect system within the hydraulic model.

In general, the calibrated model is only representative in the areas of the system where flow is monitored. Unmonitored areas are estimates of system conditions but without data to calibrate to, their model results for dry- and wet-weather flow conditions cannot to be confirmed against field data.

To calibrate the hydraulic model for both dry- and wet-weather conditions the following general steps were taken:

1. Base Wastewater Production (BWP): Water meter consumption from December 1, 2014 through February 28, 2015 were converted to flow rates and spatially input as flows based on Thiessen polygons to the nearest manholes bounded by the City's sanitary sewer subbasins.
2. Dry-weather Infiltration (DWI): Weekend and weekday flows were averaged from December 1, 2014 through February 28, 2015 for each flow monitor and DWI was calculated using the Stevens-Schutzbach method (Equation 5-1) The resulting DWI was then applied to the junctions in the corresponding flow monitoring and flow allocation basins based on the length multiplied by diameter of the immediately upstream pipes.
3. Weekday and weekend diurnal patterns: Weekend and weekday flows were averaged from December 1, 2014 through February 28, 2015 and the resulting diurnal patterns were

normalized for each flow monitor. The resulting normalized patterns were applied to the junctions in the corresponding flow monitoring and flow allocation basins.

4. Average Daily Dry-Weather Flow (ADWF): ADWF was calibrated based on winter flow monitoring data for both weekday and weekend flows. This process is discussed in Section 5.6.1.
5. Rainfall Derived Infiltration and Inflow (RDII): The City's rainfall and flow meter data for the days preceding the June 2014 storm was then applied to adjust the BWP to include summer DWI.
6. Wet-Weather RTK values were calculated using RDII Analyst for the June 2014 storm and applied to the model.
7. Wet-Weather RTK values were calibrated with the City's flow meters. This process is discussed in Section 5.6.2.

This section discusses the dry- and wet-weather calibration process and resulting model inputs.

5.6.1 Dry-Weather Model Results Comparison

As noted previously, the selected dry-weather period was from December 1, 2014 through February 28, 2015 as the December 2015 to February 2016 time period was much wetter than typical winters. During this time of the year, there is very little to no outdoor water use and it is useful for comparing to winter water meter use. The model is calibrated based on the flow monitors to match the ADWF and the characteristic diurnal peak flows that include BWP and DWI for both the weekdays and weekends because the June 2013 wet-weather calibration event occurred over four days that included both these time periods. To remove flow outliners typical with flow monitors and to avoid choosing an arbitrary day with which to base calibration, the dry-weather flow monitoring data was averaged over the three winter months separately for both weekdays and weekends. Any days with precipitation were removed from this analysis along with the day after those as to not include residual affects of the precipitation in the analysis of ADWF.

The first step in the calibration process was to adjust the timing of the weekday and weekend diurnal curves for each flow monitoring basin and then re-apply the patterns to the flow allocation basins. The next step was to reflect the flow monitored volumes by adjusting both BWP and DWI by equal measures so to not diverge too far from the relative DWI calculated with Equation 5-2. The last step of the dry-weather calibration was to adjust the peaks and valleys of the diurnal curves to reflect shape of daily flows from each flow allocation basin.

Given that the winter flow monitor data does not represent a specific isolated day of flow because it was averaged over three months and that the modeling for the 2016 WTCSMP is using a dynamic hydraulic engine, more focus was placed on matching the flow patterns rather than absolute flow peaks and volumes. A comparison of flows and volumes are provided in Table 5.9 for weekday ADWF and Table 5.10 for weekend ADWF. Corresponding graphical flow comparisons are provided in Figure 5.14 for weekday ADWF and Figure 5.15 for weekend ADWF. Due to the cumulative nature of flows with a collection system, the contribution of flow from each flow allocation basin had to be balanced throughout the system. This approach does not always result in the best individual flow monitoring basin correlation but does result in a better system-wide match between observed and modeled flows within the collection system.

Table 5.9 Weekday ADWF Calibration Results (Maximum and Average Flows)

Flow Monitor	Flow Monitor Flows		Model Flows			Comparison	
	Average Flow (gpm)	Maximum Flow (gpm)	Average Flow (gpm)	Maximum Flow (gpm)	Peak Hour Factor (Q_{max}/Q_{avg})	Percent Error between Average Flows	Percent Error between Max Flows
FM_01A0001	128	223	129	215	1.7	1.5%	-3.6%
FM_02AA004	N/A	N/A	545	717	1.3	N/A	N/A
FM_03C0003	137	217	155	221	1.4	12.6%	1.8%
FM_04A0004	4,110	5,546	4,305	5,432	1.3	4.8%	-2.1%
FM_04AD001	443	609	483	640	1.3	9.0%	5.0%
FM_05A0002	2,846	3,956	3,046	3,863	1.3	7.0%	-2.4%
FM_05D0010	471	940	524	913	1.7	11.4%	-2.8%
FM_06A0004	1,977	2,902	2,132	2,790	1.3	7.8%	-3.8%
FM_06CA001	137	267	147	256	1.7	7.8%	-4.2%
FM_06DA006	467	699	472	668	1.4	0.9%	-4.3%
FM_06J0020	64	131	71	133	1.9	10.8%	1.6%
FM_07A0014	260	357	288	374	1.3	10.7%	4.7%
FM_07J0003	394	832	472	1,019	2.2	19.8%	22.5%
FM_07R0005	221	421	251	434	1.7	13.5%	3.1%
FM_07S0001	422	720	478	747	1.6	13.4%	3.7%
FM_09A0005	182	299	157	234	1.5	-13.9%	-21.7%
FM_11E0016	1,100	1,883	1,417	2,223	1.6	28.8%	18.0%
FM_13F0001A	390	536	387	489	1.3	-0.9%	-8.8%
FM_14A0001	N/A	N/A	251	323	1.3	N/A	N/A
FM_15A0001	37	103	50	131	2.6	38.1%	26.5%
FM_26C0002	128	316	150	319	2.1	17.7%	0.9%

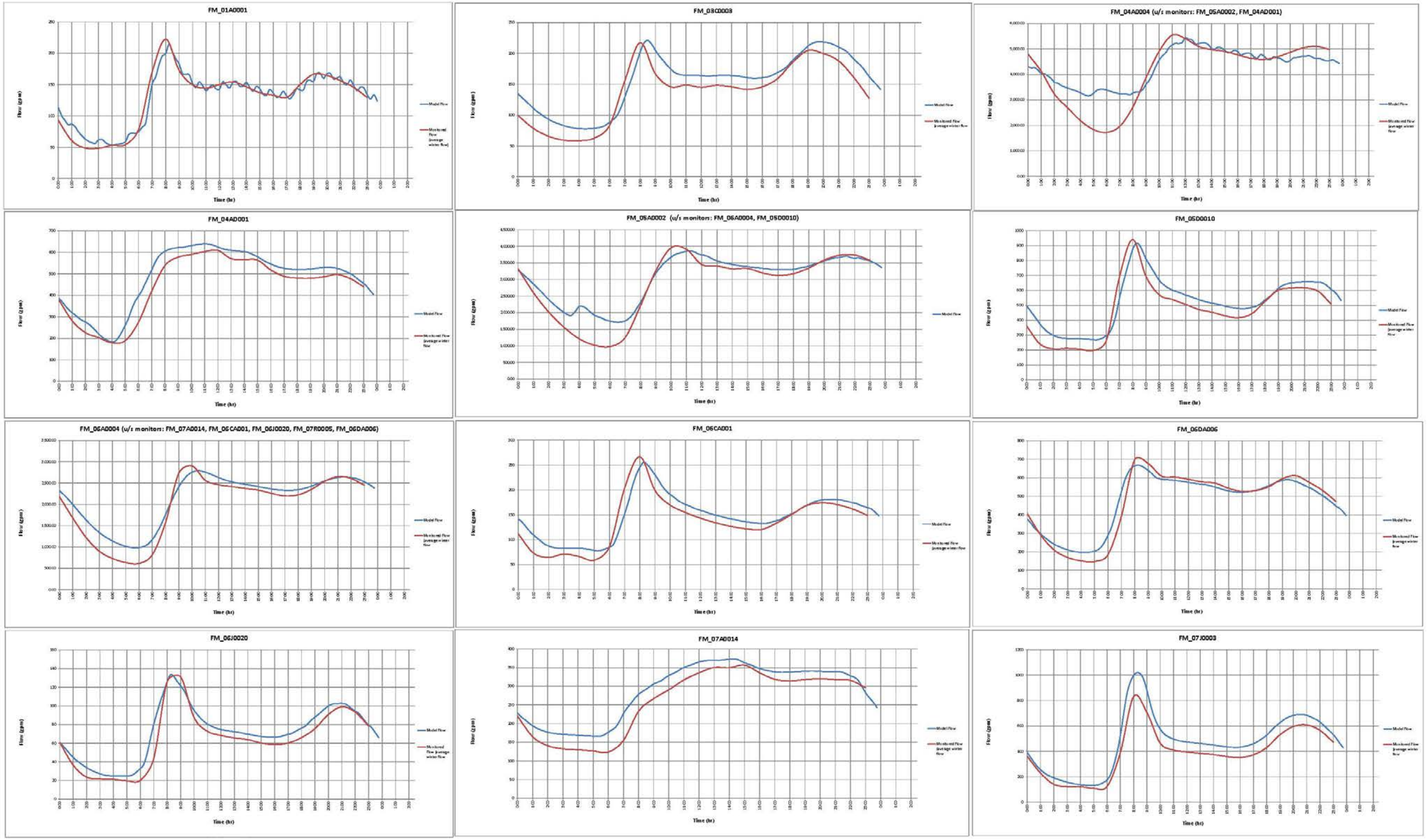
Note: Where flow data was not available to complete a comparison with model results as N/A value is placed in the corresponding locations within the table.

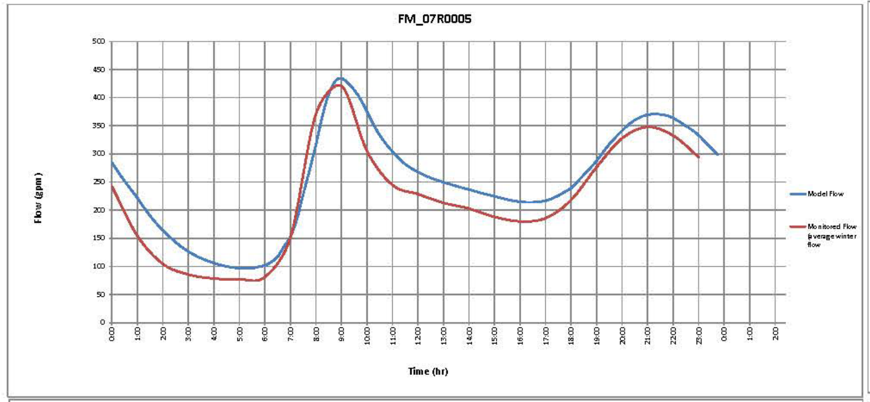
Table 5.10 Weekend ADWF Calibration Results (Maximum and Average Flows)

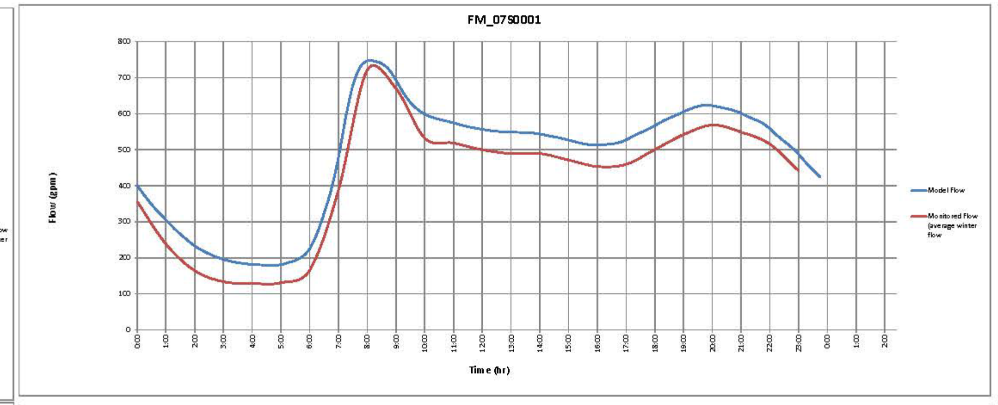
Flow Monitor	Flow Monitor Flows		Model Flows			Comparison	
	Average Flow (gpm)	Maximum Flow (gpm)	Average Flow (gpm)	Maximum Flow (gpm)	Peak Hour Factor (Q_{max}/Q_{avg})	Percent Error between Average Flows	Percent Error between Max Flows
FM_01A0001	124	191	129	194	1.5	4.6%	1.1%
FM_02AA004	N/A	N/A	545	810	1.5	N/A	N/A
FM_03C0003	156	249	155	235	1.5	-0.7%	-5.8%
FM_04A0004	4,263	6,429	4,355	6,061	1.4	2.2%	-5.7%
FM_04AD001	445	696	483	718	1.5	8.5%	3.1%
FM_05A0002	3,150	4,934	3,073	4,432	1.4	-2.5%	-10.2%
FM_05D0010	540	900	527	820	1.6	-2.4%	-8.8%
FM_06A0004	2,128	3,424	2,150	3,123	1.5	1.1%	-8.8%
FM_06CA001	150	250	148	233	1.6	-1.7%	-7.0%
FM_06DA006	461	714	471	687	1.5	2.1%	-3.8%
FM_06J0020	69	121	72	122	1.7	4.4%	1.0%
FM_07A0014	308	502	287	433	1.5	-7.0%	-13.7%
FM_07J0003	473	822	470	796	1.7	-0.6%	-3.1%
FM_07R0005	259	436	254	414	1.6	-1.9%	-4.9%
FM_07S0001	479	801	479	768	1.6	0.1%	-4.1%
FM_09A0005	116	199	157	237	1.5	35.7%	19.3%
FM_11E0016	1,280	2,085	1,419	2,119	1.5	10.8%	1.6%
FM_13F0001A	377	543	387	536	1.4	2.7%	-1.3%
FM_14A0001	N/A	N/A	249	335	1.3	N/A	N/A
FM_15A0001	53	118	51	105	2.1	-4.4%	-11.1%
FM_26C0002	163	322	152	281	1.8	-6.3%	-12.8%

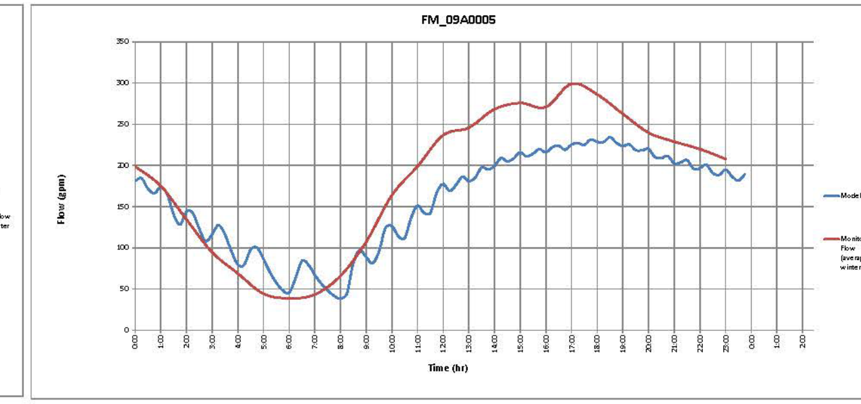
Note: Where flow data was not available to complete a comparison with model results, a N/A value is placed in the corresponding locations within the table.

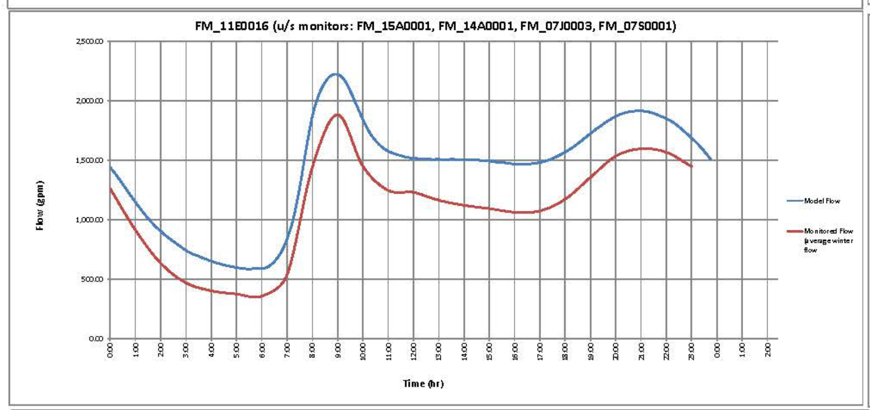
Figure 5.14 Weekday ADWF Calibration Results (Graphs)

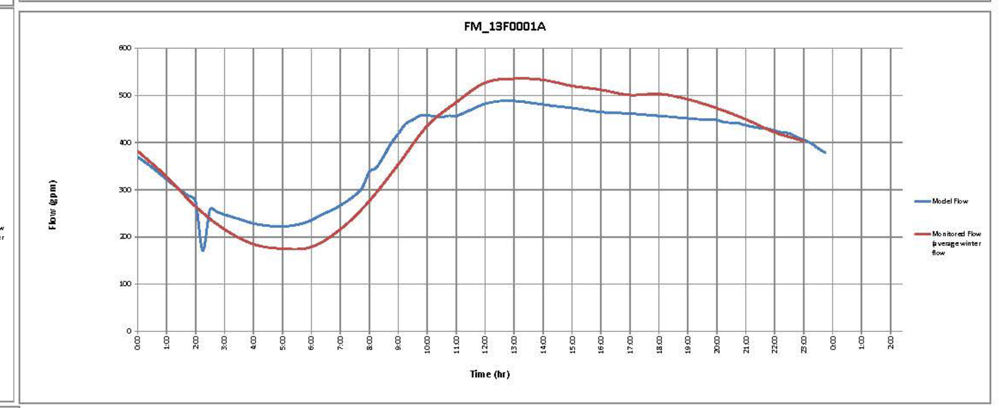


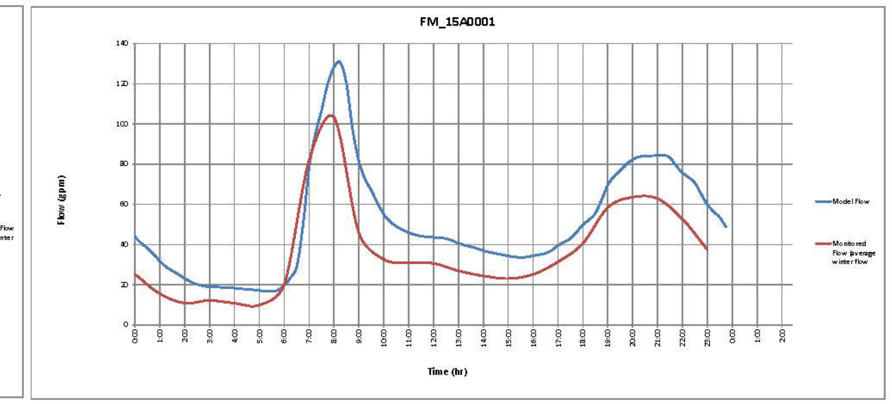

FM_07R0005
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_07S0001
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_09A0005
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_11E0016 (u/s monitors: FM_15A0001, FM_14A0001, FM_07J0003, FM_07S0001)
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_13F0001A
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_15A0001
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)

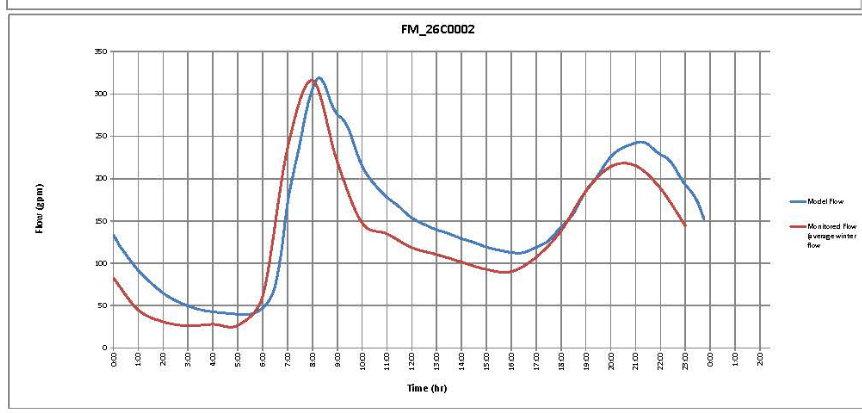
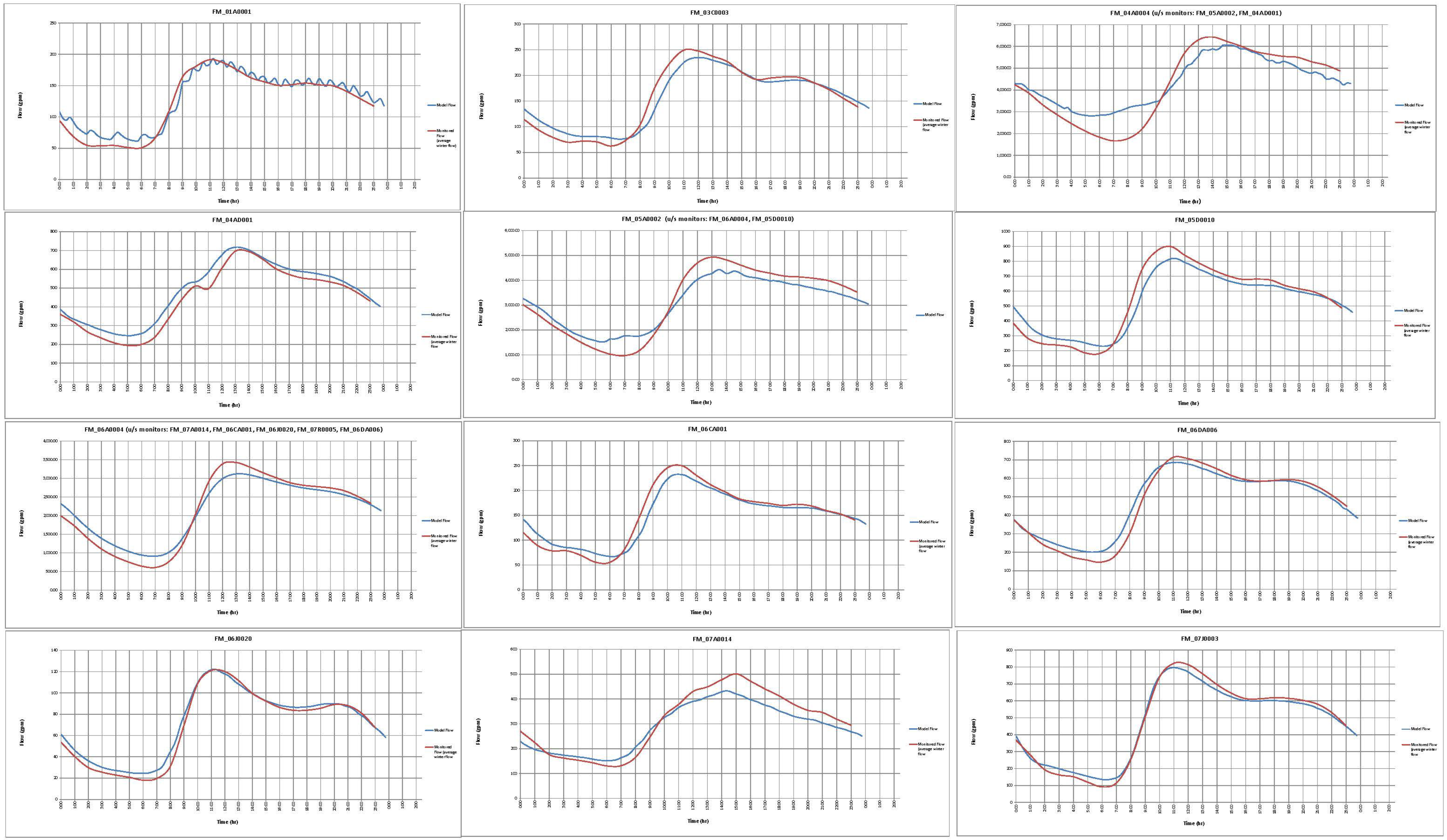
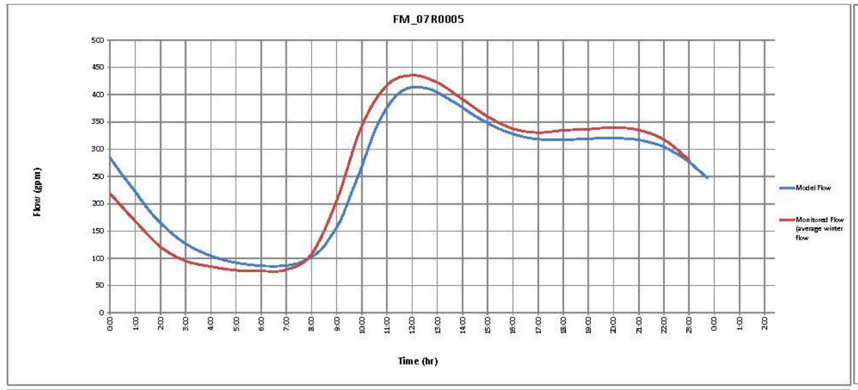
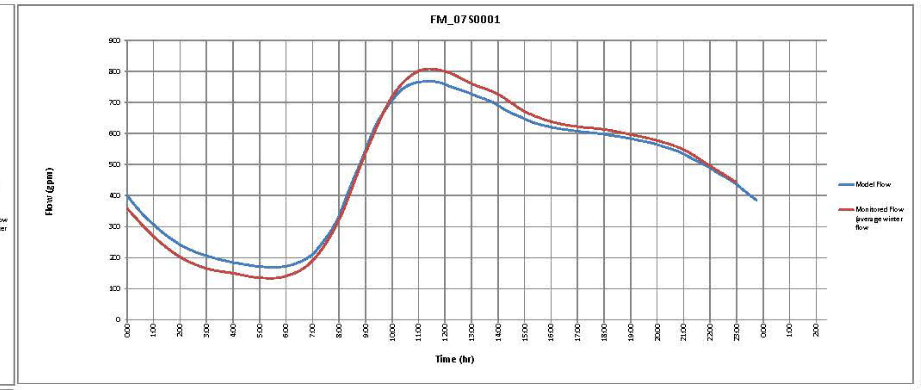
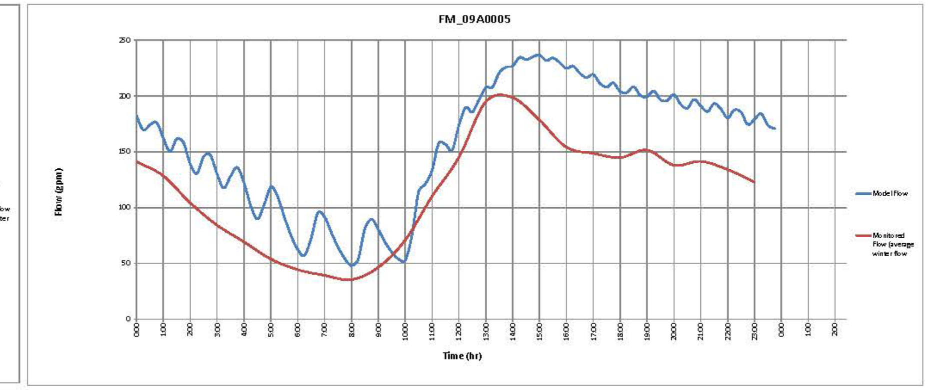

FM_26C0002
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)

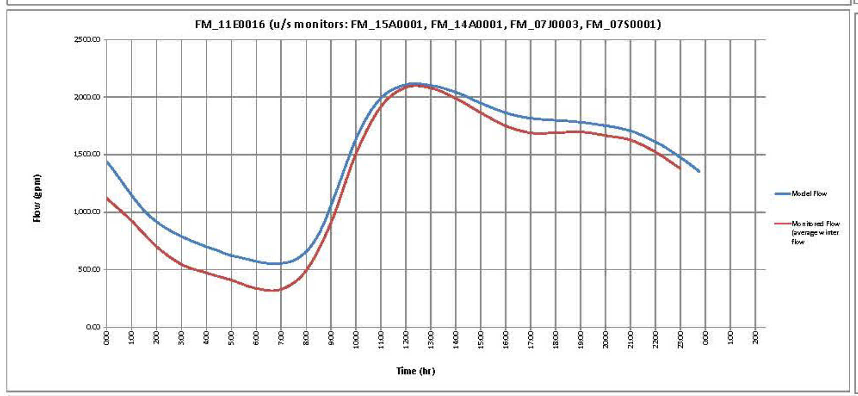
Figure 5.15 Weekend ADWF Calibration Results (Graphs)

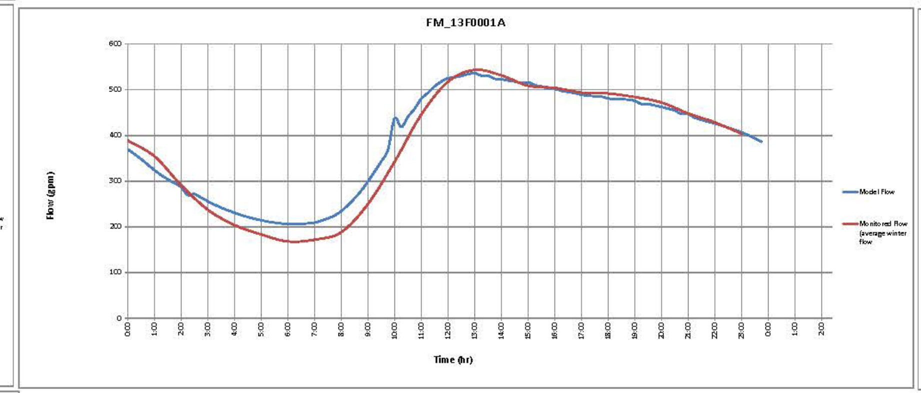


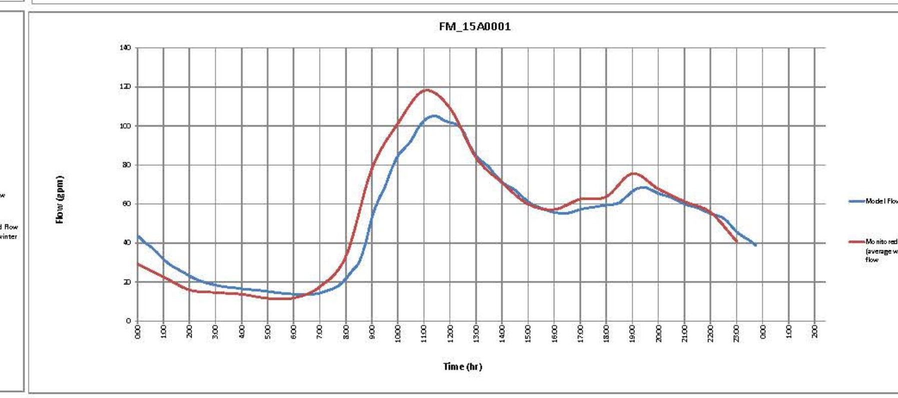

FM_07R0005
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)

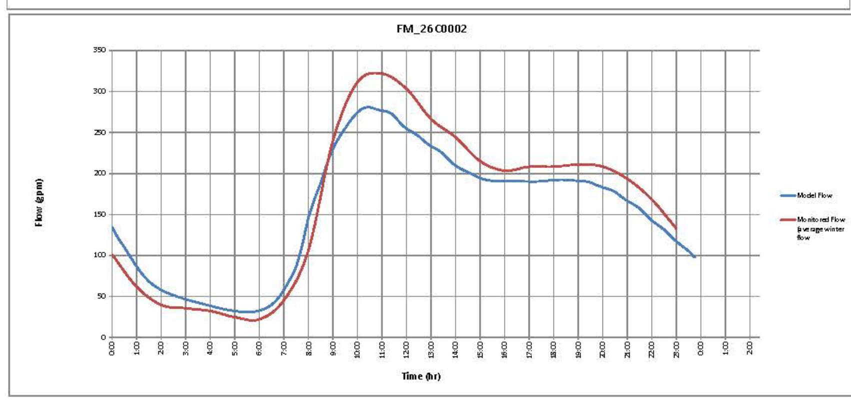

FM_07S0001
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_09A0005
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_11E0016 (u/s monitors: FM_15A0001, FM_14A0001, FM_07J0003, FM_07S0001)
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_13F0001A
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_15A0001
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)


FM_26C0002
Flow (gpm)
Time (hr)
Model Flow
Monitored Flow (average winter flow)

In addition, pumped flows from the modeled lift stations were compared to data available for these lift stations (not all lift stations had information available to compare to). These flow comparisons are provided in Table 5.11.

Table 5.11 Dry-Weather Modeled vs. Observed Lift Station Flow Comparison

Lift Station[1]	Pump Rating (gpm)	Pump Actual (gpm)	2013 Flow Testing (gpm)	2009 Flow Testing (gpm)	Modeled Maximum Flow (gpm)
Brandon	28,201	9,403	-	-	22,442
LS201.1	200	168	-	-	185
LS202.1	300	213	213	212	301
LS203.1	1,100		1,130	1,150	1,100
LS204.1	200	460	470	395	458
LS205.1	150	450	280	510	449
LS206.1	500	530	525	545	530
LS213.1			122	145	180
LS215.1	2,000 / 3,333	-	3,538	-	3,600
LS218.1	3,750	2,270	3,354	3,700	3,750
LS220.1	-	360	346	395	404
LS221.1	100	150	192	180	150
LS224.1	800	680	915	670	1,400
LS225.1	-	160	150	130	159
LS227.2	750	730	690	710	750
LS229.1	-	160	-	-	202
LS233.1	300	330	-	310	363
LS234.1	-	225	-	205	269
LS235.1	-	125	-	145	122

[1] Decimal following the pump station number indicates the number of pumps operating.

The calibrated BWP summary is provided in Table 5.12 for each flow allocation basin and Table 5.13 for each major sanitary sewer basin. The calibrated winter DWI is provided in Table 5.14 and calibrated winter DWI metrics are provided in Table 5.15.

Table 5.12 Calibrated BWP by Flow Allocation Basin

Flow Allocation Basin	Water Meter Based Flow (gpm)	Calibrated BWP (gpm)
FAB_01A0001	104	109
FAB_02AA004	506	532
FAB_03C0003	165	135
FAB_04A0004	472	613
FAB_04AD001	625	437
FAB_05A0002	298	328
FAB_05D0010	423	466
FAB_06A0004	1,086	815
FAB_06CA001	127	129
FAB_06DA006	369	417
FAB_06J0020	101	66
FAB_07A0014	224	236
FAB_07J0003	340	425
FAB_07R0005	304	228
FAB_07S0001	545	436
FAB_09A0005	204	122
FAB_11E0016	287	201
FAB_13F0001A	355	284
FAB_14A0001	204	214
FAB_15A0001	92	46
FAB_25A	1	1
FAB_26C0002	232	209
FAB_Airport	130	137
FAB_Basin17	66	69
FAB_ESSS	50	53
FAB_PS215_west	121	127
FAB_Renner	0	35
FAB_WstrnIntrcptrByp	802	802
Total	**8,233**	**7,672**

Table 5.13 Calibrated BWP by Major Sewer Basin

Major Sewer Basin	Calibrated BWP (gpm)
1	109
2	413
3	170
4	872
5	792
6	695
7	1,582
8	595
9	152
10	897
11	290
12	166
13	95
14	214
15	48
16	152
17	39
18	120
20	48
21	9
23	0
25	1
26	115
28	60
Total	**7,634**

Table 5.14 Calibrated DWI by Flow Allocation Basin

Flow Allocation Basin	Flow Monitor Basin	Stevens-Schutzbach Method Calculated DWI (gpm)	Calibrated Winter (Dec. 2014 – Feb. 2015) DWI (gpm)	Calibrated Summer (June 2014) DWI (gpm)
FAB_01A0001	FM_01A0001	19	24	97
FAB_02AA004	FM_02AA004	82	82	82
FAB_03C0003	FM_03C0003	23	22	39
FAB_04A0004	FM_04A0004	138	224	1,127
FAB_04AD001	FM_04AD001	72	52	209
FAB_05A0002	FM_05A0002	55	74	415
FAB_05D0010	FM_05D0010	78	100	498
FAB_06A0004	FM_06A0004	103	85	423
FAB_06CA001	FM_06CA001	24	27	109
FAB_06DA006	FM_06DA006	59	78	312
FAB_06J0020	FM_06J0020	8	5	22
FAB_07A0014	FM_07A0014	50	62	248
FAB_07J0003	FM_07J0003	44	55	110
FAB_07R0005	FM_07R0005	31	25	123
FAB_07S0001	FM_07S0001	51	45	90
FAB_09A0005	FM_09A0005	16	12	18
FAB_11E0016	FM_11E0016	32	27	44
FAB_13F0001A	FM_13F0001A	70	67	97
FAB_14A0001	FM_14A0001	37	37	110
FAB_15A0001	FM_15A0001	4	2	3
FAB_25A	-	-	-	-
FAB_26C0002	FM_26C0002	10	9	14
FAB_Airport	-	23	33	49
FAB_Basin17	-	10	14	21
FAB_ESSS	-	N/A	1	1
FAB_PS215_west	-	19	19	29
FAB_Renner	-	N/A	N/A	N/A
FAB_WstrnIntrcptrByp	-	130	181	272
Total		**1,188**	**1,362**	**4,562**

Note: Where flow data was not available to calculate values, a N/A value is placed in the corresponding locations within the table.

Table 5.15 Calibrated Winter DWI Metrics by Flow Allocation Basin

Flow Allocation Basin	Flow Monitor Basin	Sum of Calibrated DWI Allocated (gpd)	DWI/Acre (gpd/Acre)	DWI/Flow Monitor Pipes) (gpd/(inch-diameter* mile))	Total DWI as a Percent of ADWF
FAB_01A0001	FM_01A0001	34,809	31	291	19%
FAB_02AA004	FM_02AA004	117,851	58	287	15%
FAB_03C0003	FM_03C0003	31,010	38	167	14%
FAB_04A0004	FM_04A0004	322,863	154	536	5%
FAB_04AD001	FM_04AD001	75,324	70	233	11%
FAB_05A0002	FM_05A0002	106,645	112	398	2%
FAB_05D0010	FM_05D0010	143,416	73	391	19%
FAB_06A0004	FM_06A0004	121,956	20	112	4%
FAB_06CA001	FM_06CA001	39,351	50	231	19%
FAB_06DA006	FM_06DA006	112,212	100	399	17%
FAB_06J0020	FM_06J0020	7845	6	53	8%
FAB_07A0014	FM_07A0014	89,265	121	712	22%
FAB_07J0003	FM_07J0003	78973	33	230	12%
FAB_07R0005	FM_07R0005	35537	25	120	10%
FAB_07S0001	FM_07S0001	64517	35	168	9%
FAB_09A0005	FM_09A0005	17909	5	63	8%
FAB_11E0016	FM_11E0016	39542	35	214	2%
FAB_13F0001A	FM_13F0001A	96955	26	263	17%
FAB_14A0001	FM_14A0001	52657	12	173	15%
FAB_15A0001	FM_15A0001	2841	2	24	4%
FAB_26C0002	FM_26C0002	13556	4	39	6%

5.6.2 Wet-Weather Model Results Comparison

Following ADWF calibration, the model was calibrated to RDII response from the June 2014 storm event, a 25- to 1000-year plus event depending on the area of the collection system. This event is an ideal calibration even due to its magnitude compared to the 25-year storm level of service and relative uniformity across the City. The wet-weather flow model was calibrated using the following inputs for the June 14-18, 2014 event:

- Gauge Adjusted Radar Rainfall (GARR) for June 2014 Event (Figure 5.12)
- Flow monitors recording flow for this event

As stated in Section 5.5.2, flow allocation to the sewershed area is based on existing and future developed area with no contributions from open space and other non-developed areas. The initial

RDII Analyst calculated RTK parameters were executed in the model with the GARR rainfall and the resulting modeled flow response compared to the flow monitoring data. The weeks leading up to the calibration event received a fair amount of rainfall, resulting in higher daily flow rates than what was calibrated for the winter months. Therefore, the first step was to adjust the DWI loads to reflect the flow prior to the calibration rainfall event. These adjusted DWI loads were previously presented in Table 5.14. The RTK parameters were then adjusted to reflect the flow response at the flow monitors for June 14 through June 18.

Typically, for most single storm event sanitary sewer modeling, only the initial depth of stored initial abstraction is required and the long-term RTK values are not necessary. However, given the multiple peaks and two waves of precipitation within this calibration rainfall event, the long-term response and infiltration recovery is vital to this calibration. While more rainfall occurred during the first wave of precipitation, the collection system response was greater during and after the second wave (Figure 5.16) likely due to the saturated soil and flooding conditions from the first wave.

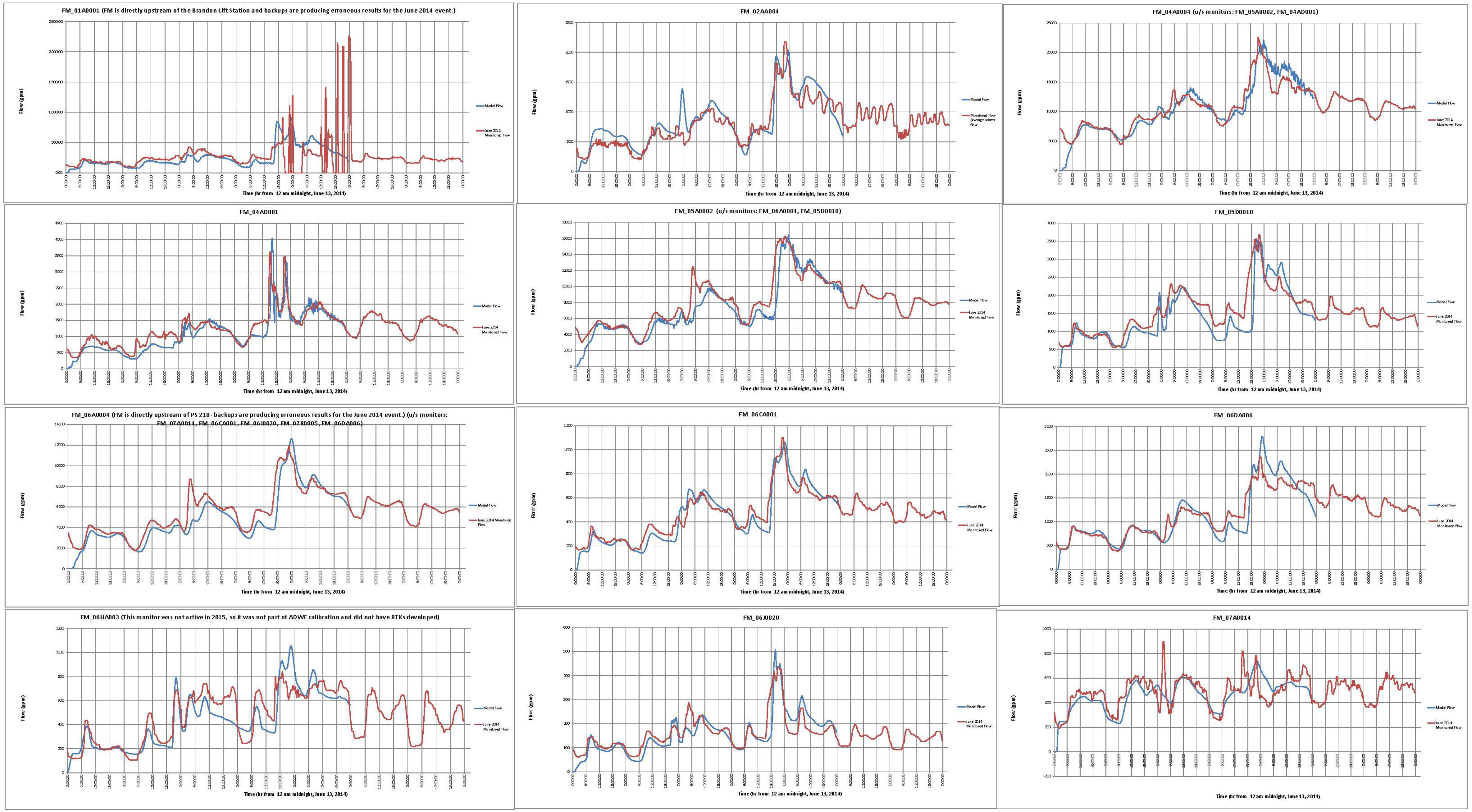
Flow spikes and dropouts due to local sewer surcharging are typical and the flow monitors used for this calibration are no different. Given this and that the modeling for the 2016 WTCSMP is using a dynamic hydraulic engine, more focus was again placed on matching the flow curves rather than absolute flow peaks and volumes. A comparison of calibrated wet-weather flows and volumes are provided in Table 5.16. Corresponding graphical flow comparisons are provided in Figure 5.16.

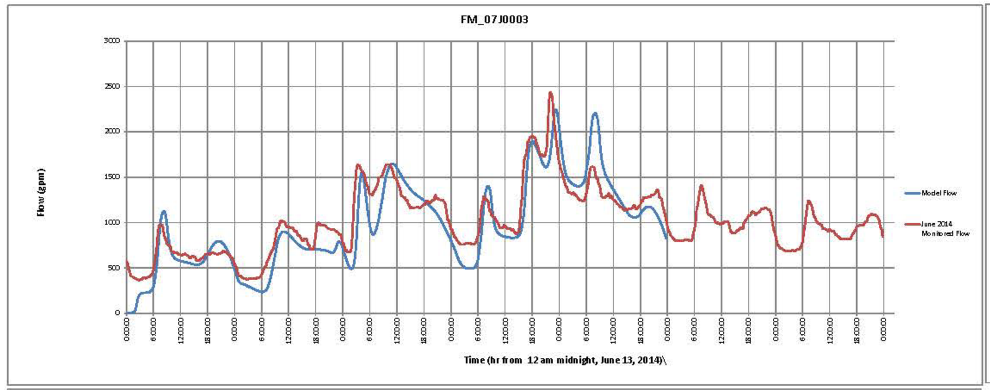
Table 5.16 June 2014 Wet-Weather Calibration Results (Maximum and Average Flows)

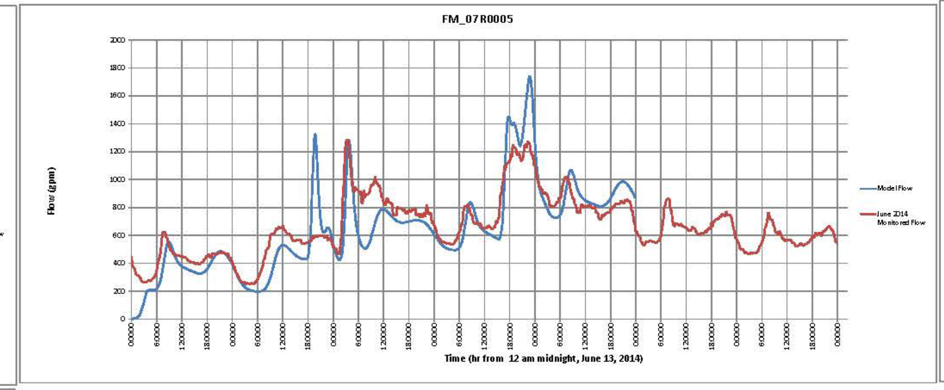
	Flow Monitor Flows		Model Flows		Comparison	
Flow Monitor	Average Flow (gpm)	Maximum Flow (gpm)	Average Flow (gpm)	Maximum Flow (gpm)	Percent Error between Average Flows	Percent Error between Max Flows
FM_01A0001	257	2,257	257	924	0.0%	-59.1%
FM_02AA004	809	2,178	848	2,028	4.8%	-6.9%
FM_03C0003	N/A	N/A	N/A	N/A	N/A	N/A
FM_04A0004	10,758	22,543	10,501	22,003	-2.4%	-2.4%
FM_04AD001	1,259	3,608	1,093	4,041	-13.2%	12.0%
FM_05A0002	8,052	16,253	7,215	16,425	-10.4%	1.1%
FM_05D0010	1,530	3,678	1,384	3,568	-9.6%	-3.0%
FM_06A0004	5,562	11,910	4,877	12,634	-12.3%	6.1%
FM_06CA001	467	1,101	447	1,061	-4.4%	-3.7%
FM_06DA006	1,189	2,354	1,098	2,784	-7.6%	18.2%
FM_06HA003	465	840	436	1,055	-6.3%	25.6%
FM_06J0020	156	435	157	507	0.6%	16.5%
FM_07A0014	491	892	458	745	-6.7%	-16.6%
FM_07J0003	1,014	2,434	964	2,242	-4.9%	-7.9%
FM_07R0005	663	1,283	645	1,741	-2.7%	35.7%
FM_07S0001	1,197	3,205	1,011	3,272	-15.6%	2.1%
FM_09A0005	292	789	247	1,266	-15.4%	60.5%
FM_11E0016	2,915	6,711	2,927	7,991	0.4%	19.1%
FM_13F0001A	817	3,258	1,038	4,185	27.0%	28.5%
FM_14A0001	414	726	366	694	-11.8%	-4.5%
FM_15A0001	N/A	N/A	N/A	N/A	N/A	N/A
FM_26C0002	N/A	N/A	N/A	N/A	N/A	N/A

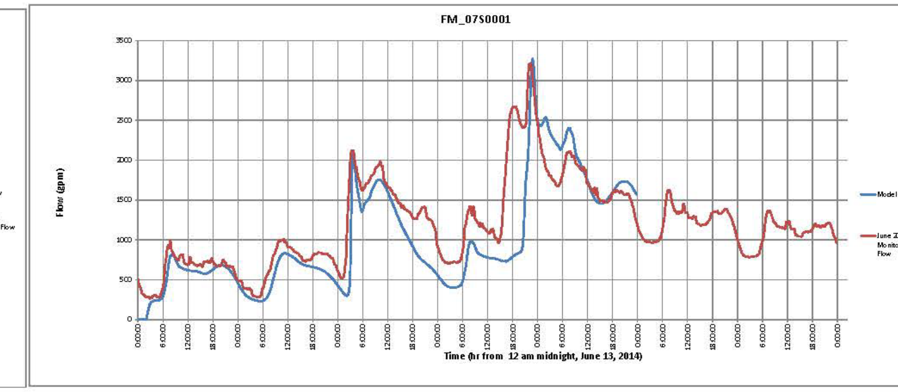
Note: Where flow data was not available to complete a comparison with model results, a N/A value is placed in the corresponding locations within the table.

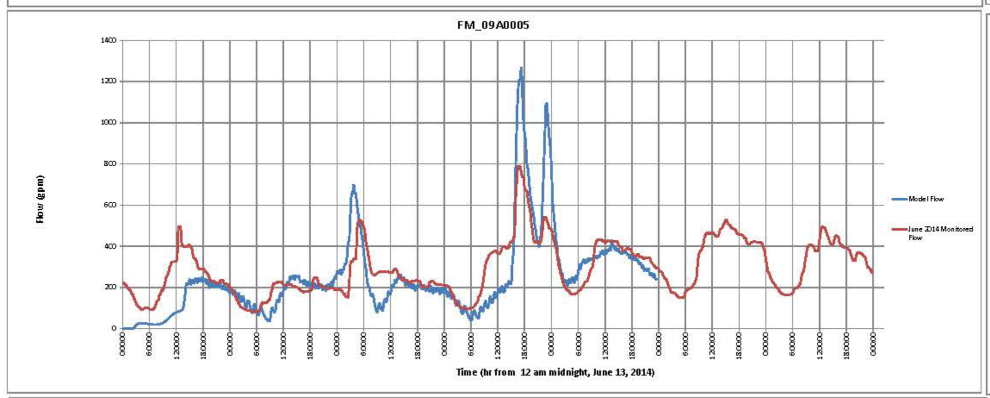
Figure 5.16 June 2014 Wet-Weather Calibration Results (Graphs)

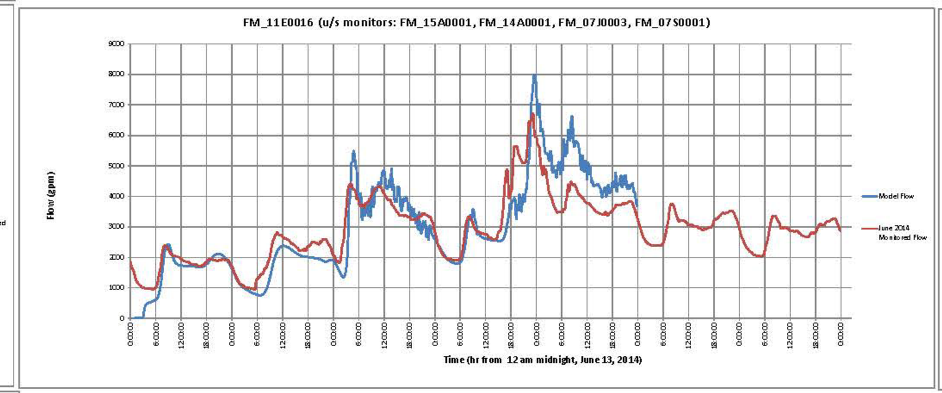


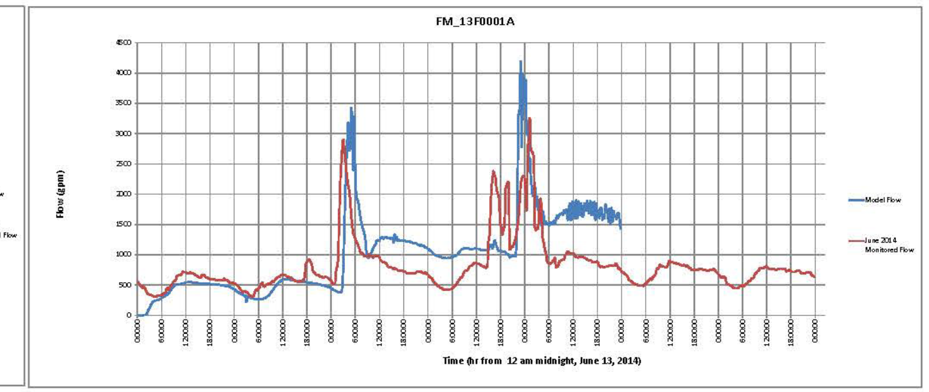

FM_07J0003
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)\

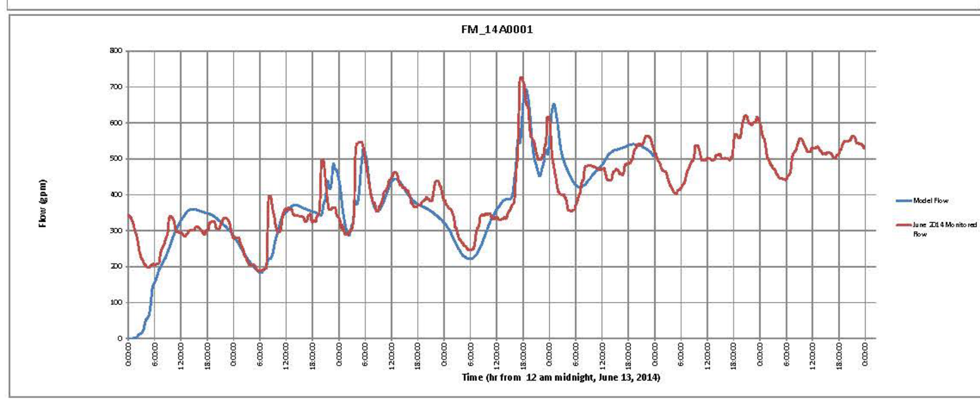

FM_07R0005
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)


FM_07S0001
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)


FM_09A0005
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)


FM_11E0016 (u/s monitors: FM_15A0001, FM_14A0001, FM_07J0003, FM_07S0001)
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)


FM_13F0001A
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)


FM_14A0001
Flow (gpm)
Model Flow
June 2014 Monitored Flow
Time (hr from 12 am midnight, June 13, 2014)

As with the ADWF calibration, pumped flows from the modeled lift stations were compared to data available for these lift stations (not all lift stations had information available to compare to). These flow comparisons are provided in Table 5.17.

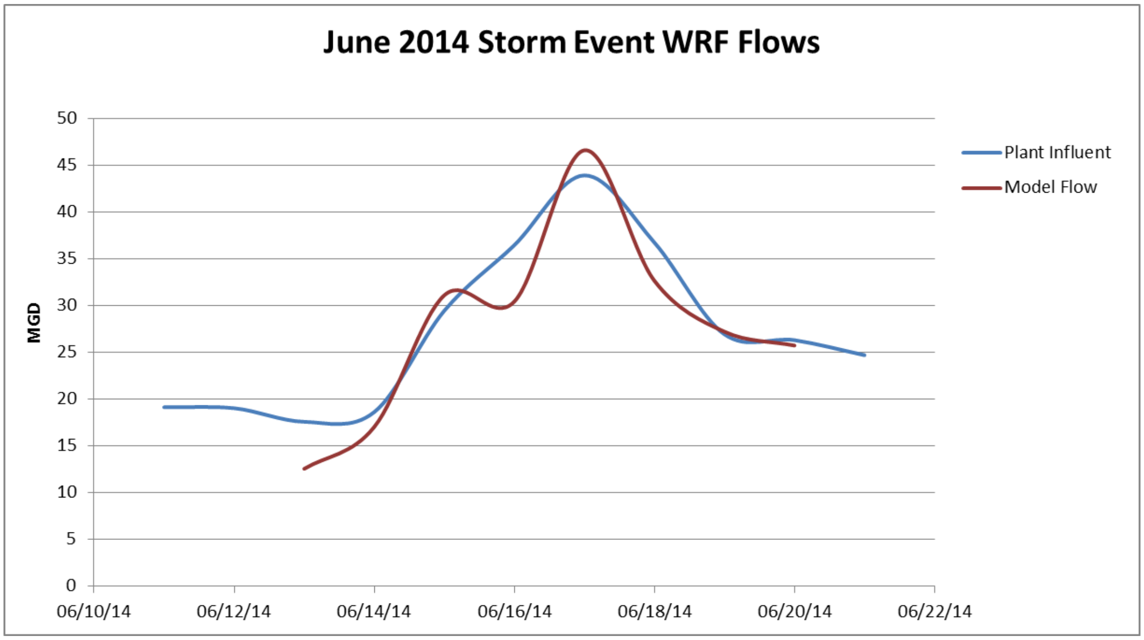
Table 5.17 Wet-Weather Modeled vs. Observed Lift Station Flow Comparison

Lift Station[1]	Pump Rating (gpm)	Pump Actual (gpm)	2013 Flow Testing (gpm)	2009 Flow Testing (gpm)	Modeled Maximum Flow (gpm)
Brandon	28,201	9,403	-	-	22,442
LS201.1	200	168	-	-	185
LS202.1	300	213	213	212	220
LS203.1	1,100	-	1,130	1,150	1,100
LS204.1	200	460	470	395	458
LS205.1	150	450	280	510	449
LS206.1	-	530	568	570	530
LS206.2	500	520	525	545	471
LS213.1	-	-	122	145	180
LS215.1	2000/3333	-	2,848	-	3,600
LS215.2	2000/3333	-	3,538	-	3,600
LS215.3	2000/3333	-	3,240	-	3,600
LS215.4	2000/3333	-	3,428	-	3,600
LS218.1	3,750	2,270	3,354	3,700	3,750
LS218.2	3,500	3,700	3,292	3,780	3,631
LS218.3	3,500	3,800	3,582	2,800	3,616
LS218.4	3,500	3,600	3,510	-	3,601
LS220.1	-	360	346	395	404
LS221.1	100	150	192	180	150
LS224.1	800	680	915	670	1,400
LS224.2	800	650	915	615	726
LS225.1	-	160	150	130	159
LS227.2	750	730	690	710	750
LS229.1	-	160	-	-	202
LS229.2	-	160	-	-	120
LS233.1	300	330	-	310	363
LS234.1	-	225	-	205	269
LS235.1	-	125	-	145	122

[1] Decimal following the pump station number indicates the number of pumps operating.

The flow at the WRF influent during the calibration storm was compared against the model results, with the results provided in Figure 5.17. Only average daily influent flow values were available for comparison so the plant influent flow values in the figure are substantially smoothed compared to the actual flows conveyed to the WRF during the calibration storm event.

Figure 5.17 June 2014 Wet-Weather Calibration Results at the WRF



As shown in the preceding tables and figures, the calibrated model correlates well with flow monitor data for the June 14 through June 18, 2014 rainfall event. The final, calibrated, RTK numbers are provided in Table 5.18 and Table 5.19. These RTK parameters are used for capacity anlaysis storm modeling and collection system analysis for the future growth on the existing collection system. RTK values used for future trunk sewers are discussed in Section 0.

A thematic map of the model results based on the calibration analysis for the June 2014 storm is presented in Figure 5.18. This figure is based on the hydraulic analysis criteria that are discussed in detail in Chapter 9.

Table 5.18 Calibrated RTK Hydrograph Shape Values* Used to Model 2015 RDII**

Unit Hydrograph Group ID (Char)	Parameters for Month	R1 (Short-Term) (Fraction)	T1 (Short-Term) (hours)	K1 (Short-Term) (Ratio)	R2 (Mid-Term) (Fraction)	T2 (Mid-Term) (hours)	K2 (Mid-Term) (Ratio)	R3 (Long-Term) (Fraction)	T3 (Long-Term) (hours)	K3 (Long-Term) (Ratio)
FAB_01A0001*	6: Jun	0.009052	0.9	2.0894	0.014443	10.08	1.9584	0	26	10
FAB_02AA004	6: Jun	0.009052	0.9	2.0894	0.014443	10.08	1.9584	0	26	10
FAB_03C0003*	6: Jun	0.0146	0.9	2.0894	0.1313	10.08	1.9584	0.0268	26	10
FAB_04A0004	6: Jun	0.01464	1.2	1.9733	0.03876	9.6	2.92364	0.0879	26.4228	10.0321
FAB_04AD001	6: Jun	0.015	0.05	3.98	0.02325	10	2.8214	0.0333	25	10
FAB_05A0002	6: Jun	0.00052	2.5	0.08032	0.2061	10	1.9169	0.1035	26	10
FAB_05D0010	6: Jun	0.01593	0.465	2.22495	0.1371	2.37534	7.43016	0.4168	26.4228	30.0963
FAB_06A0004	6: Jun	0.0064	0.775	3.2341	0.01761	3.9589	7.3209	0.07764	26.4228	10.0321
FAB_06CA001	6: Jun	0.006014	0.78	3.24837	0.01827	3.96	7.32504	0.0783	26.4228	10.020167
FAB_06DA006	6: Jun	0.00912	0.78	3.231179	0.0408	3.96	7.32876	0.0833	26.4228	10.080168
FAB_06HA004**	6: Jun	0.008	0.775	3.234	0.018	3.959	7.321	0.2	26.423	20
FAB_06J0020	6: Jun	0.002015	0.06	0.1685	0.0022	12	5.8385	0.0074	24	24
FAB_07A0014	6: Jun	0.00434	6	0.9644	0.00198	12	2.9445	0.0058	24	6
FAB_07J0003	6: Jun	0.0044	0.775	2.8926	0.011	7.9178	1.9585	0.0175	26.4228	10.0001
FAB_07R0005	6: Jun	0.00486	0.3	3.3495	0.00272	1.8	9.8265	0.01855	24	3
FAB_07S0001	6: Jun	0.00825	0.6	0.5834	0.024625	3.12	4.1223	0.128	24	6
FAB_09A0005	6: Jun	0.00434	0.12	0.008907	0.00132	1.8	0.29255	0.0814	3.8	6
FAB_11E0016	6: Jun	0.047	0.775	3.3928	0.2041	7.9178	5.1653	0.2022	26.4228	10.0321
FAB_13F0001A	6: Jun	0.0113	0.12	0.4016	0.0085	0.6	1.5249	0.0404	24	6
FAB_14A0001	6: Jun	0.00315	0.4	0.0482	0.00594	1.6	5.7806	0.06495	22	6
FAB_15A0001*	6: Jun	0.00121	1.0075	7.7136	0.00165	7.9178	10.77175	0.0007	26.4228	10.0001

Table 5.18 Calibrated RTK Hydrograph Shape Values* Used to Model 2015 RDII**

Unit Hydrograph Group ID (Char)	Parameters for Month	R1 (Short-Term) (Fraction)	T1 (Short-Term) (hours)	K1 (Short-Term) (Ratio)	R2 (Mid-Term) (Fraction)	T2 (Mid-Term) (hours)	K2 (Mid-Term) (Ratio)	R3 (Long-Term) (Fraction)	T3 (Long-Term) (hours)	K3 (Long-Term) (Ratio)
FAB_25A*	6: Jun	0.00341	0.12	0.008907	0.0011	1.8	0.29255	0.0666	3.8	6
FAB_26C0002*	6: Jun	0.01593	0.465	2.22495	0.1371	2.37534	7.43016	0.4168	26.4228	30.0963
FAB_Airport*	6: Jun	0.00565	0.12	0.2008	0.0017	0.6	1.5249	0.0202	24	6
FAB_Basin17*	6: Jun	0.0146	0.9	2.0894	0.1313	10.08	1.9584	0.03484	26	10
FAB_ESSS*	6: Jun	0.00315	0.4	0.0482	0.00594	1.6	5.7806	0.06495	22	6
FAB_PS215_west*	6: Jun	0.015	0.05	3.98	0.02325	10	2.8214	0.0333	25	10
FAB_WstrnIntrcptrByp*	6: Jun	0.01725	0.05	3.98	0.0279	10	2.8214	0.05994	25	10

*non-calibrated basin, took the calibration data from the Flow Monitor basins that the FAB was initially assigned.

**basin not part of ADWF calibration nor part of initial RTK estimates; adjustments made manually

*** R = fraction of rainfall volume entering the collection system as RDII
T = time from the onset of rainfall to the peak of the Unit Hydrograph
K = ratio of time to recession of the Unit Hydrograph to T

Table 5.19 Calibrated RTK Infiltration* Values Used to Model 2015 RDII**

Unit Hydrograph Group ID (Char)	Parameters for Month	IAD Max Depth (Short-Term) (in)	IAD Recovery (Short-Term) (in)	IAD Initial Depth (Short-Term) (in)	IAD Max Depth (Mid-Term) (in)	IAD Recovery (Mid-Term) (in)	IAD Initial Depth (Mid-Term) (in)	IAD Max Depth (Long-Term) (in)	IAD Recovery (Long-Term) (in)	IAD Initial Depth (Long-Term) (in)
FAB_01A0001*	6: Jun	3.19104	0.37075	0	3.11625	0.37075	0	2.493	3.7075	0
FAB_02AA004	6: Jun	3.19104	0.37075	0	3.11625	0.37075	0	2.493	3.7075	0
FAB_03C0003*	6: Jun	3.19104	0.37075	0	3.11625	0.37075	0	2.493	3.7075	0
FAB_04A0004	6: Jun	1.6	0	0	3.05	0	0	2.4	3.5	0
FAB_04AD001	6: Jun	3	0	0	2	0	0	0	0	0
FAB_05A0002	6: Jun	6	0	0	500	0	0	2	0	0
FAB_05D0010	6: Jun	2.8	1.4	0	2.86695	3.2	0	2.493	4	0
FAB_06A0004	6: Jun	3.75	0.35	0	2.5	1.05	0	2.5	7	0
FAB_06CA001	6: Jun	3.75	0.35	0	2.5	1.05	0	2.5	7	0
FAB_06DA006	6: Jun	3.75	0.35	0	2.5	1.05	0	2.5	7	0
FAB_06HA004**	6: Jun	1.9	0.6	0	2	1.5	0	2	2.5	0
FAB_06J0020	6: Jun	2	7	0	0	1.05	0	2	1.05	0
FAB_07A0014	6: Jun	0.11	0	0	0.055	0	0	0	0	0
FAB_07J0003	6: Jun	2.1	0	0	2.05	0	0	0	0	0
FAB_07R0005	6: Jun	1.1	3	0	0.5	3	0	1	3	0
FAB_07S0001	6: Jun	2	7	0	2	7	0	2	17.5	0
FAB_09A0005	6: Jun	3	0.35	0	3	10.5	0	2.66	17.5	0
FAB_11E0016	6: Jun	2	4.2	0	2	4.2	0	2	7	0
FAB_13F0001A	6: Jun	2.3	7	0	2.2	7	0	2	7	0
FAB_14A0001	6: Jun	0.5	2.8	0	2	2.8	0	2	7	0

Table 5.19 Calibrated RTK Infiltration* Values Used to Model 2015 RDII**

Unit Hydrograph Group ID (Char)	Parameters for Month	IAD Max Depth (Short-Term) (in)	IAD Recovery (Short-Term) (in)	IAD Initial Depth (Short-Term) (in)	IAD Max Depth (Mid-Term) (in)	IAD Recovery (Mid-Term) (in)	IAD Initial Depth (Mid-Term) (in)	IAD Max Depth (Long-Term) (in)	IAD Recovery (Long-Term) (in)	IAD Initial Depth (Long-Term) (in)
FAB_15A0001*	6: Jun	10.1	0	0	5.05	0	0	0	0	0
FAB_25A*	6: Jun	3	0.35	0	4	21	0	2.66	17.5	0
FAB_26C0002*	6: Jun	2.8	1.4	0	2.86695	3.2	0	2.493	4	0
FAB_Airport*	6: Jun	2.3	7	0	2.2	7	0	2	7	0
FAB_Basin17*	6: Jun	3.19104	0.37075	0	3.11625	0.37075	0	2.493	3.7075	0
FAB_ESSS*	6: Jun	0.5	2.8	0	2	2.8	0	2	7	0
FAB_PS215_west*	6: Jun	3	0	0	2	0	0	0	0	0
FAB_WstrnIntrcptrByp*	6: Jun	3	0	0	2	0	0	0	0	0

*non-calibrated basin, took the calibration data from the Flow Monitor basins that the FAB was initially assigned.

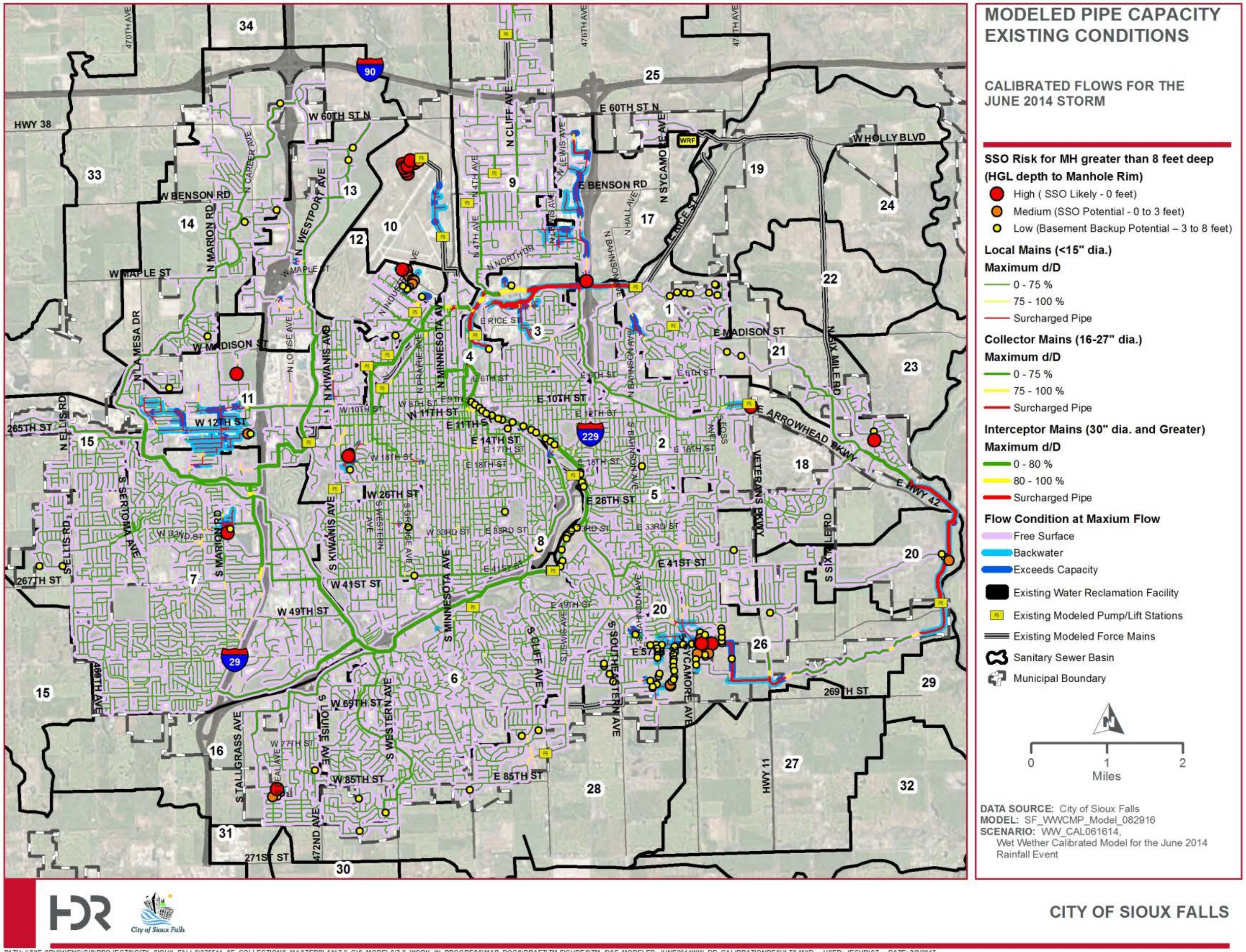
**basin not part of ADWF calibration nor part of initial RTK estimates; adjustments made manually

*** IAD Max Depth - Maximum initial abstraction loss possible. Rainfall depth in excess of the maximum abstraction depth would be converted to an RDII according to the R, T and K parameters

IAD Recovery -Rate at which the initial abstraction loss recovers during the dry periods between two rain events

IAD Initial Depth - Depth of the abstraction losses already satisfied at the beginning of the simulation. If a grid cell is left empty its corresponding parameter value is assumed to be 0

Figure 5.18 Calibrated Model Results for the June 2014 Storm



PATH: \\SXF-SRV01\ENG\GIS\PROJECTS\CITY_SIOUX_FALLS\275541_SF_COLLECTIONS_MASTERPLAN\7.0_GIS_MODELS\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\TM FIGURES\TM_6\SF_MODELED_JUNE2014WW_DD_CALIBRATIONRESULTS.MXD - USER: JECHRIST - DATE: 2/9/2017

5.6.3 Additional Calibration and Modeling Recommendations

While the calibration described in this section produced favorable modeling results for use in the 2016 WTCSMP, there are additional calibration recommendations for future work. The following list discuses these recommendations:

- There are a number of areas that were not served by a flow monitor. These areas include the airport, the Western Interceptor (Basins 10 and 12), Lewis Road, the Outfall Trunk, Basin 17, and the majority of the ESSS. These areas represent data gaps in the current analysis and it is recommended to add flow monitors to monitor these locations in the near-future to confirm model flows and calibration in these contributing areas.
- Place additional flow monitors throughout the system over time to develop smaller flow monitoring basins for model validation and updates and as needed for more detailed capacity analysis.
- Run and possibly re-calibrate the model to additional, single wave storm events that produce an equivalent 10- or 25-year recurrence interval rainfall depth to better understand the sensitivity of the existing and future capacity analysis to various types of storm events.
- Install additional flow monitors immediately downstream of areas with existing modeled capacity issues to verify flows prior to implementation of a CIP project.
- All existing flow monitors and meters including those at lift stations, equalization basins, and WRF influent should be calibrated at least once a year, if not twice a year.
- Repair and calibrate or replace flow meters at equalization based and WRF influent for more reliable and incremental measurement of flow including peak flows at these locations

5.6.4 Development of the Capacity Analysis Storm

The June 14 through June 18, 2014 rainfall event produced rainfall depths in excess of the City design standard 25-year, 96-hour rainfall depth (Section 5.5.2). To analyze the existing system and future growth, a Capacity Analysis Storm reflecting the 25-year rainfall event needed to be developed. Because RTK values were developed for conditions specific to the calibration event, the rainfall pattern averaged across the City (Figure 5.10) was normalized and then adjusted based on the NOAA Atlas 14 25-year, 4-day rainfall depth of 5.69 inches. Figure 5.19 presents the Capacity Analysis Storm rainfall pattern used for this current 2016 WTCSMP and Figure 5.20 presents the corresponding rainfall mass curve.

Figure 5.19 25-Year, 96-Hour Capacity Analysis Storm Rainfall Pattern

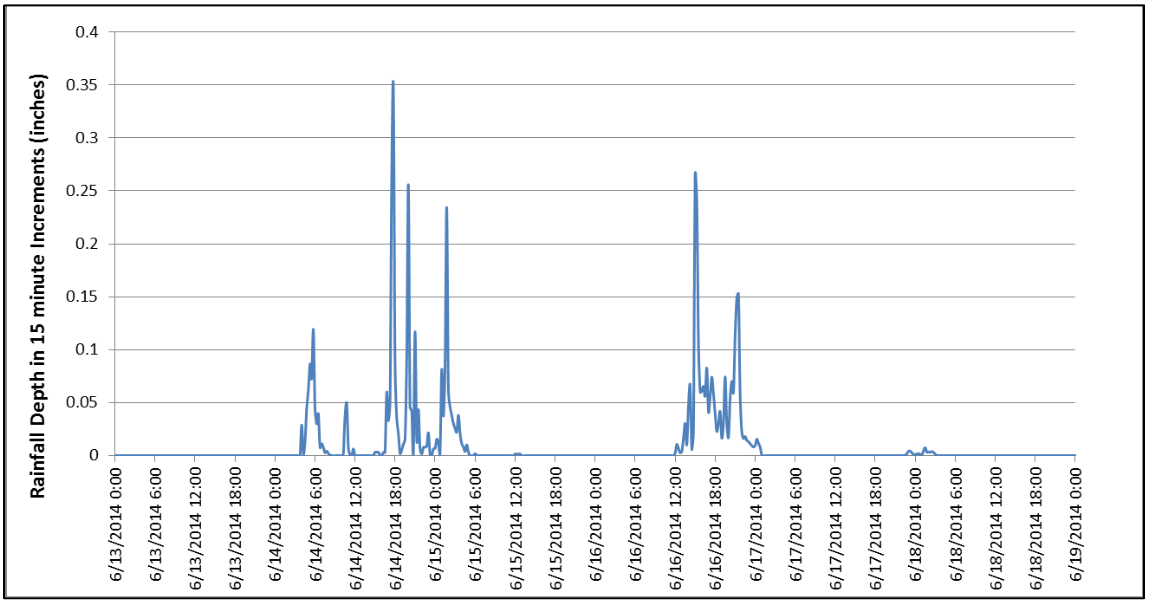
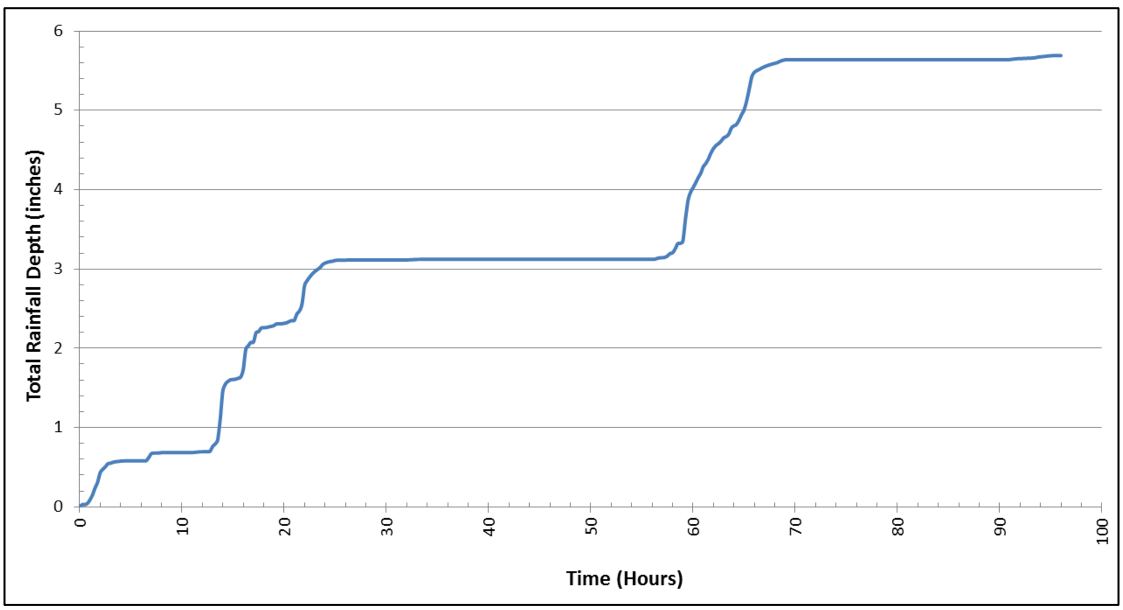


Figure 5.20 25-Year, 96-Hour Capacity Analysis Storm Mass Curve



5.7 Future Conditions Flow Development

Future flow development was based on TAZ data for the 2026, 2036, 2066, and 2116 planning years as described in Chapter 2, Population and Land Use Planning and Chapter 4, Wastewater Flows and Loads. These planning years are also defined by City's development Tiers, with Tier 1 corresponding to immediate developments and Tiers 2, 3, 4, and 5 corresponding to the planning years 2026 (10-year, near-term), 2036 (20-year, mid-term), 2066 (50-year, long-term), and 2116 (100-year, long-range), respectively. Development of future loadings and trunk sewer extensions are based on future growth projects contained in the TAZ and development Tier areas as discussed in Chapters 2 and 4.

Thiessen polygons were used to allocate future BWP, DWI, and RDII. Thiessen polygons were developed for each planning year for each model manhole based on the planning tier boundary extent. For basins that are completely contained by a planning tier, the entire basin was anticipated to experience growth, meaning that Thiessen polygons filled the entire basins and flow projections were distributed on a Thiessen polygon area-weighted basis throughout the basins. For basins that are currently partially developed, developed areas were removed from the subbasins and associated Thiessen polygons, meaning that future flow loads in partially developed basins were only applied to areas that are currently undeveloped.

5.7.1 Dry-Weather

This section discusses future BWP and DWI flow development and allocation approach.

Base Wastewater Production

The future flow development for the collection system is discussed in Chapter 4. For future BWP loadings, negative flow trends were removed meaning that all basins are assumed to have either no growth (which replace a projected negative growth) or positive growth. BWP allocation is performed spatially based on the difference between existing flows and future projections developed from TAZ data. Future BWP allocation is developed on a sewer basin basis and distributed to the manholes based on Thiessen polygons, as described previously. Table 5.20 summarizes the total BWP as well as the flow increase over 2015 conditions for each planning year period. Future BWP is applied as a separate load to the model (third row in the model under dry-weather loading).

Table 5.20 Base Wastewater Production Distributed to the Model for Each Planning Year

Major Sewer Basin	Total Base Wastewater Production (with negative trends removed) (gpm)						Base Wastewater Production Increase from Existing (with negative trends removed) (gpm)				
	2015 Calibrated	2026	2036	2040	2066	2116	2026	2036	2040	2066	2116
1	109	122	133	133	206	206	13	24	24	97	97
2	413	413	413	413	413	413	0	0	0	0	0
3	170	171	171	489	489	489	1	1	319	319	319
4	872	872	872	986	986	986	0	0	114	114	114
5	792	812	828	828	828	828	20	36	36	36	36
6	695	732	761	1,013	1,181	1,184	37	66	318	486	489
7	1,582	1,655	1,711	1,997	2,149	2,151	73	129	415	567	569
8	595	595	595	595	595	595	0	0	0	0	0
9	152	188	216	356	526	650	36	64	204	374	498
10	897	897	897	897	897	897	0	0	0	0	0
11	290	317	338	444	813	813	27	48	154	523	523
12	166	166	166	166	166	166	0	0	0	0	0

Table 5.20 Base Wastewater Production Distributed to the Model for Each Planning Year

Major Sewer Basin	Total Base Wastewater Production (with negative trends removed) (gpm)						Base Wastewater Production Increase from Existing (with negative trends removed) (gpm)				
	2015 Calibrated	2026	2036	2040	2066	2116	2026	2036	2040	2066	2116
13	95	130	156	181	296	296	35	61	86	201	201
14	214	426	588	644	1,089	1,092	212	374	430	875	878
15	48	197	312	412	900	2,933	149	264	364	852	2,885
16	152	393	578	715	885	1,064	241	426	563	733	912
17	39	50	59	87	187	187	11	20	48	148	148
18	120	335	501	574	910	910	215	381	454	790	790
19	0	70	123	145	315	370	70	123	145	315	370
20	48	109	155	180	216	216	61	107	132	168	168
21	9	139	239	279	406	406	130	230	270	397	397
22	0	86	151	178	192	203	86	151	178	192	203
23	0	31	55	64	102	149	31	55	64	102	149
25	1	71	125	148	171	2,015	70	124	147	170	2,014
26	115	484	768	914	1,236	1,236	369	653	799	1,121	1,121
27	0	162	287	337	726	751	162	287	337	726	751
28	60	299	483	571	896	1,458	239	423	511	836	1,398
29	0	14	25	30	44	44	14	25	30	44	44
30	0	0	0	0	44	997	0	0	0	44	997
31	0	0	0	0	47	299	0	0	0	47	299
32	0	0	0	0	90	608	0	0	0	90	608
33	0	9	16	19	133	159	9	16	19	133	159
34	0	59	105	123	500	2,764	59	105	123	500	2,764
Total	**7,634**	**10,004**	**11,827**	**13,917**	**18,635**	**27,536**	**2,370**	**4,193**	**6,283**	**11,001**	**19,902**

Regional Customers

Anticipated flow increases from existing regional customers and flows from potential new regional customers were developed for each planning year and added as point loads to established connection points in the model.

Table 5.21 summarizes the modeled maximum day flow loads anticipated from regional customers. These flows were added as point loads to the model as a conservative constant inflow to the model manhole elements defined in Table 5.21.

Table 5.21 Modeled Regional Customer Future Loadings by Planning Year

Regional Customer	2026 Planning Year		2036 Planning Year		2066 Planning Year		2116 Planning Year		Notes
	Model Junction Loading Point	Max. Day Flow Load (gpm)	Model Junction Loading Point	Max. Day Flow Load (gpm)	Model Junction Loading Point	Max. Day Flow Load (gpm)	Model Junction Loading Point	Max. Day Flow Load (gpm)	
City of Brandon and Corson	N/A	1,008	N/A	1,226	N/A	2,691	N/A	4,563	Directly to the plant
City of Baltic	N/A	0	09GB004	176	09GB004	263	09GB004	409	Tie into the same location as Renner through either Basin 9 or 25
City of Crooks	N/A	0	BSN34DEX_11	209	BSN34DEX_11	317	BSN34DEX_11	498	Tie into Basin 34
City of Garretson	N/A	0	BSN25_8	107	BSN25_8	107	BSN25_8	105	Tie into Basin 19
City of Rowena	N/A	0	20C0004	5	20C0004	7	20C0004	10	Tie into the ESSS trunk
City of Valley Springs	N/A	0	N/A	80	N/A	82	N/A	85	Directly to the plant
City of Tea	BSN16G_3	1,057	BSN16G_3	1,499	BSN16G_3	2,314	BSN16G_3	3,979	Tie into Basin 16
City of Hartford	N/A	0	BSN34CEX1_2	509	BSN34CEX1_2	760	BSN34CEX1_2	d	Tie into Basin 34
City of Lennox	N/A	0	BSN16H_1	264	BSN16H_1	283	BSN16H_1	313	Tie into the same location as Tea through Basin 16
Wall Lake Sanitary District	N/A	0	N/A	9	BSN15EX11_9	9	BSN15EX11_9	8	Tie into Basin 15
City of Harrisburg	HARRISBURG	790	HARRISBURG	1,170	HARRISBURG	2,172	HARRISBURYTR_13	3,810	Tie directly to ESSS PS240 through Tier 4, then tie into Tier 5 trunk
City of Canton	N/A	0	CANTON	368	CANTON	400	CANTON	454	Tie directly to ESSS PS240
City of Worthing	N/A	0	WORTHING	238	WORTHING	442	WORTHING	775	Tie directly to ESSS PS240
John Morell	03B0012	278	03B0012	278	03B0012	278	03B0012	278	John Morell is allowed to discharge, need to account for this in future flows

Dry-Weather Infiltration

Existing summer DWI was calculated and calibrated based on the flow monitoring basins. DWI was then summarized for each major sewer basin and a summer DWI per sewer basin area was calculated (DWI/acre) for 2015 conditions. The 35th percentile DWI per acre from the existing flow analysis was then determined using only major sewer basins that were built out in 2015. This resulted in a calculated 35th percentile 2015 DWI of 0.068 gpm/acre that was applied to the future condition Thiessen polygons for each planning year. Table 5.22 summarizes these future DWI calculations.

The future DWI allocation was only applied to model manholes that did not have an existing summer DWI associated with it. This means that if a DWI was calculated for a manhole under existing 2015 conditions, then that DWI was maintained with the associated metrics provided in Table 5.23, otherwise it was projected based on the manhole's Thiessen polygon area and 0.068 gpm/acre.

Table 5.22 35th Percentile DWI Calculation

Fully Developed Major Sanitary Basin	Calibrated 2015 Wet-Weather DWI (gpm)	Major Sanitary Basin Area (acres)	DWI per Acre (gpm/acre)
2	67	1,511	0.044
3	67	1,149	0.059
4	906	2,349	0.386
5	791	2,905	0.272
6	384	5,373	0.071
7	563	7,312	0.077
		35th Percentile	**0.068**

Table 5.23 Calibrated Winter DWI Metrics by Flow Allocation Basin

Flow Allocation Basin	Flow Monitor Basin	Sum of Calibrated DWI Allocated (gpd)	DWI/Acre (gpd/Acre)	DWI/Flow Monitor Pipes) (gpd/ (inch-diameter* mile))	Total DWI as a Percent of ADWF
FAB_01A0001	FM_01A0001	49,708	45	416	13%
FAB_02AA004	FM_02AA004	117,851	58	287	10%
FAB_04A0004	FM_04A0004	1,802,487	858	2990	12%
FAB_04AD001	FM_04AD001	144,458	134	446	9%
FAB_05A0002	FM_05A0002	521,374	550	1945	5%
FAB_05D0010	FM_05D0010	621,094	317	1695	31%
FAB_06A0004	FM_06A0004	244,559	39	225	3%
FAB_06CA001	FM_06CA001	171,313	219	1006	27%
FAB_06DA006	FM_06DA006	432,272	385	1538	27%
FAB_06J0020	FM_06J0020	33,026	24	223	15%
FAB_07A0014	FM_07A0014	187,455	254	1494	28%
FAB_07J0003	FM_07J0003	227,442	96	661	16%
FAB_07R0005	FM_07R0005	199,893	140	673	22%
FAB_07S0001	FM_07S0001	148,316	80	386	10%
FAB_09A0005	FM_09A0005	19,906	6	70	6%
FAB_11E0016	FM_11E0016	39,077	35	212	1%
FAB_13F0001A	FM_13F0001A	177,750	48	482	12%
FAB_14A0001	FM_14A0001	105,315	25	345	20%

5.7.2 Wet-Weather

Existing RDII RTK parameters were calculated and calibrated based on the flow monitoring basins (Table 5.18 and Table 5.19). Future conditions RDII were based on the 35th percentile of RTK values for these flow monitoring basins (Table 5.24 and Table 5.25). RDII contributing areas were calculated based on the manhole Thiessen polygons for each planning year. RDII contributing areas were only allowed to remain the same or increase over the planning period. Summary future wet-weather flows are not provided by major sewer basin due to the dynamic nature of the development of RDII from the RTKs. Chapter 9, Collection System Analysis and Improvement Alternatives, has a summary of the resulting flows at the WRF influent for each of the planning years based on this future flow allocation approach.

Table 5.24 35th Percentile RTK Hydrograph Shape Values Calculation

Unit Hydrograph Group ID (Char)	Parameters for Month	R1 (Short-Term) (Fraction)	T1 (Short-Term) (hours)	K1 (Short-Term) (Ratio)	R2 (Mid-Term) (Fraction)	T2 (Mid-Term) (hours)	K2 (Mid-Term) (Ratio)	R3 (Long-Term) (Fraction)	T3 (Long-Term) (hours)	K3 (Long-Term) (Ratio)
Future_35th_percentile	6: Jun	0.004745	0.375	0.86915	0.00786	2.933835	2.8214	0.034455	24	9

R = fraction of rainfall volume entering the collection system as RDII
T = time from the onset of rainfall to the peak of the Unit Hydrograph
K = ratio of time to recession of the Unit Hydrograph to T

Table 5.25 35th Percentile RTK Infiltration Values Calculation

Unit Hydrograph Group ID (Char)	Parameters for Month	IAD Max Depth (Short-Term) (in)	IAD Recovery (Short-Term) (in)	IAD Initial Depth (Short-Term) (in)	IAD Max Depth (Mid-Term) (in)	IAD Recovery (Mid-Term) (in)	IAD Initial Depth (Mid-Term) (in)	IAD Max Depth (Long-Term) (in)	IAD Recovery (Long-Term) (in)	IAD Initial Depth (Long-Term) (in)
Future 35th Percentile	6: Jun	2.075	0.35	0	2	0.37075	0	2	2.875	0

IAD Max Depth - Maximum initial abstraction loss possible. Rainfall depth in excess of the maximum abstraction depth would be converted to an RDII according to the R, T and K parameters
IAD Recovery -Rate at which the initial abstraction loss recovers during the dry periods between two rain events
IAD Initial Depth - Depth of the abstraction losses already satisfied at the beginning of the simulation. If a grid cell is left empty its corresponding parameter value is assumed to be 0

5.8 Future Model Facilities

This section discusses sanitary collection system facilities developed for use in future conditions modeling. Future conditions are analyzed for the four planning periods of 2026, 2036, 2066, and 2116. However, there are numerous locations where development is anticipated to occur in the upstream portions of projected sewersheds before downstream trunk sewers are constructed. Because of this, interim solutions are anticipated that will send future flows through the existing collection system prior to the major future trunk sewers being built. These interim solutions can include pump stations diverting flow to existing trunk sewers, equalization basins, and/or upsizing the existing collection system.

The results of the future collection system modeling and improvement identification is discussed in detail in Chapter 9 - Collection System Analysis and Improvement Alternatives.

5.8.1 Pipes and Manholes

For future growth, the City's major sanitary basins were modified or extended to accommodate anticipated build out for the development Tiers. Future trunk sewer extensions were developed using the trunk extensions conceptualized in the 2002 facilities plan developed by Black and Veatch as a base. These 2002 trunk extensions were adjusted or extended based on new topographic information, new growth areas, and discussions with City staff. Manholes were placed at 1,000 foot intervals for profile generation and future flow loading points. Ground elevations and inverts were based first on the 2012 LiDAR data and then on 2008 contour data in areas where 2012 data isn't available. Manhole inverts were assumed to be 10 feet deep and adjusted accordingly to create positive pipe slopes. Future trunk sewers are sized based on ultimate 2116 flow.

5.8.2 Pumping Stations and Force Mains

There are numerous locations within the projected collection system that will require either temporary or permanent pump stations as well as associated force mains. For temporary pump stations, these locations are typically diverting future flows to the existing collection system due to downstream facilities being built in a future year. For permanent pump stations, these locations are typically low areas in the landscape that cannot be served by gravity mains or areas where it is not practical to accommodate future flows through the City.

5.8.3 Flow Equalization Facilities

The most practical way of accommodating future growth extensions into the existing system is through the use of equalization basins. Equalization basins are sized and modeled to have a reasonable drain time for the 25-year, 96-hour Capacity Analysis Storm. There are numerous locations conceptualized to have equalization facilities depending on the improvement alternative.

5.8.4 Remote Treatment Facilities

There are a couple of locations, on the east and west sides of the City where a future remote treatment facility may be a feasible option of handling future flows. Although these future potential treatment facilities are not modeled explicitly, they are sized based on the modeled projected peak flows after equalization to these locations .

5.9 Abbreviations

ADWF	Average Daily Dry-Weather Flow
BWP	Base Wastewater Production
CIP	Capital Improvement Program
City	City of Sioux Falls
DWI	Dry-weather Infiltration
gpm	Gallons per Minute
mgd	Million Gallons per Day
RDII	Rainfall Derived Infiltration and Inflow
SIU	Significant Industrial User
TAZ	Traffic Analysis Zone

5.10 References

Black & Veatch, “City of Sioux Falls Sanitary Sewer Collection System Facilities Plan”, 2002.

Unknown Author. Wastewater Collection System Facilities Plan. 1990

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Chapter 6 – Regulatory Planning

2016 Wastewater Treatment and Collection System Master Plan

Sioux Falls, SD

February 2018

Table of Contents

Tables

Figures

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Chapter 6 Regulatory Planning

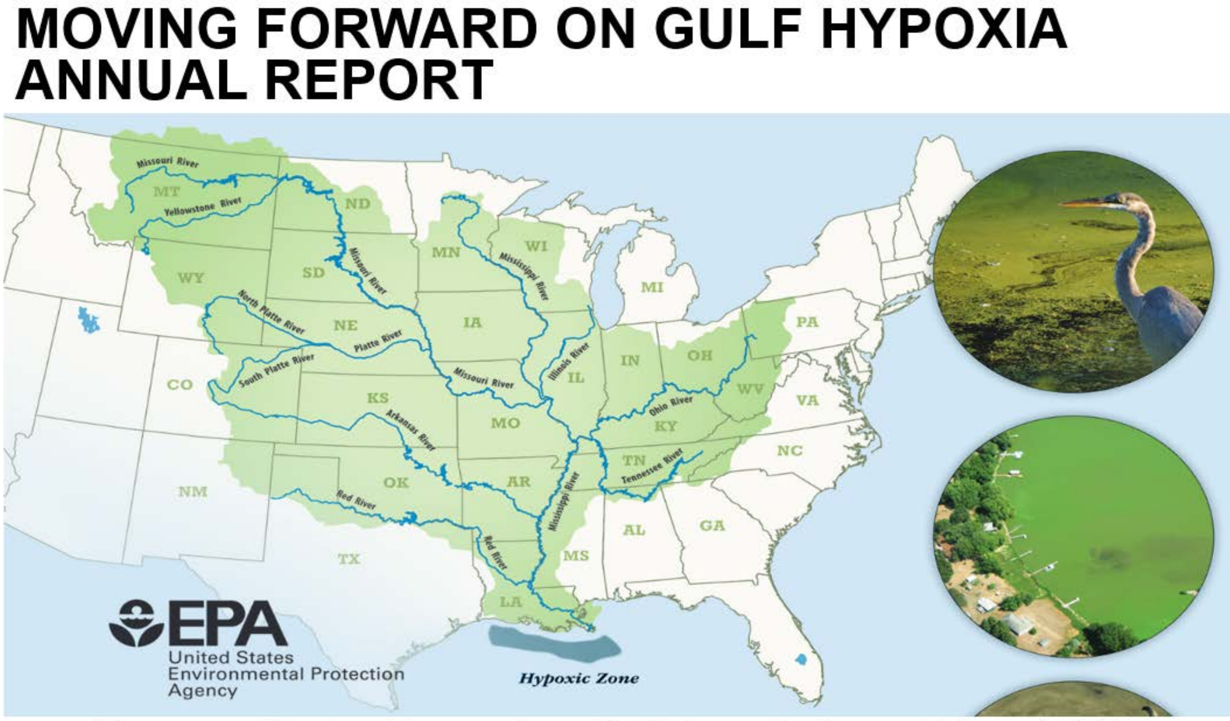
6.1 Introduction

This section of the master plan is to provide regulatory information to be used in planning for the City's wastewater treatment needs for the next 20 years and beyond. The goal is to best identify the physical modifications required to plan for potential future Surface Water Discharge (SWD) permit changes. Specific planning emphasis is to address ammonia limits, which are expected to be implemented by 2027 and nutrient discharge limits, which are expected to be implemented by 2032 with planning for continued treatment through year 2047.

The anticipated regulatory requirement of more strict ammonia and nutrient removal from wastewater treatment facilities (WRF's) discharges will be a critical factor in the planning for improvements at the Sioux Falls WRF and design of potential satellite wastewater treatment plant(s). A wider regional focus on nutrients is occurring because of the Gulf of Mexico hypoxia shown in Figure 6.1. Hypoxic zones are areas in the ocean of such low oxygen concentration that animal life suffocates and dies, and as a result are sometimes called "dead zones. The focus on solving these environmental endangerments is driving efforts to reduce nutrient discharges throughout the Missouri River watershed, which includes discharges from the Sioux Falls WRF, as shown Figure 6.1. In fact, due to the lack of progress on the part of the states, legislation has begun pushing the EPA to take primacy and implement these new nutrient standards on a federal level. To avoid more stringent limits directly enforced by the EPA, surrounding states including Minnesota, Iowa, Wisconsin, Montana and Colorado are in the process of incorporating nutrient discharge limits, which indicates that any municipal wastewater treatment facility, such as the Sioux Falls WRF, should be prepared for new and/or more stringent nutrient limits for future discharge permits. The regulatory planning and associated dates in this section are based on the best available information from the South Dakota Department of Environment and Natural Resources (SDDENR), United's States Environmental Protection Agency (US EPA) and surface water discharge permit development in other states within this watershed.

As outlined in this chapter, the nutrient removal treatment capacity evaluations along with the recommended improvements are based on meeting a "Level 1" maximum monthly average Total Nitrogen (TN) requirement of less than 10 mg/l and a monthly average Total Phosphorus (TP) limit of 1 mg/l. However, the City should be aware there is a significant level of ongoing effort in determining nutrient criteria across the U.S. As such, future nutrient discharge limits should still be considered to be very unpredictable. Proposed limits have been challenged in court by environmental activist groups and/or the EPA in instances where the proposed limits were considered to be inappropriate or untimely. In some states, legal action has greatly accelerated the implementation of more stringent discharge limits. Therefore, there is a chance that the limits may be more restrictive than Level 1, but Level 1 is consistent with limits imposed in similar U.S. states.

Figure 6.1 Missouri River and Gulf of Mexico Hypoxic Zone



- (Source – Moving Forward on Gulf Hypoxia Annual Report 2015 – Gulf of Mexico Watershed Nutrient Task Force)

The primary driver for reduction in ammonia in the Big Sioux River and Skunk Creek is the 2013 EPA update to the 1999 and 2009 aquatic life ambient water quality criteria, which is approximately half of the current ammonia permitted values.

There are several significant issues that influence the wastewater facilities planning and discharge limitations for the City of Sioux Falls:

- New and future discharge permits with the greatest affect being ammonia and nutrient discharge limits.
- Increased design flow affecting permit limits and non-degradation provisions to the Big Sioux River and Skunk Creek (if a Westside WRF is constructed).
- Big Sioux River and Skunk Creek water quality. Both water bodies are considered impaired due to e-coli.
- Revised federal ammonia nitrogen criteria adopted in 2013, which will be incorporated into South Dakota water quality standards at the completion of the next triennial review in 2017 and implemented into Sioux Falls WRF NPDES Permit.
- 40 CFR Part 503 regulation impacts on biosolids

Discussions with SDDENR, experience with recent permits being drafted in South Dakota and review of WRF influent and effluent data have identified the significant issues that are likely to be introduced in future updated discharge permits, which include: new ammonia nitrogen discharge limit and new total nitrogen (TN) and total phosphorus (TP) limits. The ammonia limits are fairly well defined based on the new federal ammonia criteria however; many factors affect the future TN and

TP limits. At this time, the TN and TP numeric limits in the upcoming discharge permits cannot be absolutely defined. However, a progression of more stringent limits has been developed based on discussions with SDDENR and comparisons with how other similar Midwest states are dealing with implementing these pending EPA driven limits. The ammonia, TP and TN limits have significant effects on treatment processes. The existing treatment processes will require modification/expansion to meet these anticipated limits.

The first step in the process will likely include additional monitoring in the upcoming discharge permit. Requirements are likely to include more complete effluent quality data with a focus on more intensive requirements for ammonia and nutrients. This was verified by the SDDENR, stating that total nitrogen and total phosphorous monitoring will be included. They also indicated that if they can get the permit issued before the next triennial review, they would not have to update the ammonia limits until the next permit reissue.

Biosolids are affected by 40 CFR Part 503 regulations. The City intends to move away from the existing lagoon storage and city land application methods after 2021 to a dewatering process. The dewatering was assumed in the analysis to produce sludge that is 24% solids and to dry sludge to 92% solids. The dried cake would be stored in an aboveground pad/bunker for giveaway (half) and for contracted land application (half) on existing land application sites. The biosolids would need to meet Class A or Class B requirements, Class A if given to the public and Class B if land applied.

6.1.1 Ammonia Water Quality Criteria

In 2013, EPA updated the freshwater ammonia aquatic life ambient water quality criteria in accord with the provisions of Section 304(a) of the Clean Water Act to reflect the latest scientific knowledge. The largest impact for ammonia is the presence, or not, of fresh water mussels. The anticipated mussel toxicity criteria are significantly more stringent than those currently in place for the Sioux Falls WRF.

6.1.2 Total Maximum Daily Load

As with ammonia, changing water quality regulations for nutrients dictate that consideration be given to modifications to improve treated wastewater effluent quality. The South Dakota Department of Natural Resources (SDDENR) is required to develop Total Maximum Daily Load Evaluation (TMDL) for all water bodies on the 303(d) list which includes the Big Sioux River (the current receiving water body and for the potential Eastside WRF) and Skunk Creek (the potential receiving stream for a Westside WRF). A TMDL determines the total amount of a constituent that a water body may receive from all sources without exceeding water quality standards. A TMDL may require a reduction in constituent loading to meet water quality standards.

The Big Sioux River in the current effluent discharge area is impaired based on Escherichia coli but has an EPA approved TMDL. The Big Sioux River in the likely discharge area for an Eastside WRF and Skunk Creek both require a TMDL and are categorized as a Priority 1 and are scheduled for completion in 2016 for total suspended solids and e-coli. The SDDENR indicated that these TMDLs will need to account for the loading from the new WWTFs and approved by EPA before they can issue permits for them. They have been in discussions with EPA about what revisions we will need to make to the TMDLs. The SDDENR indicated that the TMDL will likely include allocations for future discharges. Future permits for new or expanded facilities would be issued under this allocation.

6.1.3 Numeric Nutrient Criteria

Numeric water quality limits are intended to control excessive nutrient (nitrogen and phosphorus) pollution in streams, rivers, and lakes. The intent of numeric nutrient discharge limits is to provide water quality that protects the beneficial uses of these water bodies. As previously described, areas of the country already have numeric standards in place and others are developing them. It is not uncommon for nutrient criteria to be set below the limits of technology. In South Dakota, minimal work has been done to date on developing numeric nutrient criteria. The SDDENR is encouraging systems to plan to meet Level 1 criteria in master planning efforts.

6.1.4 Viruses

The EPA is currently working on Ambient Water Quality Criteria (AWQC) for Viruses, which needs to be considered for potential impacts to the Sioux Falls WRF. They are considering quantitative microbiological risk assessment (QMRA) and/or epidemiology along with analysis of bacteriophage analysis to develop the criteria. Many illnesses are viral driven and are inactivated at a slower rate than bacteria (especially with chlorine disinfection) and phages are a good surrogate for human enteric viruses. In conversation with the SDDENR, the inclusion of AWQC for viruses is currently not on their timeline for implementation.

6.2 Timing for Planning

Anticipated regulatory changes that will be imposed on the WRF were evaluated along with the potential impact on the proposed improvements required to meet those conditions for the next 20 years and beyond. Specific planning emphasis addressed ammonia limits, which are expected to be implemented by 2026 and nutrient discharge limits, which are expected to be implemented by 2031, with planning for continued treatment through year 2047

6.2.1 Ammonia

The primary driver for reduction in ammonia in the existing and potential receiving water bodies (Big Sioux River and Skunk Creek) is the 2013 EPA update to the 1999 and 2009 aquatic life ambient water quality criteria, most notably impacted by the presence or absence of freshwater mussels. The limits are anticipated to be approximately half of the current ammonia permitted values. Freshwater mussels are found in the Big Sioux River, including the White Heelsplitter, Fragile Papershell, Pink Papershell, Mapleleaf and Giant Floater (*Freshwater Mussel Survey of the 39-Mile District - Missouri National Recreational River, South Dakota and Nebraska, Jeff Shearer and Doug Backlund, South Dakota Game, Fish & Parks with Stephen K. Wilson, National Park Service (SD GFP Report 2005-08*).

6.2.2 Nutrients

The nutrient removal treatment capacity evaluations along with the recommended improvements are based on meeting a “Level 1” Total Nitrogen (TN) requirement of less than 10 mg/l and a Total Phosphorus (TP) limit of 1 mg/l. Planning to meet Level 1 is consistent with discussions with SDDENR and limits imposed in similar U.S. states. The City should be aware there is a significant level of ongoing effort in determining nutrient criteria across the U.S. As such, future nutrient discharge limits should still be considered to be very unpredictable. Proposed limits have been challenged in court by environmental activist groups and/or the EPA in instances where the proposed limits were considered to be inappropriate or untimely. In some states, legal action has greatly accelerated the implementation of more stringent discharge limits. Therefore, there is a chance that the limits may be more restrictive than Level 1.

The following Table 6.1 presents a summary of anticipated future Sioux Falls WRF discharge permit renewal dates and the anticipated limitations to be included in each permit. In addition, the corresponding recommended activity for the City is listed. The permit sequence is defined as follows:

- Current permit (Operating Under Expired Permit): No reissuance date has been proposed.
- Permit #1 (2022) – Compliance Schedule for New Ammonia Standards
- Permit #2 (2027) – New Ammonia Standards
- Permit #3 (2032) – New Nutrient Standards

Table 6.1 Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit	NA	Plan for anticipated more stringent ammonia standards. Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability.
		Schedule for construction –major projects will be dependent upon issuance of a new discharge permit and its compliance schedule.
		Proactively evaluate if incorporating river flow based and mass vs. concentration limits are beneficial to the WRF.
Permit #1 2022	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project to be constructed by 2025.
Permit #2 2027	New Ammonia Standards	Assuming required improvements for ammonia removals complete.
		Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2029.
Permit Cycle (Year)	**Projected Limitations**	**Recommended Activity**
Permit #3 2032	New Nutrient Standards : Total Maximum Monthly Average Nitrogen @ 8-10 mg/l TN and Total Monthly Average Phosphorus Limits at <1.0 mg/l P	Assuming modifications to achieve nutrient reduction (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty.
		Track potential proposed changes in the nutrient standards.
Permit #4 2037	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

6.3 Surface Water Discharge Permit

The City of Sioux Falls' WRF has been operating under an expired surface water discharge permit since June 30, 2005, and no draft has been presented to the City. HDR contacted the SDDENR to discuss the permitting issues and it was indicated that a draft would not be ready until next spring (2017) at the earliest. Based on actions on discussions with the SDDENR and other recent/proposed wastewater treatment plant effluent discharge permits, it is anticipated the most significant likely change affecting the treatment capacity would be more stringent ammonia limits and total nitrogen and total phosphorous monitoring requirements. As mentioned previously, If the updated permit issued before the next triennial review, the SDDENR would not have to update the ammonia limits until the next permit reissue (2022).

When the discharge permit is renewed, the basis is anticipated to be the Total Maximum Daily Loads (TMDLs) for waters at levels necessary to achieve and maintain water quality standards. The SDDENR will provide a draft permit and Sioux Falls will have have an opportunity to review and comment on the proposed permit. The SDDENR would review such comments and make a determination on whether to incorporate the City's comments. The SDDENR will then publish the surface water quality permit limits in a local newspaper for a 30-day public comment period. If the permit is contested, the SDDENR will decide whether or not to incorporate the comments. If the comments would be further disputed, a contested hearing would be conducted and the Secretary would consider the evidence and issue a final decision with the permit changes to reflect the decision.

The following sections contain a summary of the key permitted parameters which will impact the updated permit:

- Ammonia
- BOD
- Escherichia coli (E. coli)
- Total Suspended Solids (TSS) and,
- Dissolved Oxygen

6.3.1 Ammonia

As mentioned, ammonia limits will likely offer the greatest challenge for treatment and permit compliance at the Sioux Falls WRF. Other South Dakota municipalities have draft permits with effluent limits for ammonia which vary monthly and are calculated based on actual receiving stream and plant flow as variables. It is recommended that Sioux Falls investigate the option of having flow based discharge limits. In addition, it would be prudent to investigate load based discharge limits vs. the typical concentration based limits, as the impact and potential benefits vary by facility. These ammonia limits include both monthly averages and daily maximum ammonia calculations for determining concentration based limits.

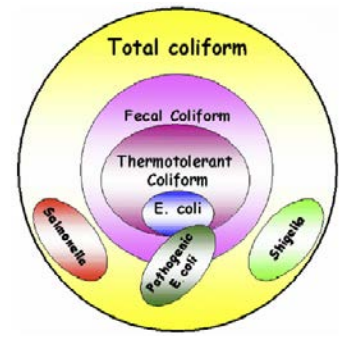
6.3.2 Biochemical Oxygen Demand (BOD)

Recent issued and draft permits in South Dakota have also seen slight reductions in effluent BOD limits. Such a change would be relatively minor, would have limited impact and would be unlikely to drive improvements at the Sioux Falls WRF.

6.3.3 Escherichia coli (E. coli)

The existing permit includes a monthly limit of Fecal Coliform less than 200 colonies/100ml geometric mean and a daily max of 400 colonies/100ml. This limit was effective from May 1 to September 30. This parameter measures an arbitrary indicator organism selected to give an indication of disinfection effectiveness, which has historically been the Fecal Coliform group. This has been used since these bacteria are native to the intestinal tract of warm-blooded animals and, thus, are dispersed in fecal material. As a rule, these bacteria are harmless and even aid in digestion. They are useful indicators because they are always present when there is fecal contamination, they exist in a water source longer than most pathogens, and they disappear rapidly under the same conditions that remove pathogens.

The switch to E. coli is being implemented since E. coli are considered to have a higher association with disease outbreaks, than general Fecal Coliforms and Fecal coliform testing can experience “false-positives” from plant-based bacteria.



Typically, the new permits stipulate E. coli organisms shall not exceed a concentration of 126 per 100 milliliters as a geometric mean. E. coli is a subset of the Fecal Coliform family and the limit of 126 was derived from a typical concentration on E. coli in the fecal coliform group (63%). While this is typical, some facilities have seen issues complying with the E. coli limit vs. the fecal coliform limit. Sioux Falls has been sampling and running duplicate tests, monitoring for Fecal coliform and E. coli since September 2011, to proactively evaluate if the anticipated indicator organism switch will impact the test result. This has been demonstrated not to be an issue at the Sioux Falls WRF.

6.3.4 Total Suspended Solids (TSS)

Recent reissued or draft permits in South Dakota with total suspended solids (TSS) concentration limits similar to the Sioux Falls WRF (30 mg/L, 30-day average and 45 mg/L 7-day average) were unchanged. Based on this precedent and discussions with SDDENR we anticipate no change in TSS limits for the Sioux Falls WRF.

6.3.5 Dissolved Oxygen

The current dissolved oxygen minimum limits are 5.0 for April, May, September and October and 5.5 for the other eight months and it is not anticipated that significant changes would be proposed in a new permit. Dissolved oxygen monitoring demonstrates the levels are significantly higher than these levels consistently and these limits will continue to be met with the current cascade aeration steps and can be supplemented with the existing post aeration system, but is not anticipated to be required.

6.4 Future Permit Limits

This section contains a summary of the key future treatment limits including the following permit parameters:

- Permit #2 -Ammonia
- Permit #3 -Total Nitrogen
- Permit #3 -Total Phosphorus

6.4.1 Ammonia Limits (Permit #2, 2013 EPA Ammonia Criteria)

A potential regulatory driver for future SWD permits is the Permit #2 Ammonia Criteria which lower toxicity limits. The largest impact for ammonia is the presence (or not) of fresh water mussels. The anticipated mussel toxicity criteria are significantly more stringent than those currently in place for the Sioux Falls WRF.

Table 6.2 summarizes the existing SWD permit limits along with the potential ammonia limits when a mussel water quality criterion is used. Per discussions with SDDENR, the potential ammonia limits are one-half of the of current ammonia limits. The revised federal ammonia nitrogen criteria will be incorporated into South Dakota water quality standards at the completion of the next triennial review in 2017 and implemented into permits for compliance monitoring.

Table 6.2 Existing (2005) and Potential Permit #2 Ammonia Limits

	Existing Permit 30-day Average mg/l	Existing Permit Daily Max mg/l	Estimated Future Permit 30-day Average mg/l	Estimated Future Permit Daily Max mg/l
January	4.3	7.5	2.1	3.7
February	4.3	7.5	2.1	3.7
March	4.3	7.5	2.1	3.7
April	2.0	3.5	1.0	1.7
May	2.0	3.5	1.0	1.7
June	2.0	3.5	1.0	1.7
July	2.0	3.5	1.0	1.7
August	2.0	3.5	1.0	1.7
September	2.7	4.7	1.3	2.3
October	2.7	4.7	1.3	2.3
November	4.3	7.5	2.1	3.7
December	4.3	7.5	2.1	3.7

1. *Based on discussions between HDR and SDDENR, future ammonia limits could be approximately one-half of the existing limits.*

As mentioned previously, it is documented that several species of freshwater mussels exist in the Big Sioux River and its tributaries (which would include Skunk Creek). As such, it is anticipated that the more stringent ammonia limits being driven by its impact on mussels will be implemented in a renewed discharge permit for the Sioux Falls WRF.

HDR met with SDDENR to discuss the potential more stringent ammonia limits and it was indicated that any ammonia discharge limit changes may not be included until the next triennial review, scheduled for 2017. After the next triennial review, there will be a one to two year period of rulemaking. Then, as permits are renewed, they will include the proposed ammonia limits with a compliance schedule for implementation of new facilities if necessary. This may take two permit cycles. Under the current approach, incorporation of the new ammonia limits will not take place for a minimum of 10 years.

Given that mussels are present, facility planning includes treating to the new Permit #2 ammonia criteria with mussels present by 2027.

6.4.2 Nutrient Discharge Limits

Over the next three SWD permit cycles, point source discharges, such as the Sioux Falls WRF, will likely be required to monitor parameters to be used to achieve biological nutrient removal, and then will be provided a moratorium with more stringent standards in place for the year 2032. As noted previously, EPA or legal action could force a more aggressive approach in South Dakota.

Based on HDR’s conversations with SDDENR, there does not appear to be a current planned date for establishing nutrient criteria for South Dakota. Those discussions indicate that it is reasonable to plan for permit levels for nutrients consisting of discharge concentrations in the ranges of a monthly average 1.0 mg/l P and maximum daily average 10 mg/l TN to be met in year 2032.

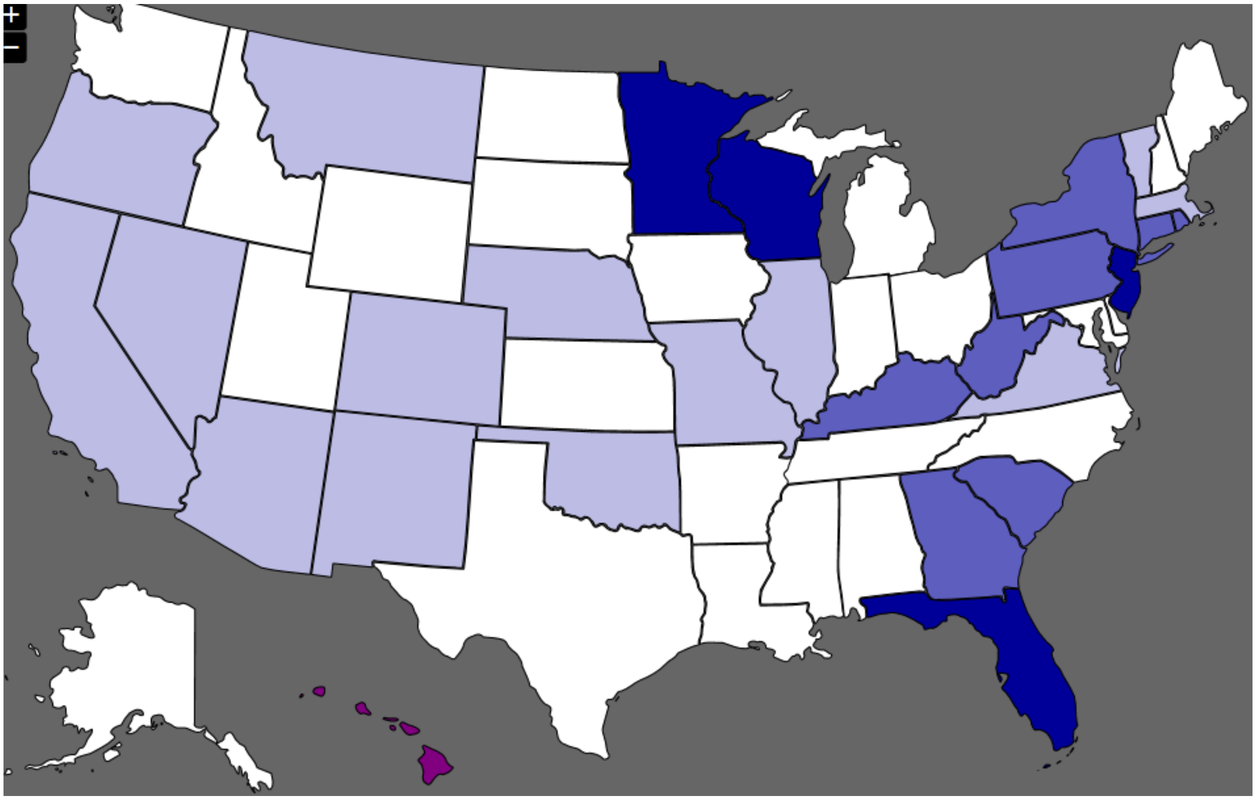
For comparison purposes, Table 6.3 summarizes the total nutrient goals for several other states in the region.

Table 6.3 Nutrient Goals for Other States in the Region

State	Total Nitrogen Goal, mg-N/L	Total Phosphorus Goal, mg-P/L
Kansas (Tier 1)	8	1.5
Iowa	10	1.0
Missouri	10	1.0
Minnesota	n/a	1.0
Wisconsin	≥ 10	1.0

Figure 6.2 depicts the total nation-wide nutrient implementation status based on the individual state’s documented milestones thru year 2019. This indicates that a plan is in place to implement some form of nutrient limits within the next few years in these states. North Dakota has a task force in place, which is actively working to address implementing nutrient limitations.

Figure 6.2 State-wide Nutrient Permit Limit Status



Two or more water types with N and/or P criteria

One water type with N and/or P criteria

Waters with N and/or P criteria

6.4.3 Emerging Constituents of Concern

There are many compounds of emerging concern. Compounds of concern to health and environmental professionals, as well as the public, include endocrine disrupting compounds (EDCs), pharmaceuticals and personal care products (PPCPs).

The term microconstituents also is frequently used to define these compounds of concern. Microconstituents have been defined by the Water Environment Foundation (WEF) as natural and man-made substances, including elements and inorganic and organic chemicals detected within water and the environment, for which continued assessment of the potential impact on human health and the environment is a prudent course of action.

Microconstituents include a variety of human and veterinary medicines (i.e., naproxen, gemifibrozil, carbamazepine and sulfamethoxazole), industrial and household products (i.e., insecticides, alkylphenols and fire retardants) and hormonal compounds like estrogens and androgens. Products containing these compounds are commonly used by both consumers and manufacturing and agriculture companies in the United States and around the world.

The compounds are excreted from humans in their waste. It's also been a common practice for consumers to flush unused or expired pharmaceuticals down the drain or into the toilet, as often suggested by law enforcement authorities and some health care providers. Some of these compounds can be effectively removed in the wastewater treatment process while others are removed less efficiently and pass through to receiving waters. Some compounds removed in wastewater treatment are accumulated in the biosolids residuals generated in the treatment process.

As analytical techniques continue to evolve, additional animal and epidemiological studies will help us better understand the implications on human health. The United States Environmental Protection Agency (EPA) has an ongoing research program aimed at understanding the effects of EDCs and other microconstituents on human health and the environment. Some compounds known to have an impact on endocrine systems – such as pesticides, herbicides, heavy metals and arsenic – are currently regulated by the EPA, but this isn't true for most of the microconstituents.

From the point where we are now in the understanding of the human health issues, it will be at least 10 years before many of these microconstituents can be regulated.

Preventing these compounds from entering the water environment would be ideal. However, pharmaceuticals and other compounds are widely used. They will continue to be contributed to sewers and wastewater treatment systems that receive human waste.

Studies have been conducted to investigate the effectiveness of wastewater treatment processes to remove microconstituents in sewage. For many compounds, substantial removals have been achieved in existing and widely used wastewater treatment processes such as secondary treatment with activated sludge. Other compounds are soluble, resistant to decomposition and have limited removal rates in existing treatment processes.

More advanced treatment processes employed for nutrient removal and reclaimed effluent reuse may enhance removal rates for some microconstituents. Longer detention times and enhanced solids separation processes, such as membrane treatment, provide better removals than conventional processes for many compounds.

Our understanding of removal mechanisms is in its early stages and much work needs to be done to increase our understanding of efficiency and optimization techniques. It appears that our standard water treatment plant processes have limited ability to remove selected microconstituents.

Typical treatment processes for treatment of microconstituents are:

<u>Microfiltration (MF) and Ultrafiltration (UF):</u> Pressure-driven membrane processes used to remove particulate matter, including turbidity and microorganisms. MF and UF are effective pre-treatment processes for reverse osmosis and nanofiltration but are not considered as effective removal processes in and of themselves from a drinking water standpoint. Membrane filtration techniques also show promise depending on the pore size of the membrane. Most of the membrane filtration systems in place weren't designed to remove microconstituents but do so by removing suspended solids.

Reverse Osmosis (RO) and Nanofiltration (NF): Pressure driven membrane processes in which hydraulic pressure in excess of a membrane's osmotic pressure is applied to push water through a dense membrane. Removal is not solely based on size exclusion, but also on diffusive and electrostatic properties. The key difference between NF and RO is that NF does not remove monovalent ions (i.e., sodium and chloride). RO usually requires higher operating pressures than NF.

Granular Activated Carbon (GAC): GAC offers large available surface area via its porous pore structure which contaminants can diffuse into and adsorb onto. GAC is effective for removal of broad classes of microconstituents and also provides other water quality benefits, such as removing taste and odor compounds. GAC is often utilized after ozonation, which is called Biologically Activated Carbon (BAC). Granular activated carbon shows promise, but its effectiveness will depend on the specific microconstituent, the presence of competing constituents and the type of activated carbon used.

Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process (UV-AOP): UV photolysis of hydrogen peroxide generates hydroxyl radicals (•OH) that have an oxidation potential greater than other strong oxidants. Hydroxyl radicals are non-selective and have fast reaction rates with organic and inorganic species present in natural waters. UV-AOP is effective for disinfection and destruction of broad classes of microconstituents. GAC can also be used for hydrogen peroxide quenching after UV-AOP.

The ability of a specific treatment process to remove the emerging contaminant in question depends on the specific compound, its concentration, form and other variables.

6.5 Regulatory Strategy Recommendations

With the potential for significant changes to upcoming discharge permits that could impact the ability to meet limits and require costly modification to the WRF, it is recommended that the City maintain a proactive role in the permitting process, working with the SDDENR prior to and during development. By doing so, concerns with potential changes can be identified and addressed immediately, even before being drafted. Some potential measures for taking the proactive action include:

- Early Engagement in the Permitting Process
  - State Numeric Nutrient Criteria Development
  - Watershed TMDLs
  - Individual Permits
- Technical Input and Support
  - Capabilities of Treatment
  - Effluent Characterization
- Long-term Support
  - Lay Foundation for Regulatory "Solutions"
  - Sustained Watershed Perspective
  - Compliance Schedule and Beyond
- Early and frequent dialog with State Regulators & Permit Writers
- Solution Orientation
  - Technology Exchange
  - Foster Shared Understanding

- Treatment Capabilities
- Limitations
- Apply Regulatory “Solutions” When Necessary
  - Consider Options which may Benefit the WRF
    - Load vs. Concentration Limits (pounds vs. mg/l)
    - Limits that Vary with Receiving Stream Flow (i.e. ammonia)
  - Avoid Unattainable Effluent Limits
  - Compliance Schedules, Variances, Site Specific Criteria, etc.

As mentioned, if a new permit is issued prior to the next triennial review, the SDDENR may not update the ammonia limits until the following permit cycle. It may be desirable to work with the SDDENR to finalize the new permit ahead of the completion of the next triennial review in 2017.

It is recommended the WRF be involved prior to the issuance of the draft permit, as the NPDES renewal period alone is inadequate to conduct a thorough evaluation. It is recommended that the WRF work with a consultant for permitting assistance to proactively address the issues, which should include conducting the modeling/analysis independently from the SDDENR. The nuances of the permit can have significant financial impacts to the WRF.

6.5.1 Emerging Constituents of Concern

The recommended WRF improvements include advanced treatment processes for nutrient removal and effluent filtration which provides enhanced removals for some pharmaceuticals and personal care products. If required in the future, there is adequate plant site space for future treatment processes and both the 5-stage MLE process and the MBR secondary treatment processes are adaptable to future treatment process enhancements.

Continued assessment of the potential regulatory impact of microconstituents in the WRF effluent permit is essential.

Chapter 7 – WRF Liquid Process Alternatives Evaluation

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Table of Contents

Tables

Figures

Appendices

Chapter 7 Liquid Process Alternatives Evaluation

7.1 Objective

The objective of this chapter is to review the baseline secondary treatment alternatives and screen alternatives from further consideration which have significantly higher initial costs and/or do not meet the non-monetary criteria developed by the planning team, i.e. acceptable process reliability. The selected alternative is identified via monetary and nonmonetary analyses for subsequent development in Chapter 10 for final costing and implementation.

7.2 Summary of Treatment Planning Basis

Based on future regulatory treatment requirements described in Chapter 6, the following Table 7.1 summarizes the treatment targeted goals. The treatment goals have a safety factor applied to the actual effluent limit to ensure that treatment is provided during minor upset conditions.

Table 7.1 Treatment Planning Basis

Parameter	Treatment Planning Basis
Design Winter Temp, Degrees Celsius	9.5
BOD Effluent Requirement, mg/l	6
Ammonia:	
Winter Maximum Daily Ammonia Limit, mg/l	1.5
Summer Maximum Daily Ammonia, mg/l	0.7
Monthly Average Total Nitrogen (TN), mg/l	8 to meet 10
Monthly Average Total Phosphorus (TP), mg/l	1

As detailed in Chapter 6 –Regulatory Planning of this Master Plan, it is anticipated that the plan for ammonia removal to meet the Permit #2 (2027) Water Quality Standards will be one-half of the current ammonia limits.

7.2.1 Future Planning Basis Considerations

As noted in Chapter 6, it is recommended to proactively evaluate if incorporating river flow based and mass versus concentration limits are beneficial to the WRF. The nuances of the permit can have significant financial impacts to the WRF. Variable limits based on river flows allows for flexible permit conditions at higher river flows and the ability to utilize peaking facilities with less restrictive treatment limits for ammonia. This also applies during wet weather flows that are statistically coincidental with higher river flows.

7.3 Evaluation Process

Alternatives were identified and evaluated through an interactive process involving City and consultant staff. Major elements of the process are described below.

7.3.1 Define Process Methodology and Evaluation Criteria

To provide a consistent planning basis, HDR, WRF and City staff reviewed the alternatives on a qualitative basis.

7.3.2 Brainstorm and Screen Ideas

A workshop was conducted with Dr. J.B. Neethling to identify any and all potential alternatives for expanding or improving the WRF facility. Following the initial brainstorm session, an initial screening step was conducted to eliminate ideas that were fatally flawed, technically unproven, excessively expensive or otherwise unworthy of detailed evaluation.

7.3.3 Detailed Development and Evaluation

Alternatives surviving the initial screening step were developed in detail. Facility sizing and cost estimating were conducted for modular expansion of plant capacity to match up with expected regulatory changes, with Phase 1 facilities constructed by 2025 to treat for Permit #2 (2027) ammonia and Phase 2 facilities constructed by 2029 to treat for the Permit #3 additional nutrient criteria to the 2036 design year flow and loadings. Alternatives were compared based on cost and non-economic criteria. Based on this analysis, preliminary recommendations for facility improvements were made.

7.3.4 Review Workshops

During the development process, meetings were conducted with City and WRF staff to review interim findings and refine the alternatives being evaluated. In addition, population projections were reviewed with the City Planning Department. These workshops presented information on the evaluation process and gained input regarding the technical issues being considered and the planning process used for developing growth projections.

7.3.5 Triggers

Improvements to secondary treatment at the Sioux Falls WRF are needed to provide reliable treatment and pumping capacity, to comply with regulatory requirements, to improve operational efficiency and to provide the ability to pass higher flows through the plant. The key driving forces, or triggers, behind the needed improvements are summarized below.

> **Age and Condition**. A number of the treatment facilities are 30+ years old and have reached their useful life to provide reliable service. Some plant components suffer from deteriorated condition, fail to comply with current codes or provide unsatisfactory and possibly unsafe working environments for the operations staff. The following have been incorporated as key cost components in the alternative life cycle evaluations.

- o Major secondary process, age-related improvements included in the alternative evaluations improvement items include:
  - Primary clarifier mechanism replacement.
  - Aeration blower and diffuser replacement.
  - Aeration basin header, and valve replacement
  - Existing final clarifier retrofit improvements.
  - Gravity thickener rehabilitation.
  - Electrical upgrades.
  - The existing trickling filters will remain in service until nutrient process improvements are put in place. The trickling filters are eliminated from future nutrient treatment alternatives due to excessive operating costs for feeding an external carbon source. Improvements for the trickling filters through the process pump station have been limited as these processes are not part of the Plant of the Future unless high BOD industrial loads drive the need for use.
- o **Operations & Energy Improvements.** Some process improvements will reduce operational costs and/or delay the need for capacity expansions in other portions of the treatment systems. Major improvement items include:
  - Aeration Blower and Fine Bubble Diffuser Replacement.
  - Fats Oils and Grease Receiving Facilities (FOG).
  - Study of best use of excess biogas.

- **Capacity for Projected Peak Flows.** While some peak flow reduction may be achieved through improvements to the collection system i.e. equalization and lining projects, this will not be enough to offset the need to increase the peak flow capacity of the plant. In particular, both adding equalization and providing a splitter box and piping to divert primary clarifier influent flows to the activated sludge portion of the plant is necessary to provide the required hydraulic capacity during high flow.

- **Capacity for Organic loading from Service Area Growth.** The WRF's service population is projected to grow from approximately 170,000 to 296,000 for the 2036 design year; increasing wastewater loadings to the treatment plant. At this rate of growth, in addition to the hydraulically-limited components of the plant, the organic capacity of several major biological treatment components will be reached in less than ten years. Without improvements to this plant or satellite facilities, the plant could risk permit violations.

- **Regulatory.** The regulatory triggers matching up with the timing and activities required are outlined in Table 7.2, which is reiterated from Chapter 6. The intent of this facility planning effort is to define the longer-term path forward for future ammonia and nutrient control so that shorter-term modifications are consistent with the long-term plan. For example, should the primary clarifier and the process pump station capacity be increased to allow for more flow through the trickling filters or should diversion/pumping facilities be provided with additional activated sludge treatment capacity.

Table 7.2 Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit	NA	Plan for anticipated more stringent ammonia standards. Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability.
		Schedule for construction –major projects will be dependent upon issuance of a new discharge permit and its compliance schedule.
		Proactively evaluate if incorporating river flow based and mass vs. concentration limits are beneficial to the WRF.
Permit #1 2022	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project to be constructed by 2025.
Permit #2 2027	New Ammonia Standards	Assuming required improvements for ammonia removals complete.
		Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2029.
Permit Cycle (Year)	**Projected Limitations**	**Recommended Activity**
Permit #3 2032	New Nutrient Standards : Total Monthly Average Nitrogen @ 8-10 mg/l TN and Total Monthly Average Phosphorus Limits at <1.0 mg/l P	Assuming modifications to achieve nutrient reduction (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty.
		Track potential proposed changes in the nutrient standards.
Permit #4 2037	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

7.3.6 Development of Costs

Capital costs are expressed in 2016 dollars. The accuracy of all costs is order of magnitude. These estimates are approximations made for comprehensive planning purposes without detailed engineering or site-specific data. Estimates of this type can be expected to vary from 30 percent less than to 50 percent more than actual final project costs.

Accuracy and Need for Future Analysis

This report is based on plant data received from WRF personnel and observations during the site visits. It is a planning level document, and the measures recommended should be implemented after conducting pre-design and design level analysis. This document uses equipment and construction cost estimates consistent with a level of accuracy corresponding to a Class 4 according to the Association for the Advancement of Cost Engineering (AACE) International Recommended Practices and Standards, No 18R-97.

The sources of construction cost data are:

- Construction cost data for the recent Sioux Falls WRF improvements, adjusted to 2016 dollars.
- Recent construction costs for other, similar facilities, adjusted to regional market conditions and 2016 dollars.
- Equipment pricing from manufacturers, including installation, structure, and housing costs.

Table 7.3 Category of Capital Cost Estimates

Estimate Class	Primary Characteristic	Secondary Characteristic			
	Level of Project Definition Expressed As Percent of Complete Definition	End Usage	Methodology (Typical Estimating Method)	Expected Accuracy Range (Typical Variation in Low and High Ranges[1])	Preparation Effort (Typical Degree of Effort Relative to Least Cost Index of 1[2])
Class 5	0 to 2	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% - +100%	1
Class 4	1 to 15	Study or Feasibility	Equipment Factored or parametric Models	L: -15% to -30% H: +20% - +50%	2 to 4
Class 3	10 to 40	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% - +30%	3 to 10
Class 2	30 to 70	Control or Bid/Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: - 5% to -15% H: +5% - +20%	4 to 20
Class 1	50 to 100	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% - +15%	5 to 100

1. *The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after applying contingency (typically at a 50 percent level of confidence) for a given scope.*
2. *If the range index value of "1" represents 0.005 percent of project costs, then an index value of 100 represents 0.5 percent. Estimate preparation effort is highly dependent on project size and the quality of estimating data and tools.*
3. *Class 4 estimates prepared for this Master Plan.*

All capital costs include allowances for site work and yard piping; contractor mark-up; contingencies; and engineering, legal and administration costs. Present worth costs are calculated using a 3.25% discount rate. Present worth O&M costs are based on 20 years of operation.

The cost estimating procedure is presented in below:

Illustration of Cost Estimating Procedure

Cost Item	Cost
Base Construction Cost	$1,000,000
Site work	$100,000
Electrical and Controls	$150,000
Subtotal A	**$1,250,000**
Mobilization and Bonds (5% of A)	$62,500
Contractor's Overhead and Profit (15% of A)	$187,500
Subtotal B	**$1,500,000**
Undeveloped Costs Not itemized (25% of B)	$375,000
Subtotal C	**$1,875,000**
Engineering, Legal, Administration (25% of C)	$468,750
Total Capital Cost	**$2,343,750**

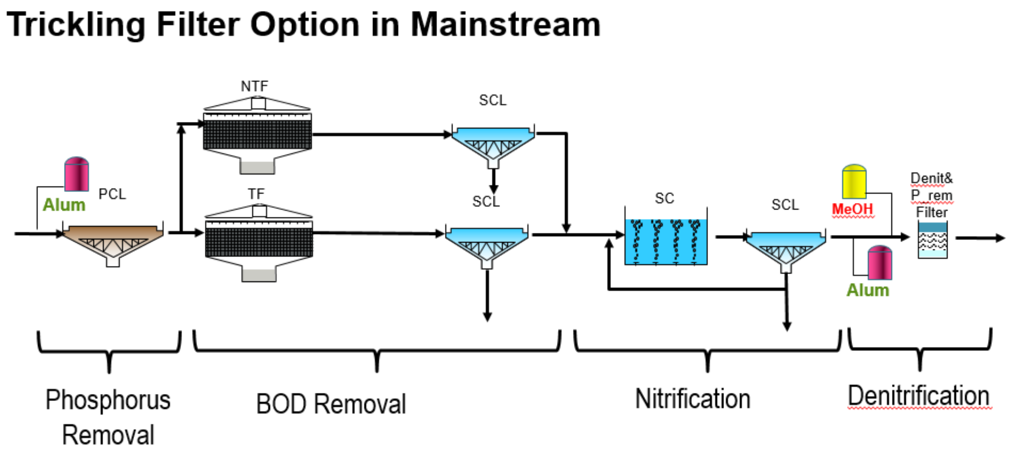
7.4 Alternatives

7.4.1 Screened Process Alternatives

As these alternatives were reviewed, the approach was to start with the end in mind. This meant the plant of the future would be required to take ammonia to below permit levels and reduce total nitrogen to a maximum daily level of 10 mg/l and maximum month total phosphorus to 1 mg/l. In addition, the objective is to provide a process that can be modified to meet lower levels as regulations progress. A complete summary PowerPoint illustrating the screened alternatives in included in Appendix 7.A – Treatment Planning Workshop #1. Additionally, the goal was to adjust the process tankage sizing and configuration as practically feasible to limit methanol feed.

The preliminary analysis showed that due to a significant amount of methanol and the operational cost of these improvements, the long-term trickling filter improvement options for nutrient removal became clearly cost prohibitive and trickling filter alternatives were eliminated. Refer to Figure 7.1 for a schematic of this process.

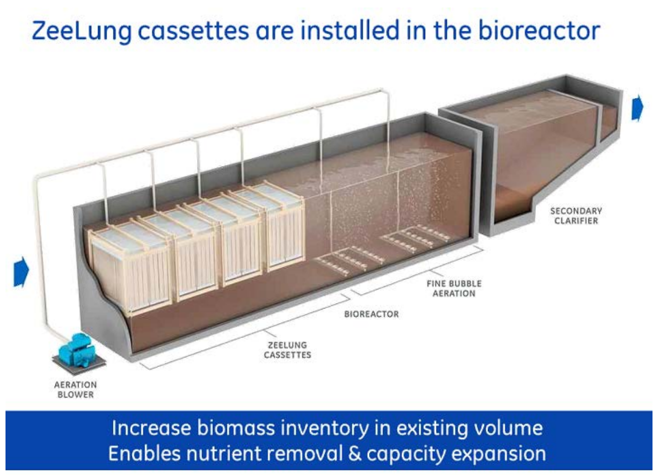
Figure 7.1 Trickling Filter Option - Eliminated



The following secondary treatment alternatives were reviewed:

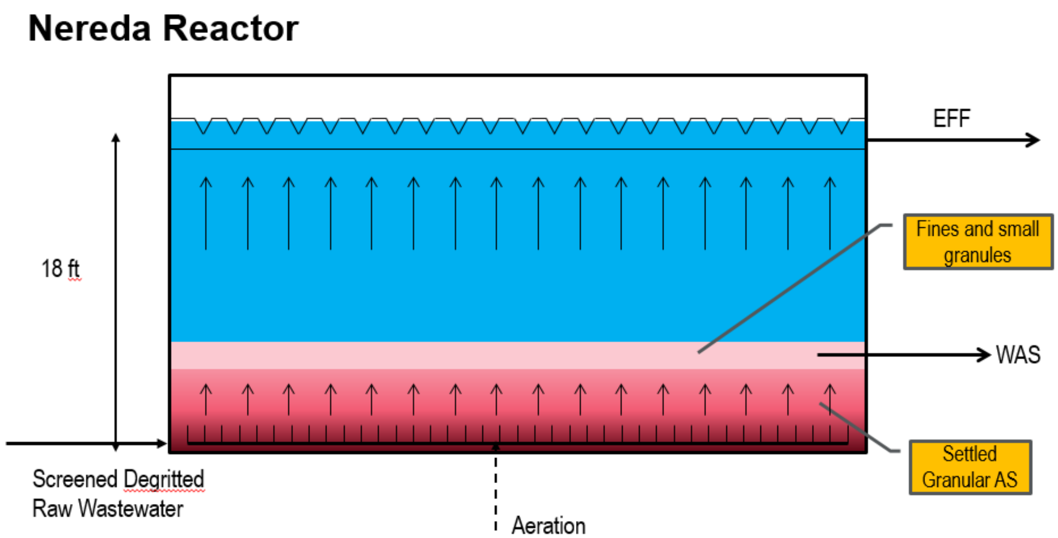
- Parallel Membrane Aerated Bioreactor, MABR (ZeeLung, OXYMEM: 2014)

Figure 7.2 Parallel Membrane Aerated Bioreactor, MABR (ZeeLung)



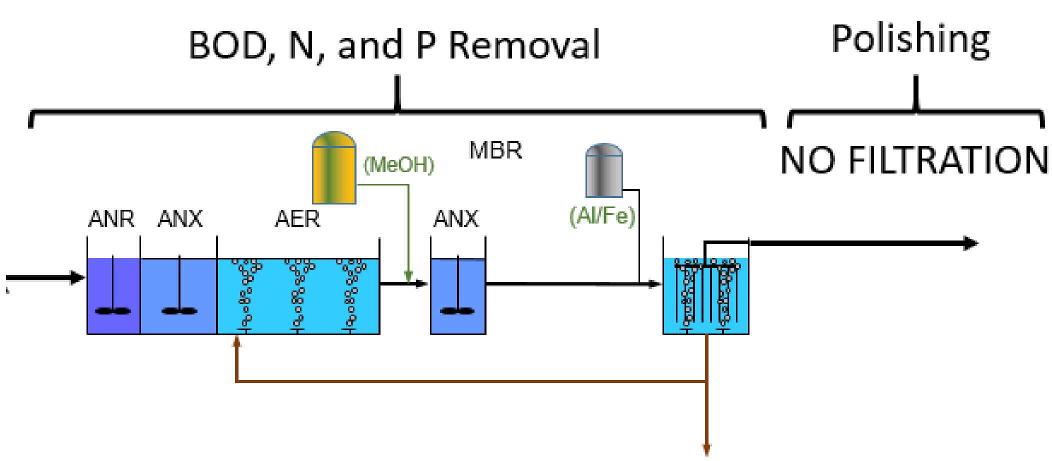
- BioMag, Granular Activated Sludge (Nereda) in Parallel

Figure 7.3 Nereda Reactor



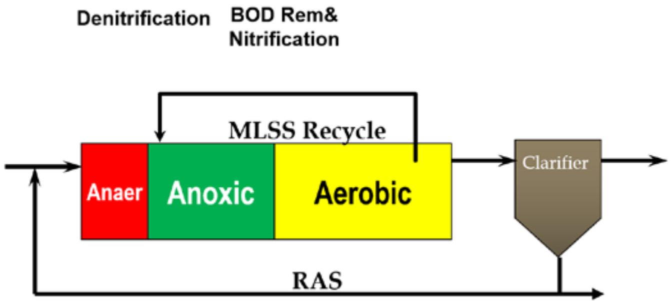
- Membrane Bioreactor, MBR

Figure 7.4 MBR System



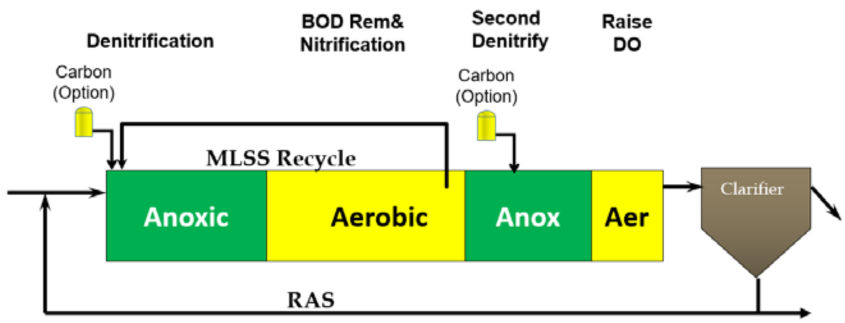
- 3-Stage Modified Ludzack Ettinger (MLE) System (Also known as 3-stage Phoredox and A2O)

Figure 7.5 3-Stage Modified Ludzack Ettinger (MLE) System



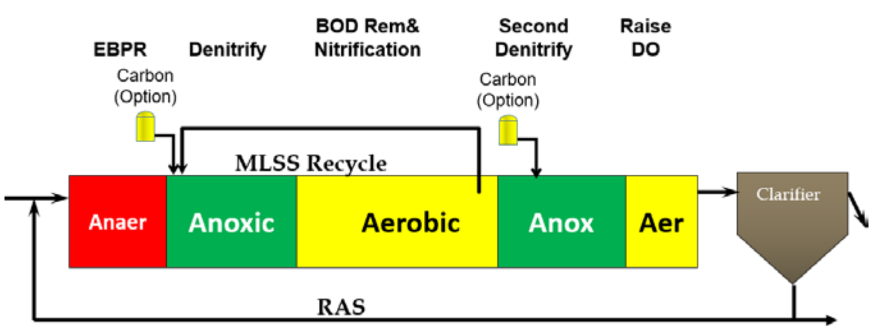
- 4-Stage Modified Ludzack Ettinger (MLE) System

Figure 7.6 4-Stage Modified Ludzack Ettinger (MLE) System



- 5-Stage Bardenpho Biological Nutrient Removal with BioP

Figure 7.7 5-Stage Bardenpho Biological Nutrient Removal



In summary, from the initial screening, the following alternatives were modified or eliminated:

- Integrated Fixed-Film Activated Sludge (IFAS) Process

    - Eliminated as even though there is smaller tankage it was not as cost effective as the Modified Ludzack Ettinger (MLE) System when evaluated as part of the Blending Study and provided no side benefits.
  - Parallel Membrane Aerated Bioreactor, MABR (ZeeLung, OXYMEM: 2014)
    - Eliminated as new technology and does not produce MBR quality effluent.
  - BioMag, Granular Activated Sludge (Nereda) in Parallel
    - Eliminated due to a limited number of proven installations.
  - Membrane Bioreactor, MBR
    - Retained for further evaluation. Approach is to add required MBR treatment as parallel process to existing activated sludge basins, eventually repurpose existing equalization, and build second phase of MBR.
  - 3-Stage Modified Ludzack Ettinger (MLE) System
    - Eliminated as was not able to meet permit limits.
  - 4-Stage Modified Ludzack Ettinger (MLE) System
    - Retained for further evaluation for nutrient removal with chemical phosphorus removal, ChemP.
  - 5-Stage Bardenpho Biological Nutrient Removal with BioP
    - Retained for further evaluation for nutrient removal with biological phosphorus removal, BioP.
  - New East Side WRF Membrane Bioreactor, MBR and 4-Stage Modified Ludzack Ettinger (MLE) System at existing WRF
    - The East Side Facility has previously been determined to be a MBR due to the residential location and small site footprint.
    - Retained for further evaluation.
- New West Side WRF Membrane Bioreactor, MBR and 4-Stage Modified Ludzack Ettinger (MLE) System at existing WRF
  - Eliminated from the 20-year plan as collection system upgrades are being made to convey to existing WRF.
  - Challenges identified with a new west side water reclamation facility were:
    - Discharge from treatment facility is generally upstream of the City and public perception of wastewater discharge through the City will likely be a challenge.
    - Expanding the existing facility as one consolidated WRF will optimize opportunity cost for capacity, as the direction of growth is to a certain extent indefinite.
    - Siting a greenfield facility in a growth area.

7.4.2 Refined Alternatives for Increasing Capacity

This section describes and presents a conceptual plan for alternatives to achieve future ammonia removals and nutrient removal. The flows and loads for Alternative 1-1 thru 1-3 correspond to Option 1 flows and loads outlined in Chapter 4. The flows and loads for Alternative 2-2 correspond to Option 2 flows and loads outlined in Chapter 4.

A comprehensive review of treatment versus pumping flows to the existing WRF are included in *Appendix 7.B – Eastside Sanitary Sewer System Treatment at PS 240, Pump Station and Force*

Main Evaluation. Based on the monetary and nonmonetary weighted decision making, pumping to and expanding the existing WRF was preferred over the PS 240 Satellite MBR.

Therefore, the final recommendation is to implement Existing WRF improvements to be continued through 2036 with the following action items:

- As the projected 20-year growth and resulting flows and loadings flows are approached, an East Side WRF would be reevaluated along with potential for additional PS 240 equalization and a third forcemain.
- The forcemain alignment and associated right-of-way needs to be further evaluated as part of preliminary design.
- A safety factor should be applied to the equalization volume to address the storm of record.
- Also note that the 50-year equalization volume was calculated to be 2.1 million gallons.

The following long-term expansion refined alternatives have been evaluated:

- Alternative 1-1 - 5 Stage Bardenpho Biological Nutrient Removal with Biological Phosphorus (BioP) removal with no carbon addition
- Alternative 1-2 - 4 Stage Bardenpho Biological Nutrient Removal with ChemP and No Carbon (Base Alternative)
- Alternative 1-3 – MBR with Chemical Phosphorus Removal (ChemP) and no Carbon
- Alternative 2-2 – New East Side WRF Membrane Bioreactor, MBR and 4-Stage Modified Ludzack Ettinger (MLE) System at existing WRF
    - (Alternative 2-2 is a combination of Alternative 1-2 constructed at the existing water reclamation facility and a new East Side MBR)
    - Flows and loads correspond to Option 2

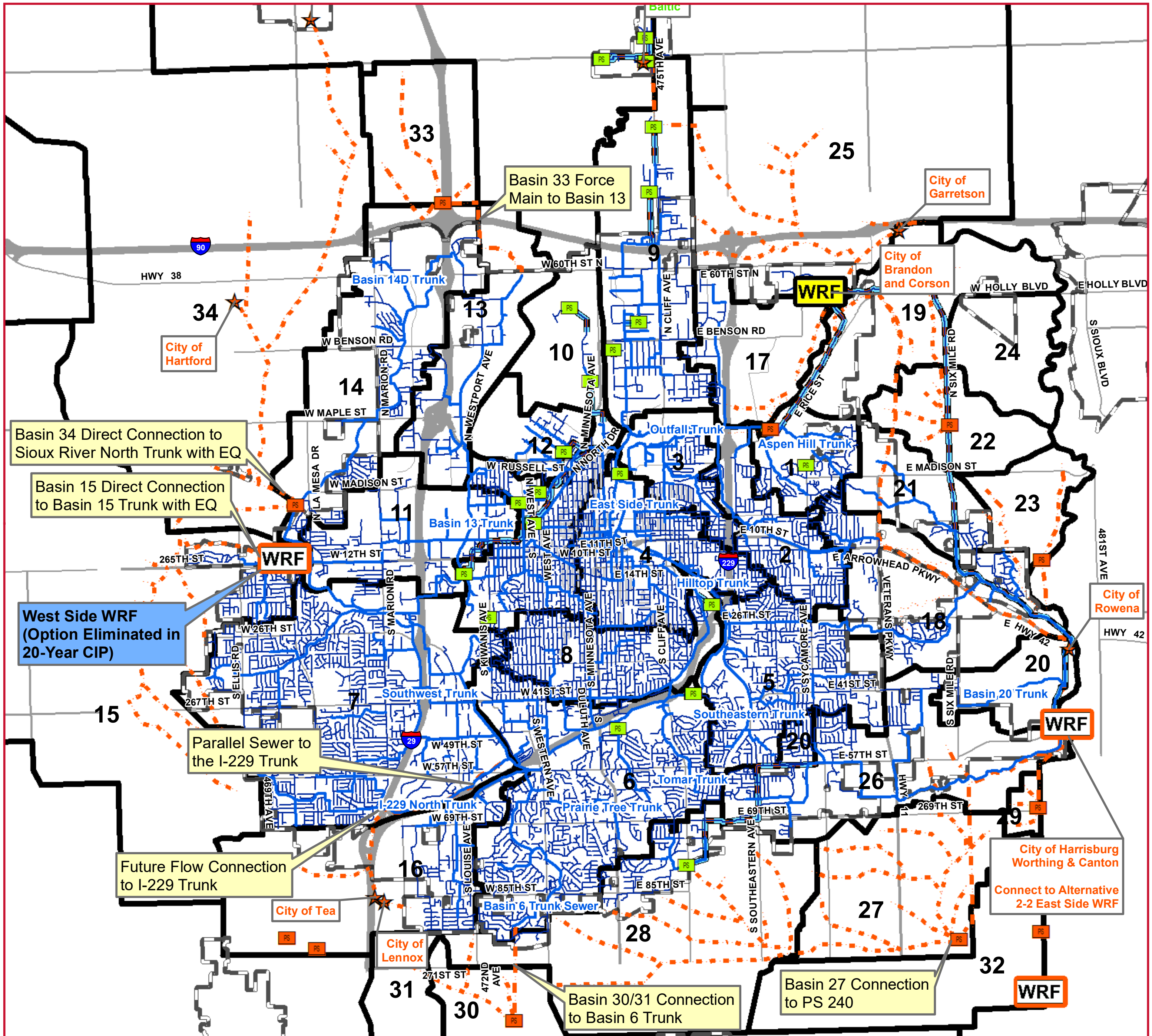
Alternatives 1-1, 1-2 and 1-3 expand the existing WRF to handle 2036 design flows and loads. Alternative 2-2 is a combination of modifications of the existing WRF and a new East Side WRF for treatment of flows from the East Side Sanitary Sewer Basins. Refer to Figure 7.8 for locations of the existing WRF, potential East Side WRF and a general location for the omitted West Side WRF.

New treatment process alternatives included the Permit #2 (2027) ammonia design target as well as the Permit #3 (2032) Total Nitrogen (TN) design target (8 mg-N/L). However, only Alternative 1-1 includes a design component for biological phosphorus removal. The remaining alternatives include chemical phosphorus removal. Long-term plans are focused on achieving steady-state effluent quality meeting permit limits while maintaining stable operation during dynamic peaking events. Again, as noted above, the goal when generating the alternatives was to reduce the need to feed methanol. Secondly, modelling showed that there was no benefit in providing additional primary clarifiers for the long-term as the carbon source was required for the anoxic nutrient removal process. Therefore, all alternatives maintained four primary clarifiers with the ability to bypass at flows exceeding the primary clarifier capacity.

The primary process consideration to shifting to an activated sludge process is that the process must then be sized to treat for BOD in the activated sludge system, which requires significantly more tank volume and additional final clarifiers. Currently, most of the BOD is removed in the trickling filters.

Figure 7.8

ALTERNATE 2036 WATER RECLAMATION FACILITY (WRF) LOCATIONS



- WRF Existing Water Reclamation Facility
- WRF Future Water Reclamation Facility Concept
- Future Regional Customer Loading Location
- Modeled Existing Pump Stations
- Modeled Future Pump Stations
- Existing Trunk Sewers
- Future Trunk Sewer Extensions (2036)
- Existing Collection System Forcemains
- Future Collection System Forcemains Concept
- Existing Collection System Sewers
- Sanitary Sewer Basin Extended to Future
- Municipal Boundary

0 1 2
Miles

DATA SOURCE: City of Sioux Falls
MODEL: SF_WWCMP_Model_082916.mxd
SCENARIO: FUT_2036_SCEN12,
Wet Wether Calibrated Model for 25yr 96 hr Atlas 14 Rainfall Depth Under the June 2014 Pattern Averaged Across the City

City of Sioux Falls

CITY OF SIOUX FALLS

Table 7.4 provides a summary of the advantages and disadvantages of the final alternatives.

Table 7.4 Advantages and Disadvantages of Final Alternatives

Alternative	Advantages	Disadvantages
1-1 And 1-2	• Matches current process configuration & hydraulic profile • Least number of new unit processes (simplest operation) • Lowest construction and operational cost	• Difficult to phase future construction of trains • Less compatible with potential future treatment requirements • Footprint requirements are larger
1-3	• Best water quality • Potential for Reuse • Benefit to disinfection process (lower chlorine requirements and lower toxicity potential) • Best ability to comply with future regulatory changes (EDCs, THMs, etc.) • Best ability to accommodate TDS removal • Small footprint • Easiest implementation • Ability to phase construction • Greatest effluent water reuse flexibility	• Higher construction cost • Operational complexity associated with membrane facility • Potential long-term reliance on single membrane supplier
2-2	• WRF Improvements match 1-2 • Eastside MBR Improvements match 1-3	• WRF Improvements match 1-2 • Eastside MBR Improvements match 1-3

Note: Alternatives 1-1 and 1-2:
-Expansion of existing biological treatment train to 4 or 5 Stage Bardenpho Biological Nutrient Removal with BioP in 1-1 and ChemP in 1-2

Alternative 1-3: Convert to MBR with ChemP and limited Carbon

Alternative 2-2: Chem P at WRF with MBR at PS 240

7.4.3 Process Evaluation Summary

The results of the BioWin treatment process analysis (Table 7.5 and Table 7.6) show the additional tank needs, applicable limiting effluent limits and flow capacities for maximum month and peak flows, respectively. The model was checked at both maximum month and maximum day diurnal for four consecutive equalized days. It is critical to size the facility to meet TN and TP on a monthly basis and to meet ammonia limits under maximum day conditions. The planning team chose to increase the tankage and feed alum to limit the methanol addition to a minimum.

The alternatives meet treatment objectives for total nitrogen and phosphorus on a maximum month basis and ammonia on a maximum day basis with no methanol feed. Alum is required, however, at a rate indicated in Table 7.5.

Table 7.5 Process Evaluation Summary -2036 Maximum Month Conditions

	Max. Month Inf. Flow	Controlling Eff. Limits		Results		Chemicals Required	
		Eff. TN	Eff. TP	MLSS	Tank Vol.	Alum	Methanol
	mgd	**mg/L**	**mg/L**	**mg/L**	**MG**	**gpd**	**gpd**
Alternative 1-1	42.7	7.7	0.8	3,051	46	100-400	0
Alternative 1-2	42.7	7.8	0.84	3,078	37	450	0
Alternative 1-3	42.7	8.0	0.8	6,928	16.6	400	0
Alternative 2-2 (Existing WRF/ East-Side WRF)	30.6	8.0	0.8	3,000	27.1	330	0
	12.1	8.0	0.8	7,000	4.7	114	0

Table 7.6 Process Evaluation Summary -2036 Peak Equalized Conditions

	Equalized Inf. Flow	Controlling Eff. Limits			Results		Chemicals Required	
		Eff. TN	Eff. TP	NH4-N	MLSS	Tank Vol.	Alum	Methanol
	mgd	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**MG**	**gpd**	**gpd**
Alternative 1-1	57	11.5	2.0	0.8	3,200	46	100-400	0
Alternative 1-2	57	11.0	1.8	0.8	3,000	37	450	0
Alternative 1-3	57	12.0	1.1	1.1	7,300	16.6	400	0
Alternative 2-2 (Existing WRF/ East-Side WRF)	46	12.0	1.1	1.1	3,100	27.1	330	0
	16	12.0	0.9	0.8	7,300	5.0	114	0

Alternative 1-1 requires substantially greater tank volume than for the other alternatives. Nine million gallons more tankage is required for Alternative 1-1 than Alternative 1-2 for biological phosphorus removal at 46 MG and 37 MG, respectively.

While, as expected, the total aeration tank volume is less than half for Alternative 1-3 –MBR at 16.6 MG due to the ability to run the facility at higher mixed liquor concentrations.

The existing final clarifiers will be renovated and the equivalent of four additional final clarifiers are required for Alternatives 1-1 and 1-2 for 2036 flows. The existing final clarifiers will be renovated and two additional clarifiers are required for alternative 2-2.

7.4.4 Alternatives – Phasing for Regulatory Trigger Points

Phase 1 consists of the design and construction of modifications required to achieve Permit #1 Ammonia removals - to be constructed by 2025 for treatment capacity through 2036.

The assumptions for this analysis include:

- Evaluation was done by utilizing the capacity of the existing primary clarifiers and bypassing the remaining flow. The bypassed flow provides the additional carbon required for nutrient removal.
- New primaries will need to be constructed with, or prior to phase 2 construction, so primary effluent can flow by gravity into the nutrient removal process.
- The trickling filters remain on-line until nutrient removal facilities are constructed.
- Flows greater than 36 mgd are diverted prior to primary clarifiers directly to activated sludge.

Initially, without modifications existing process capacities were modelled and the Permit #1 limit for ammonia is exceeded at peak day flow and loading rates. At these loadings, the expected ammonia concentration will be 3.2 mg/l which exceeds the anticipated permit limit.

The Phase 1 project would incorporate modifications to be constructed by 2025 to provide treatment for ammonia through 2036. Table 7.7 identifies the number of final clarifiers along with the activated sludge aerobic tankage requirements for Phase 1.

Table 7.7 Phase 1 Secondary Improvements

Modelled Flow Condition	# Of Final Clarifiers	Total Tank Vol.	Peak Day Effluent Ammonia	Inf. Flow	Solution/Assessment
	#	MG	mg/L	mgd	
Maximum Month (MMF) Condition					
2036 Diurnal MMF	4	8.1	0.3	42	• Capacity Adequate at Maximum Month • Meets permit
Alternative 1-1 and 1-2 Facilities Required at Maximum Daily Diurnal Condition					
	8	18.0	0.8	57.0	• 1 MG EQ Added • 9.9 MG Aeration Tankage Added • Four Final Clarifiers Added • Meets Permit
Alternative 1-3 Facilities Required at Maximum Daily Diurnal Condition					
- **Existing 37.7 mgd**	4	8.1	0.5	37.0	• 7 MG EQ added at PS 240 • Meets Permit
- **New MBR Train**	N/A	9.1	0.2	20	• 9.1 MG MBR required to treat 20 mgd.

The following secondary and tertiary improvements would be required in order to meet the permit limits through 2036.

- Alternative 1-1 and 1-2 Phase 1:
  - New Primary clarifier influent diversion (new headworks and PCs) for peak flows,
  - New Aeration tankage (Total 18 million gallons),

  - Four new final clarifiers (Total 8 Units),
  - Upsize the RAS to be able to provide 100% of peak equalized flow at 57 mgd
  - Expand deep bed filters.

- Alternative 1-3 Phase 1:
  - Influent 2 mm fine screening,
  - New parallel train MBR (9.1 million gallons aeration tankage -at lower elevation),
  - All appurtenant equipment.
- All alternatives assume that 15 MG of equalization is in place at the WRF site.

The Phase 2 project would incorporate modifications constructed by 2029 to provide total nitrogen and phosphorus removal. Both nitrogen and phosphorus can be removed through biological processes. To biologically reduce both nitrogen and phosphorus in an activated sludge system requires an anaerobic zone (no oxygen or nitrate/nitrite), an anoxic zone (no dissolved oxygen), and conventional aerated zones.

The anaerobic zones encourage the growth of specific bacteria that store and accumulate phosphorus beyond the amount needed for growth. With this approach, phosphorus is removed from the liquid stream with minimal chemical addition. However, biological nutrient removal plants usually incorporate chemical feed facilities as a backup for polishing and for feed to the recycle for phosphorus load management.

The most basic advanced treatment method for phosphorus removal is to add metal salts, typically aluminum sulfate (alum), to the wastewater. Chemical phosphorus removal relies on the precipitation of soluble (reactive) phosphorus, mostly orthophosphate ($PO4^{3-}$), followed by solids removal from the liquid stream. Other potential chemicals for chemical phosphorus removal beside alum include lime and other metal salts, such as ferric or ferrous sulfate, and ferric or ferrous chloride, or poly aluminum chloride (PACL). Metal salts can be added to raw wastewater where the precipitate settles in primary sedimentation, the secondary process (co-precipitation) as well as to a concentrated sidestream, such as solids dewatering feed. Tertiary phosphorus removal is often used as a polishing step behind biological treatment but can by itself be used for phosphorus removal in combination with effluent filtration. Chemical addition increases the overall quantity of sludge generated. Chemical addition also reduces phosphorus available for conventional recovery from dewatering centrate because chemical sludge continues to remove phosphorus after the initial precipitation reaction. Most metal salts added for chemical phosphorus removal also consume alkalinity. For every unit of ferric or alum added 0.5 units of alkalinity are consumed.

The phosphorus recycle content and associated challenges with solids handling for a biological phosphorus removal process warrant further consideration. Phosphorus handling alternatives may be considered during predesign including the following Phosphorus release (P-Release) from waste activated sludge (WAS). The current plan recommends chemical feed for “tying up” the phosphorus as the most economical solution to address the following:

- Reducing struvite accumulation in anaerobic digesters,

- Improving dewaterability of anaerobically digested biosolids and high phosphorus recycle loading from solids handling (up to 50% influent load).

Nitrogen is removed by oxidizing the ammonia compounds to nitrate, then reducing the nitrate to nitrogen gas, which is released into the atmosphere. Biological nutrient removal plants incorporate methanol, or other carbon source, chemical feed facilities as this process requires a minimum carbon to nitrogen ratio.

Alternative 1-1 - 5 Stage Bardenpho Biological Nutrient Removal with BioP

Alternative 1-1 is ultimately an entire plant using the 5-Stage Bardenpho Biological Nutrient Removal with BioP as the activated sludge process, the trickling filters will be taken off-line. Alternative 1-1 offers a Biological Nutrient Removal (BNR) alternative as an approach to achieve biological phosphorus removal with anaerobic (ANR) tankage. For this flow scheme, an additional basin is required to provide anaerobic zone capacity and an additional return pumping flow stream is added to return mixed liquor to the anoxic (ANX) zone. A process schematic of the 5-Stage Bardenpho process is shown in Figure 7.9. The site layout is similar to Alternative 1-2 as depicted in Figure 7.11. In sequence, the zones include:

- The anaerobic zone is characterized by very low dissolved oxygen levels and the absence of nitrates. The function in this zone is to encourage growth of bacteria that are responsible for phosphorus removal through low oxidation-reduction conditions. This results in the bacteria releasing the phosphorus. Most of the nitrogen is in ammonia form and passes through this zone.
- The anoxic zone is characterized by low dissolved oxygen levels but with nitrates present. In this zone, which has an adequate supply of oxygen and phosphorous in solution, the cells take up the phosphorus in excess of their normal metabolic requirements – thereby reducing phosphorus and wasting it with the activated sludge. Most of the nitrogen is in ammonia form and passes through this zone.
- The aerobic zone is aerated to add oxygen. In this zone, the ammonia nitrogen is converted to nitrites and then to nitrates. The nitrate-heavy MLSS is pumped back to the anoxic zone where lack of dissolved oxygen causes nitrates to convert to nitrogen gas using the influent organic carbon as hydrogen donors.
- The secondary anoxic zone is where any nitrates not previously recycled to the first anoxic zones.
- In the final aeration zone, dissolved oxygen levels are raised again to prevent denitrification, as it would reduce settling in the subsequent secondary clarifiers.

The basic MLE process for nitrogen removal (second and third stages) is usually not sufficient and second anoxic and aerobic zones (fourth and fifth stages) are required. The 5-Stage Bardenpho provides the fourth and fifth stages downstream of the mixed liquor recycle withdrawal point but within the same activated sludge system. Compared to the basic A2O process (stages 1 through 3) the fourth and fifth stages are relatively small. The size of the second anoxic zone depends on the amount of denitrification required and the type of carbon source added.

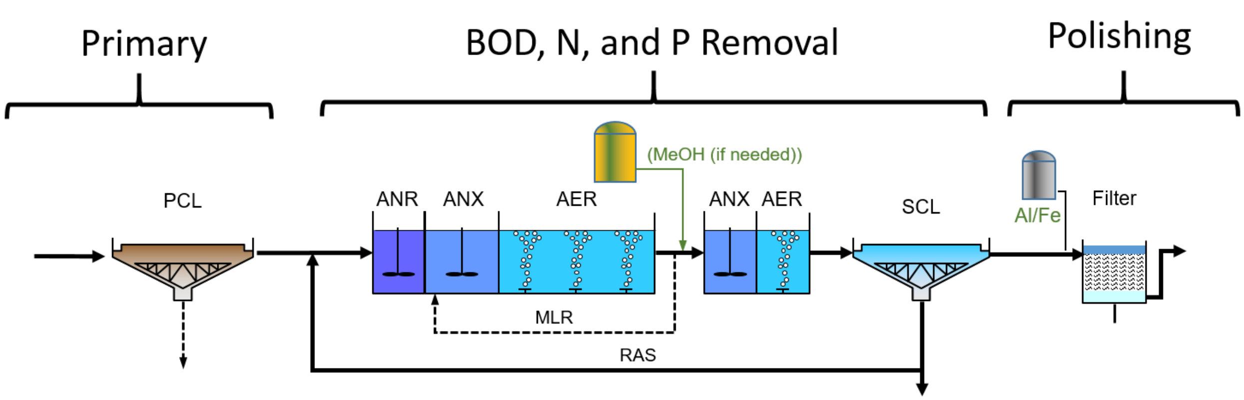
The Alternative 1-1, 5-Stage Bardenpho, facility is comprised of the following major components:

- Aeration basins configured for BioP/ nitrification / denitrification (NDN)
- RAS (mixed liquor) pumping
- Anoxic Recycle Pumping
- WAS and scum pumping
- Blowers for process aeration
- Chemical feed and storage systems for ChemP and Carbon
- Lime feed system
- Final Clarifiers
- Tertiary Filtration
- Liquid Chlorine Disinfection

Eight final clarifiers are required to handle the peak equalized 2036 flow. A high quality effluent is generated meeting current and future permit requirements. The existing activated sludge process including aeration and final clarifiers and RAS pumping would need to be expanded to meet the target design year requirements (2036) with provisions for further expandability to the future.

Tertiary treatment will include expanding the existing filters to provide the required hydraulic capacity.

Figure 7.9 Alternative 1-1 Process Flow Diagram –5 Stage Bardenpho Biological Nutrient Removal with BioP



A summary of the required improvements is outlined in Table 7.8.

Table 7.8 Alternative 1-1 – Planning Basis of Design for Phases 1 and 2

Description	Units	Existing	Total in Phase 1 (Existing + Ph. 1)	Total in Phase 2 (Ph. 1 + Ph. 2)
Average Day Flow	MGD	21	30.1	30.1
Peak Day Equalized Flow	MGD	35	57.0	57.0
Total WRF EQ Basin Volume	MG	-	15	15
Hydraulic Capacity	MGD	-	57.0	57.0
Total Basin Volume	MG	8.1	18.0	46.0
EQ Basin At East Side Pump Station 240	MG		1.0	1.0
Aeration Basin Blower Capacity[1]	SCFM	45,000 (Coarse Bubble)	79,550 (Fine Bubble)	79,550 (Fine Bubble)
Total No. Final Clarifiers[2]	No.	4.0	8.0	8.0
RAS Pumping[2]	MGD	27.0	57.0	57.0
Total Filter Capacity	MGD	34.0	57.0	57.0

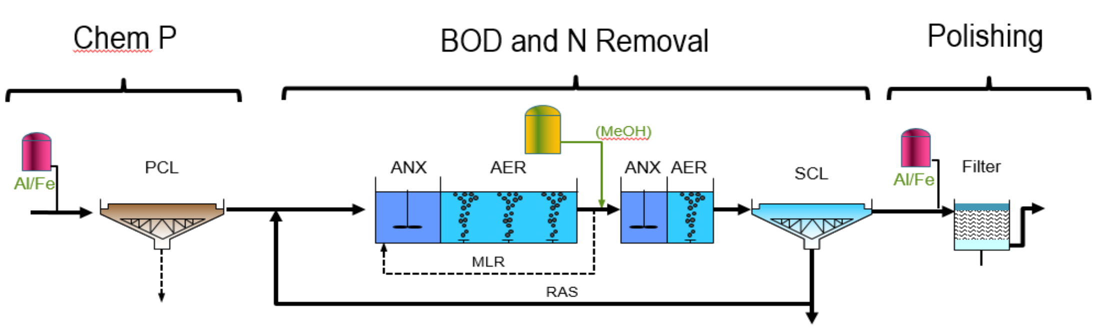
Notes: 1. Assumes Phase 1 and 2 blower capacity will be constructed in Phase 1 complete with a complete new fine bubble aeration system.
2. Existing Clarifiers and RAS Pumping will be refurbished.

The primary advantages are the lower capital costs and replacement costs, less chemical and the treatment of hydraulic peaks. The larger aeration basin footprint is a disadvantage.

Alternative 1-2 – 4 Stage Bardenpho Biological Nutrient Removal with ChemP

Alternative 1-2 is ultimately an entire plant using the 4 Stage Bardenpho Biological Nutrient Removal with ChemP activated sludge process, trickling filters will be taken off-line. Alternative 1-2 is identical to Alternative 1-1 minus the anaerobic selector tankage. Alternative 1-2 offers a Chemical Phosphorus Removal (ChemP) alternative as an approach to achieve phosphorus removal and alum or ferric are added for phosphorus removal. For this flow scheme, an additional return pumping flow stream is added to return mixed liquor to an anoxic (ANX) zone for total nitrogen removal. A process schematic of the 4-Stage Bardenpho process is shown in Figure 7.10. A site layout schematic is illustrated in Figure 7.11.

Figure 7.10 Alternative 1-2 Process Flow Diagram – 4 Stage Bardenpho Biological Nutrient Removal with ChemP



The Alternative 1-2, 4-Stage Bardenpho, facility is comprised of the following major components:

- Aeration basins configured for nitrification / denitrification (NDN)
- RAS (mixed liquor) pumping
- Anoxic Recycle Pumping
- WAS and scum pumping
- Blowers for process aeration
- Chemical feed and storage systems for ChemP and Carbon
- Lime feed system
- Final Clarifiers
- Tertiary Filtration
- Liquid Chlorine Disinfection

A summary of the required improvements is outlined in Table 7.9.

Table 7.9 Alternative 1-2 – Planning Basis of Design for Phases 1 and 2

Description	Units	Existing	Phase 1 (Existing + Ph. 1)	Phase 2 Total (Ph. 1 + Ph. 2)
Average Day Flow	MGD	21	29.8	29.8
Peak Day Equalized Flow	MGD	35	57.0	57.0
Total WRF EQ Basin Volume	MG	-	15	15
Hydraulic Capacity	MGD	-	57.0	57.0
Total Basin Volume	MG	8.1	18	37.0
East Side Pump Station 240 EQ Basin	MG		1.0	1.0
Aeration Basin Blower Capacity[1]	SCFM	45,000 (Coarse Bubble)	79,550 (Fine Bubble)	79,550 (Fine Bubble)
Total No. Final Clarifiers[2]	No.	4.0	8.0	8.0
RAS Pumping[2]	MGD	27.0	57.0	57.0
Total Filter Capacity	MGD	34.0	57.0	57.0

Notes: 1. Assumes Phase 1 and 2 blower capacity will be constructed in Phase 1 complete with a complete new fine bubble aeration system.
2. Existing Clarifiers and RAS Pumping will be refurbished.

Similar to Alternative 1-1, the primary advantages are the lower capital costs and replacement costs, and the treatment of hydraulic peaks. The larger aeration basin footprint is a disadvantage.

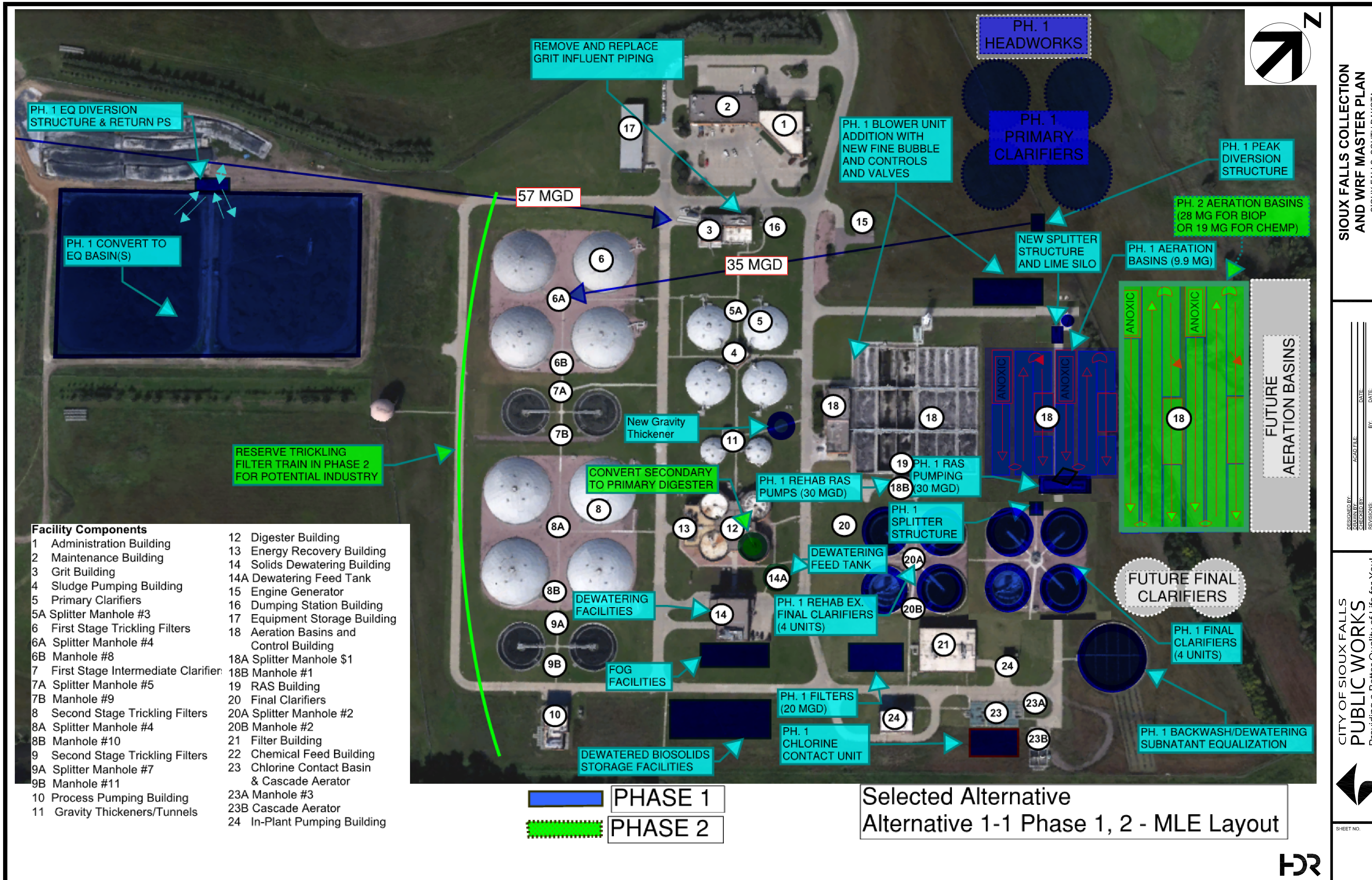


Figure 7.11 Alternative 1-2 Site Layout Schematic – 4 Stage Bardenpho Biological Nutrientlternative 1-2 Site Layout Schematic - 4 Stage Bardenpho Nutrient Removal with ChemP

Alternative 1-3 – MBR with ChemP

Alternative 1-3 is ultimately an entire plant using the Membrane Bioreactor (MBR) process. Refer to Figure 7.12 for the process schematic and Figure 7.13 for the site layout schematic. For this process, the existing tankage will be maintained to provide treatment while an MBR facility is constructed in parallel. The existing aeration basins and final clarifiers would then be converted as part of Phase 2 to equalization with new MBRs to provide the required nutrient treatment. The earthen equalization basins would be maintained. Retrofitting the existing tankage to MBRs was considered, however, it was most beneficial to lower the MBRs; this enables the units to work by gravity downstream of the primary clarifiers and eliminate secondary pumping.

The MBR facility design to increase WRF biological treatment capacity to handle a maximum month flow of 42.7 MGD and peak equalized flow of 57 MGD in the Phase 2 expansion to treat for both ammonia and nutrients. The facility is to be expandable on a modular basis. The MBR facility is comprised of the following major components:

- Fine screening (2 mm specific to protect MBR process)
- Aeration basins configured for nitrification / denitrification (NDN)
- RAS (mixed liquor) pumping
- WAS and scum pumping
- Membrane tanks
- Permeate pumps
- Blowers for process aeration and membrane scouring
- Chemical feed and storage systems for membrane cleaning
- Chemical feed and storage systems for ChemP and Carbon
- Lime feed system
- Repurpose existing aeration basins and final clarifiers to equalization

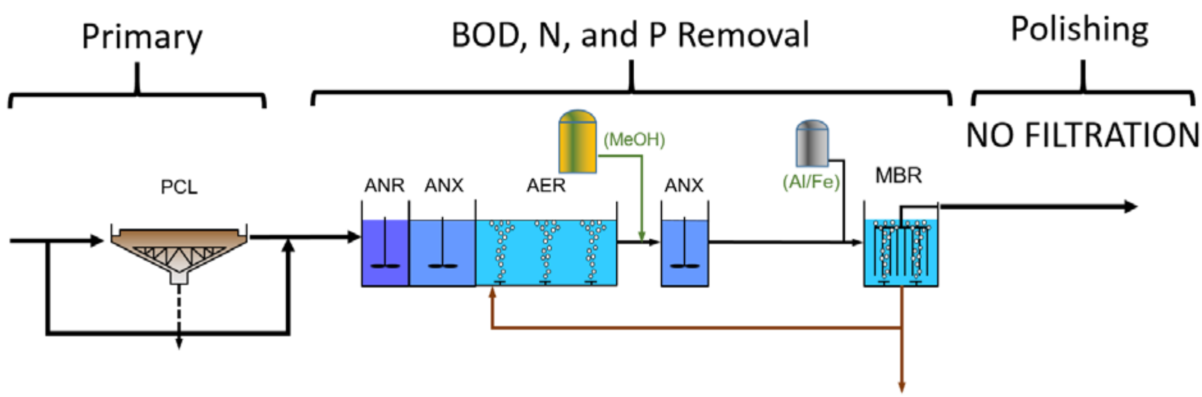
The MBR treatment process is a suspended growth treatment process where effluent is drawn through hollow-fiber membranes immersed in an aerated tank. The process tankage upstream of the membrane tanks are based on the specific treatment requirements but there are several characteristics unique to MBR. Because of the high dissolved oxygen concentration in the membrane tank, typically more than 6 mg/L, and the required recycle rates, the BNR/MBR configuration requires a RAS deoxygenation zone. From the RAS de-oxygenation, approximately 25% of the recycle is fed to the anaerobic zone while the majority of the flow is fed to the anoxic zone.

As with Alternative 1-2, chemical feed is the method for phosphorus removal with this alternative.

A Membrane Bioreactor (MBR) is the combination of the conventional activated sludge process with membrane filtration. When used for domestic wastewater, MBR processes outperform other processes by producing a high quality effluent capable of meeting the most stringent limits set for sensitive water supplies or reuse supply. MBRs can be operated at much higher MLSS rates resulting in reduced footprint. MBRs perform well at removing phosphorus, because phosphorus associated with particulates is removed with a higher efficiency.

Aside from the high effluent quality, the MBR smaller footprint is an advantage. The primary disadvantages are the high capital costs, membrane replacement costs, and the inability to handle hydraulic peaks.

Figure 7.12 Alternative 1-3 Process Schematic – MBR with ChemP and Limited Carbon



A summary of the required improvements is outlined in Table 7.10.

Table 7.10 Alternative 1-3 – Planning Basis of Design for Phases 1 and 2

Description	Units	Existing	Phase 1 (Existing + Ph. 1)	Phase 2 Total (Ph. 1 + Ph. 2)
Average Day Flow	MGD	21	30.1	30.1
Peak Day Equalized Flow	MGD	35	57.0	57.0
Total WRF EQ Basin Volume	MG	-	15	15
Total Basin Volume	MG	8.1 (Repurposed For EQ)	9.1	16.5
East Side Pump Station 240 EQ Basin	MG		1.0	1.0
Aeration Basin Blower Capacity[1]	SCFM	45,000 (Coarse Bubble)	79,550 (Fine Bubble)	79,550 (Fine Bubble)
RAS Pumping	MGD	27.0	57.0	57.0
Total Filter Capacity	MGD	34.0	57.0	57.0

Notes: 1. Assumes Phase 1 and 2 blower capacity will be constructed in Phase 1 complete with a complete new fine bubble aeration system.

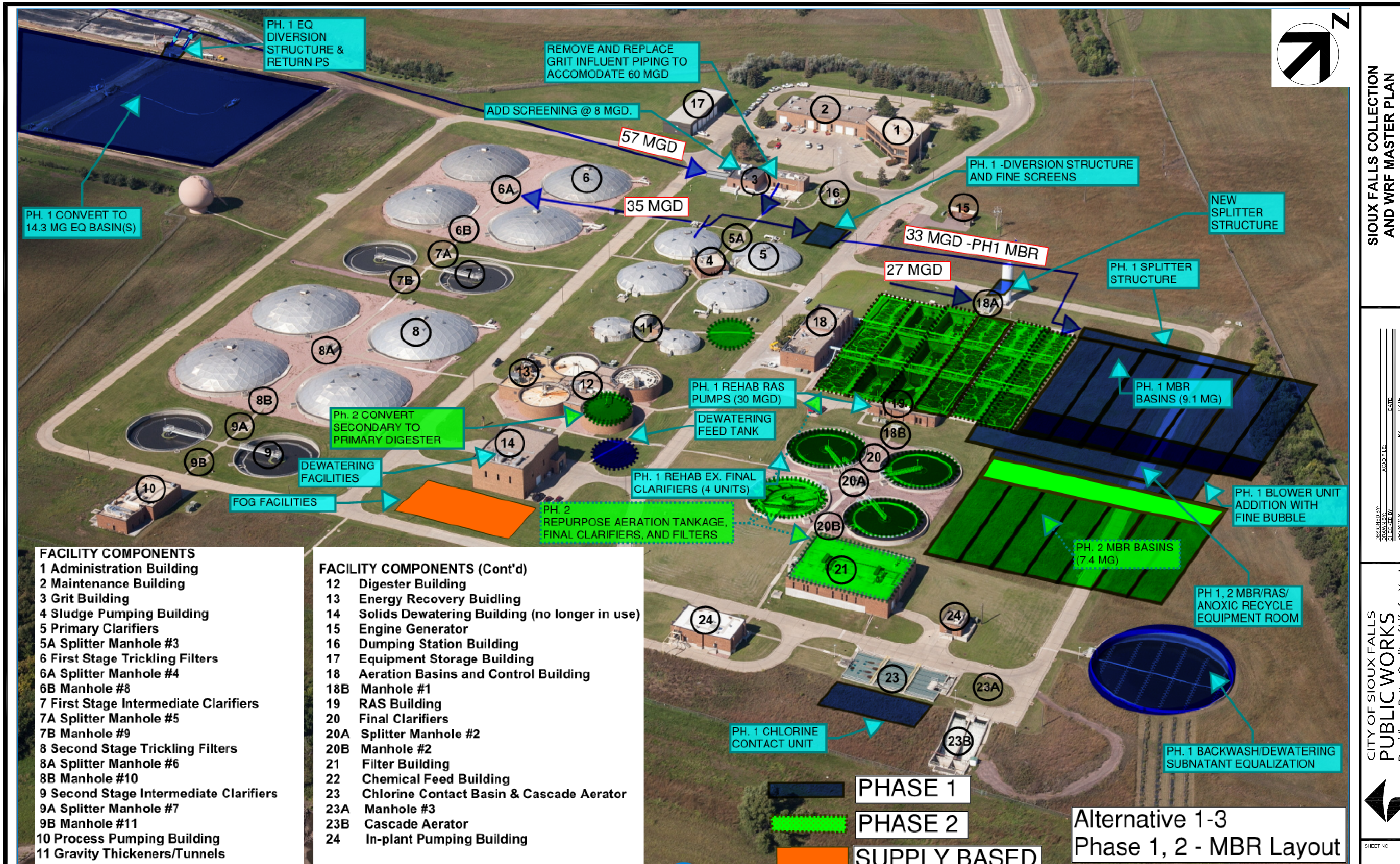


Figure 7.13 Alternative 1-3 Site Layout Schematic - MBR with ChemP and No Carbon

Alternative 2-2 – Chem P at WRF with MBR at PS 240

Alternative 2-2 is a combination of Alternative 1-2 – 4 Stage Bardenpho Chemical Phosphorus Removal at WRF with a new satellite East Side Sanitary Sewer (ESSS) WRF consisting of a Membrane Bioreactor (MBR) process. The ESSS MBR was determined as the preferred treatment alternative per previous studies and paired with the “Base” 4 Stage Bardenpho process at the existing WRF. Refer to Figure 7.14 and 7.15 for site layout and process schematics for the ESSS MBR at the PS 240 location.

For Alternative 2-2, the eastside satellite MBR facility was sized with a capacity of 16 MGD which is the project 2036 max equalized flow for the eastside to treat for both ammonia and nutrients. A 7 MG equalization basin was included to equalize flow to 16 MGD. The facility is to be expandable on a modular basis. The facility would be planned to treat the entire liquid stream from the connected service area. The existing pump station/forcemain has up to 3.5 mgd and could be used for some flexibility. The original concept for this plant was that waste activated solids would be returned to the existing WRF by combining with flows in the LS240 forcemain.

The MBR facility is comprised of the following major components:

- Fine screening (2 mm)
- Aeration basins configured for nitrification / denitrification (NDN)
- RAS (mixed liquor) pumping
- WAS and scum pumping
- Membrane tanks
- Permeate pumps
- Blowers for process aeration and membrane scouring
- Chemical feed and storage systems for membrane cleaning
- UV disinfection

Chemical feed is the method for phosphorus removal with this alternative.

A summary of the required liquid process improvements is outlined in Table 7.11.

Table 7.11 Alternative 2-2 – Planning Basis of Design for Phases 1 and 2

Description	Units	Existing	Phase 1 - 2036 Ammonia	Phase 2 Total
Existing WRF Improvements				
Average Day Flow	MGD	16.1	30.1	30.1
Peak Day Equalized Flow	MGD	35	50	50
Total WRF EQ Basin Volume	MG	-	15	15
Hydraulic Capacity	MGD	-	50	50
Total Basin Volume	MG	8.1	16.5 (8.4 MG Additional)	31.5 (14.9 MG Additional)
East Side Pump Station 240 EQ Basin	MG		1.0	1.0
Aeration Basin Blower Capacity[1]	SCFM	45,000 (Coarse Bubble)	59,000 (Fine Bubble)	59,000 (Fine Bubble)
Total No. Final Clarifiers[2]	No.	4.0	6.0	6.0
RAS Pumping[2]	MGD	27.0	51.0	51.0
Total Filter Capacity	MGD	34.0	51.0	51.0
New ESSS MBR				
Total Aeration Basin Volume	MG		7.0 MG	7.0 MG
Pump Station 240 EQ Basin	MG		7.0	7.0
Aeration Basin Blower Capacity[1]	SCFM		23,000 (Fine Bubble)	23,000 (Fine Bubble)

Notes:
1. Assumes Phase 1 and 2 blower capacity will be constructed in Phase 1 complete with a complete new fine bubble aeration system.
2. Existing Clarifiers and RAS Pumping will be refurbished.

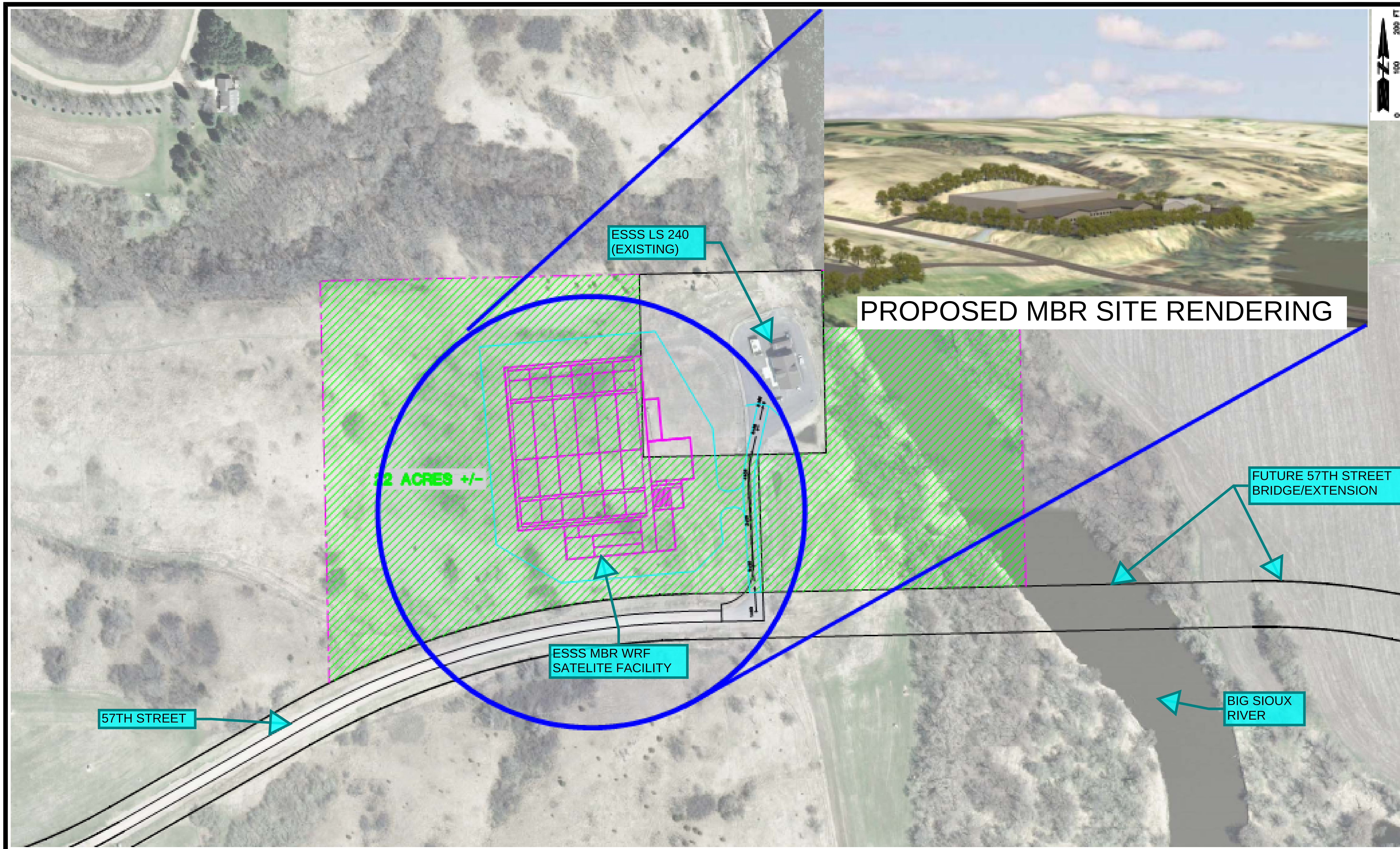


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Figure 7.14 Alternative 2-2 Process Layout Schematic

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ROOM SCHEDULE

DESCRIPTION	SIZE	UNIT
ADMIN. LAB	2,885	S.F.
CONTROL ROOM	804	S.F.
HEADWORKS	6,974	S.F.
PUMP ROOM	3,114	S.F.
BLOWERS/COMPRESSORS	2,533	S.F.
DIP TANKS/MEMBRANE REPAIR AREA	2,998	S.F.
DE OXYGENATION ZONE	2,882	S.F.
ANAEROBIC	8,300	S.F.
PRE-ANOXIC	13,800	S.F.
AERATION	41,400	S.F.
POST-ANOXIC	28,200	S.F.
MEMBRANE	12,631	S.F.
CHEMICAL/STORAGE FEED	2,152	S.F.
STORAGE/MAINTENANCE AREA	3,324	S.F.
POTENTIAL REUSE PUMP STATION	1,333	S.F.
POTENTIAL U.V.	2,182	S.F.
HEADWORKS (BUILDOUT)	9,018	S.F.

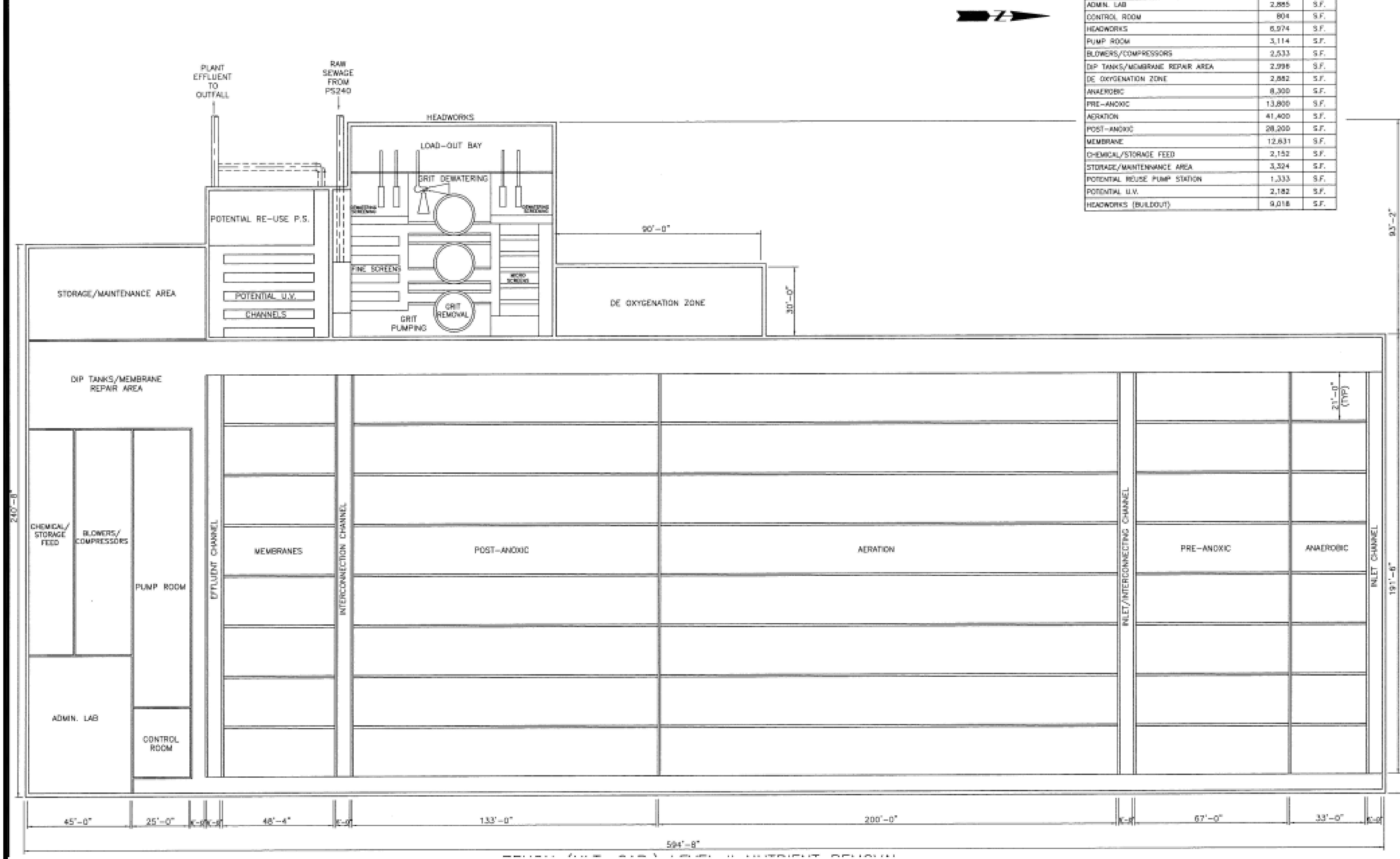

Figure 7.15 Alternative 2-2 Site Layout Schematic – PS 240 ESSS MBR

SIOUX FALLS COLLECTION AND WRF MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

DESIGNED BY:
DRAWN BY:
CHECKED BY:
REVISIONS:
ACAD FILE:
BY: DATE:
BY: DATE:

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7.4.5 Monetary Screening

Comparative order of magnitude construction costs, total project cost and life cycle present value costs have been estimated for each of the alternatives and are summarized in Table 7.12.

Alternative 1-2 - Chemical Phosphorus Removal at WRF was used as the “base” alternative for cost comparison purposes, as it is the lowest cost alternative.

Comparison of Project Costs

An order of magnitude opinion of comparative construction costs for the three alternatives are presented in Table 7.12 in comparison to Alternative 1-2 (Base).

- In Phase 1, Alternative 1-1 is the same as Alternative 1-2 (Base) since nutrient removal is not yet incorporated.
- Alternative 1-1 and 1-2 (Base) have the lowest comparative Phase 1 project cost at $130.5 million.
- Alternative 1-1 in comparison to Alternative 1-2 (Base) is $28.6 million (40%) greater in Phase 2 and a total of $28.6 million (14%) more. The higher capital costs are due to the higher cost of the additional anaerobic tankage for phosphorus removal.
- Alternative 1-3 in comparison to Alternative 1-2 (Base) is $30.2 million (23%) greater in Phase 1, $26 million (36%) greater in Phase 2 and a total of $56.1 million (28%) more. The higher capital costs are due to the higher initial cost of the installed membrane equipment.
- Alternative 2-2 in comparison to Alternative 1-2 (Base) is $42.9 million (33%) greater in Phase 1, $13.3 million less (-18%) in Phase 2 and a total of $29.5 million (15%) more. The higher capital costs are due to the higher cost of the installed membrane equipment and the upfront costs of a greenfield treatment site.

Note, the selected alternative along with the phasing of individual components are further refined and presented in Chapter 10 and will continue to evolve as part of the City’s capital improvement planning efforts.

Table 7.12 Opinion of Comparative Costs for Phases 1 and 2

	Description	Project	Percentage Applied	Alternative 1-1 - Biological Phosphorus Removal at WRF			Alternative 1-2 - Chemical Phosphorus Removal at WRF			Alternative 1-3 - Membrane Bioreactor at WRF			Alternative 2-2 - Chem P at WRF with MBR at PS 240		
				WRF Phase 1 - Construction Cost	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total
Prelim.	New Headworks		-	$7,000,000	$0	$7,000,000	$ 7,000,000	$ -	$ 7,000,000	$ 7,000,000	$ -	$ 7,000,000	$ 7,000,000	$ -	$ 7,000,000
	Grit Influent Pipe Upsizing (1) (2)	1	-	$800,000	$0	$800,000	$ 800,000	$ -	$ 800,000	$ 800,000	$ -	$ 800,000	$ 800,000	$ -	$ 800,000
Primary	New Primary Clarifiers		-	$9,000,000	$0	$9,000,000	$ 9,000,000	$ -	$ 9,000,000	$ -	$ -	$ -	$ 6,800,000	$ -	$ 6,800,000
	PC Diversion Box Process Bypass (1) (2)	1	-	$900,000	$0	$900,000	$ 900,000	$ -	$ 900,000	$ 900,000	$ -	$ 900,000	$ 600,000	$ -	$ 600,000
Aeration Basins and MB	Add Interior Walls to Existing Aeration Basins		-	$0	$1,000,000	$1,000,000	$ -	$ 1,000,000	$ 1,000,000	$ -	$ -	$ -	$ -	$ 1,000,000	$ 1,000,000
	Aeration Basin Upgrades (1)	6	-	$1,900,000	$0	$1,900,000	$ 1,900,000	$ -	$ 1,900,000	$ 1,900,000	$ -	$ 1,900,000	$ 1,900,000	$ -	$ 1,900,000
	Aeration Basin Splitter Box		-	$1,100,000	$500,000	$1,600,000	$ 1,100,000	$ 500,000	$ 1,600,000	$ 1,100,000	$ 500,000	$ 1,600,000	$ 1,000,000	$ 300,000	$ 1,200,000
	Aeration Basins		-	$18,500,000	$46,800,000	$65,300,000	$ 18,500,000	$ 33,100,000	$ 51,600,000	$ 17,000,000	$ 13,900,000	$ 31,000,000	$ 15,800,000	$ 26,900,000	$ 42,700,000
	Aeration Basin Blowers		-	$3,600,000	$0	$3,600,000	$ 3,600,000	$ -	$ 3,600,000	$ 3,900,000	$ -	$ 3,900,000	$ 2,900,000	$ -	$ 2,900,000
	Chemical Feed		-	$0	$200,000	$200,000	$ -	$ 200,000	$ 200,000	$ -	$ 200,000	$ 200,000	$ -	$ 200,000	$ 200,000
Secondary	Replace RAS and WAS Pumps		-	$200,000	$0	$200,000	$ 200,000	$ -	$ 200,000	$ 200,000	$ -	$ 200,000	$ 200,000	$ -	$ 200,000
	Rehab Final Clarifiers		-	$3,100,000	$0	$3,100,000	$ 3,100,000	$ -	$ 3,100,000	$ 3,100,000	$ -	$ 3,100,000	$ 3,100,000	$ -	$ 3,100,000
	Final Clarifiers		-	$8,200,000	$0	$8,200,000	$ 8,200,000	$ -	$ 8,200,000	$ -	$ -	$ -	$ 5,000,000	$ -	$ 5,000,000
Tertiary	Filter Expansion	4	-	$3,400,000	$0	$3,400,000	$ 3,400,000	$ -	$ 3,400,000	$ -	$ -	$ -	$ 3,200,000	$ -	$ 3,200,000
	Chlorine Contact Expansion (1) (2)	5	-	$1,500,000	$0	$1,500,000	$ 1,500,000	$ -	$ 1,500,000	$ 1,500,000	$ -	$ 1,500,000	$ 1,500,000	$ -	$ 1,500,000
	Effluent Flow Meter Improvements		-	$200,000	$0	$200,000	$ 200,000	$ -	$ 200,000	$ 200,000	$ -	$ 200,000	$ 200,000	$ -	$ 200,000
General	Convert Biosolids Lagoons to Equalization Basins		-	$3,300,000	$0	$3,300,000	$ 3,300,000	$ -	$ 3,300,000	$ 3,300,000	$ -	$ 3,300,000	$ 3,300,000	$ -	$ 3,300,000
	Site Work/Demo		1.0%	$600,000	$500,000	$1,100,000	$ 600,000	$ 300,000	$ 1,000,000	$ 800,000	$ 500,000	$ 1,200,000	$ 7,200,000	$ 300,000	$ 7,400,000
	Site Piping		2.0%	$1,300,000	$1,000,000	$2,200,000	$ 1,300,000	$ 700,000	$ 1,900,000	$ 1,500,000	$ 900,000	$ 2,500,000	$ 1,500,000	$ 600,000	$ 2,100,000
	Miscellaneous Improvements		1.0%	$600,000	$500,000	$1,100,000	$ 600,000	$ 300,000	$ 1,000,000	$ 800,000	$ 500,000	$ 1,200,000	$ 800,000	$ 300,000	$ 1,100,000
Construction Subtotal (Excluding Contingency)			-	**$65,100,000**	**$50,400,000**	**$115,500,000**	**$ 65,100,000**	**$ 36,100,000**	**$ 101,200,000**	**$ 80,200,000**	**$ 49,100,000**	**$ 129,300,000**	**$ 86,500,000**	**$ 29,500,000**	**$ 116,000,000**
Undefined Contingency			25.0%	$16,300,000	$12,600,000	$28,900,000	$ 16,300,000	$ 9,000,000	$ 25,300,000	$ 20,000,000	$ 12,300,000	$ 32,300,000	$ 21,600,000	$ 7,400,000	$ 29,000,000
Construction Subtotal (Including Contingency)			-	**$81,400,000**	**$63,000,000**	**$144,400,000**	**$ 81,400,000**	**$ 45,200,000**	**$ 126,600,000**	**$ 100,200,000**	**$ 61,400,000**	**$ 161,600,000**	**$ 108,100,000**	**$ 36,800,000**	**$ 145,000,000**
General Conditions, Mobilization			5.0%	$4,100,000	$3,100,000	$7,200,000	$ 4,100,000	$ 2,300,000	$ 6,300,000	$ 5,000,000	$ 3,100,000	$ 8,100,000	$ 5,400,000	$ 1,800,000	$ 7,200,000
Excise/Sales Tax Allowance			5.0%	$4,300,000	$3,300,000	$7,600,000	$ 4,300,000	$ 2,400,000	$ 6,600,000	$ 5,300,000	$ 3,200,000	$ 8,500,000	$ 5,700,000	$ 1,900,000	$ 7,600,000
Overhead & Profit			15.0%	$13,500,000	$10,400,000	$23,900,000	$ 13,500,000	$ 7,500,000	$ 20,900,000	$ 16,600,000	$ 10,200,000	$ 26,700,000	$ 17,900,000	$ 6,100,000	$ 24,000,000
Bonds & Insurance			2.0%	$2,100,000	$1,600,000	$3,700,000	$ 2,100,000	$ 1,100,000	$ 3,200,000	$ 2,500,000	$ 1,600,000	$ 4,100,000	$ 2,700,000	$ 900,000	$ 3,700,000
Total Construction Cost			-	**$105,300,000**	**$81,500,000**	**$186,700,000**	**$ 105,300,000**	**$ 58,400,000**	**$ 163,700,000**	**$ 129,600,000**	**$ 79,400,000**	**$ 209,000,000**	**$ 139,800,000**	**$ 47,600,000**	**$ 187,500,000**
Engineering, Administration, Legal, Permitting			24.0%	$25,300,000	$19,600,000	$44,800,000	$ 25,300,000	$ 14,000,000	$ 39,300,000	$ 31,100,000	$ 19,100,000	$ 50,200,000	$ 33,600,000	$ 11,400,000	$ 45,000,000
Total Project Cost			-	**$130,500,000**	**$101,000,000**	**$231,500,000**	**$ 130,500,000**	**$ 72,400,000**	**$ 203,000,000**	**$ 160,700,000**	**$ 98,400,000**	**$ 259,100,000**	**$ 173,400,000**	**$ 59,100,000**	**$ 232,500,000**
Equivalent Annual 20-Year Project Cost at 3.25% Interest			-	**$9,000,000**	**$6,900,000**	**$15,900,000**	**$ 9,000,000**	**$ 5,000,000**	**$ 14,000,000**	**$ 11,100,000**	**$ 6,800,000**	**$ 17,800,000**	**$ 11,900,000**	**$ 4,100,000**	**$ 16,000,000**

Operations and Maintenance Costs

Order of magnitude opinions of comparative O&M costs are presented in Table 7.13. The O&M costs presented are the costs associated with the alternative treatment processes. This includes costs from primary clarifier effluent through filtration, as it applies. O&M costs associated with the rest of the WRF (e.g. pretreatment, solids handling) are not included in this cost comparison.

Operations/Maintenance Unit Rates	
Power	$0.100/kWh
Labor	$50.00/hr.
Diesel	$2.75/gal
Natural Gas	$5.71/k ft^3

The primary observations include the following:

- Total annual O&M costs for Alternatives 1-1 and 1-2 are the same in Phase 1.
- Alternative 1-1 in comparison to Alternative 1-2 (Base) is $0.4 million (14%) less in Phase 2 and a total of $0.4 million (8%) less. The lower operation costs are due to less chemical required for phosphorus removal. Alternative 1-1 uses approximately one-third the amount required for the remaining alternatives.
- Alternative 1-3 in comparison to Alternative 1-2 (Base) is $0.85 million (62%) greater in Phase 1, $0.41 million (14%) in Phase 2 and a total of $1.26 million (24%) more. The higher operation and maintenance costs are due to the higher operation, maintenance and replacement costs of the installed membrane equipment.
- Alternative 2-2 in comparison to Alternative 1-2 (Base) is $0.7 million (31%) greater in Phase 1, $0.46 million (51%) less in Phase 2 and a total of $0.24 million (5%) more. The higher operation and maintenance are due to the higher operation and maintenance cost of the installed membrane equipment and the additional personnel required for a separate greenfield treatment site.

Table 7.13 Comparative Operations and Maintenance Annual Cost

Description	Alternative 1-1 - Biological Phosphorus Removal at WRF			Alternative 1-2 - Chemical Phosphorus Removal at WRF			Alternative 1-3 - Membrane Bioreactor at WRF			Alternative 2-2 - Chem P at WRF with MBR at PS 240		
	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total
Total Project Cost	$ 170,340,000	$ 101,030,000	$ 271,370,000	$ 170,340,000	$ 72,440,000	$ 242,780,000	$ 200,040,000	$ 98,450,000	$ 298,480,000	$ 211,140,000	$ 59,090,000	$ 270,220,000
(process energy costs)	$ 1,100,000	$ 1,680,000	$ 2,780,000	$ 1,100,000	$ 1,680,000	$ 2,780,000	$ 1,500,000	$ 1,690,000	$ 3,190,000	$ 1,430,000	$ 1,620,000	$ 3,060,000
(PS 240 pump power costs)	$ 270,000	$ -	$ 270,000	$ 270,000	$ -	$ 270,000	$ 270,000	$ -	$ 270,000	$ 30,000	$ -	$ 30,000
(Cost savings for using siphon instead of MBR permeate pumps)	$ -	$ -	$ -	$ -	$ -	$ -	$ 60,000	$ 30,000	$ -	$ -	$ -	$ -
Energy Costs	$ 1,370,000	$ 1,680,000	$ 3,050,000	$ 1,370,000	$ 1,680,000	$ 3,050,000	$ 1,560,000	$ 1,810,000	$ 3,370,000	$ 1,460,000	$ 1,620,000	$ 3,090,000
Chemical Costs	$ -	$ 170,000	$ 170,000	$ -	$ 650,000	$ 650,000	$ -	$ 650,000	$ 650,000	$ -	$ 650,000	$ 650,000
Material Costs	$ 50,000	$ 110,000	$ 170,000	$ 50,000	$ 90,000	$ 150,000	$ 190,000	$ 170,000	$ 370,000	$ 170,000	$ 70,000	$ 240,000
Labor Costs	$ 820,000	$ 600,000	$ 1,420,000	$ 820,000	$ 550,000	$ 1,360,000	$ 1,330,000	$ 740,000	$ 2,070,000	$ 1,750,000	$ 490,000	$ 2,240,000
Total Operations & Maintenance	$ 2,240,000	$ 2,560,000	$ 4,800,000	$ 2,240,000	$ 2,970,000	$ 5,210,000	$ 3,090,000	$ 3,380,000	$ 6,470,000	$ 3,380,000	$ 2,840,000	$ 6,220,000

Total Present Value

Table 7.14 presents a summary of the order of magnitude comparative present value for the complete project. The primary observations below are compared base on the Equivalent Annual Cost (EAC) for the project cost plus the operation and maintenance costs:

- Total annual life cycle costs for Alternatives 1-1 and 1-2 are the same in Phase 1.
- Alternative 1-1 in comparison to Alternative 1-2 (Base) is $1.5 million (20%) more in Phase 2 and a total of $1.6 million (7%) more on an annual basis. This equates to approximately $22.6 million difference in the 20-year net present value. The driving factor is the significant basin sizes required for the addition of anaerobic selectors and the associated equipment.
- Alternative 1-3 in comparison to Alternative 1-2 (Base) is $2.8 million (21%) greater in Phase 1, $2.2 million (28%) in Phase 2 and a total of $5 million (23%) more on an annual basis. This equates to approximately $73.9 million difference in the 20-year net present value. The higher costs are due to the higher capital, operation, maintenance and replacement costs of the installed membrane equipment.
- Alternative 2-2 in comparison to Alternative 1-2 (Base) is $3.9 million (28%) greater in Phase 1, $1.1 million (13%) less in Phase 2 and a total of $2.9 million (13%) more on an annual basis. The higher capital costs are due to the higher operation and maintenance cost of the installed membrane equipment and the additional personnel required for a separate greenfield ESSS treatment site.

Table 7.14 Comparative Life Cycle Costs

Description	Alternative 1-1 - Biological Phosphorus Removal at WRF			Alternative 1-2 - Chemical Phosphorus Removal at WRF			Alternative 1-3 - Membrane Bioreactor at WRF			Alternative 2-2 - Chem P at WRF with MBR at PS 240		
	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total	Phase 1 - 2036 NH3 Only	Phase 2 - 2036 Nutrient Removal	Phase 1 + Phase 2 Total
Total Project Cost	$ 170,340,000	$ 101,030,000	$ 271,370,000	$ 170,340,000	$ 72,440,000	$ 242,780,000	$ 200,040,000	$ 98,450,000	$ 298,480,000	$ 211,140,000	$ 59,090,000	$ 270,220,000
Operations & Maintenance - 20 Year Present Value, 3.25%	$ 32,580,000	$ 37,250,000	$ 69,830,000	$ 32,580,000	$ 43,210,000	$ 75,790,000	$ 44,880,000	$ 49,150,000	$ 94,030,000	$ 49,150,000	$ 41,270,000	$ 90,420,000
Construction, Operations & Maintenance Present Value	**$ 202,920,000**	**$ 138,270,000**	**$ 341,190,000**	**$ 202,920,000**	**$ 115,650,000**	**$ 318,570,000**	**$ 244,920,000**	**$ 147,600,000**	**$ 392,510,000**	**$ 260,280,000**	**$ 100,360,000**	**$ 360,640,000**
Equivalent Annual 20-Year Project Cost and O&M Cost at 3.25% Interest	**$ 14,000,000**	**$ 9,500,000**	**$ 23,500,000**	**$ 14,000,000**	**$ 8,000,000**	**$ 21,900,000**	**$ 16,800,000**	**$ 10,200,000**	**$ 27,000,000**	**$ 17,900,000**	**$ 6,900,000**	**$ 24,800,000**

7.4.6 Non-Monetary Screening

Besides costs, other non-monetary considerations are important in screening and eventually selecting an alternative for implementation Table 7.15 presents non-monetary criteria for screening the four alternatives.

The three most important were determined to be; *Reliability*, *Process Operational Requirements*, and *Maintenance Requirements*.

As indicated by Table 7.15, the MBR Alternatives 1-3 was rated highest; followed by the 4 and 5-stage Bardenpho Alternatives 1-1 and then 1-2.

Table 7.15 Non-Monetary Criteria Ranking[a]

Criteria	Weighted %	Alternative 1-1		Alternative 1-2		Alternative 1-3		Alternative 2-2	
		Activated Sludge, BIOP BNR		Activated Sludge, ChemP BNR		MBR, ChemP		WRF Activated Sludge, ChemP BNR with ESSS MBR	
		Score	Total	Score	Total	Score	Total	Score	Total
Flexibility for More Stringent Discharge Requirements	10.0%	4.0	0.40	3.0	0.30	5.0	0.50	3.0	0.30
Reliability (Bullet Proof)	20.0%	4.5	0.90	4.0	0.80	5.0	1.00	4.0	0.80
Process Operational Requirements	18.0%	4.5	0.81	3.0	0.54	4.0	0.72	3.0	0.54
Maintenance Requirements	18.0%	4.5	0.81	4.0	0.72	3.0	0.54	2.0	0.36
Ability for Future Expansion	14.0%	3.5	0.49	3.5	0.49	5.0	0.70	3.5	0.49
Resource Recovery (Green)	6.0%	3.0	0.18	2.0	0.12	4.8	0.29	3.0	0.18
Ability to Handle Peak Flows	14.0%	4.5	0.63	4.5	0.63	3.5	0.49	3.5	0.49
Total Weighted Score	100%	**4.22**		**3.60**		**4.24**		**3.16**	

Note: [a] Ranking from 1 to 5, with 1 worst and 5 best

In general, the MBR alternative is rated highest for flexibility because at more stringent discharge requirements the process has:

- Best water quality
- Potential for Reuse
- Benefit to disinfection process (lower chlorine requirements and lower toxicity potential)
- Best ability to accommodate TDS removal
- Smallest footprint
- Easiest implementation
- Ability to phase construction
- Greatest reuse flexibility

The following sections include rational for each non-monetary criteria tailored to this Project per Planning Team discussions.

Flexibility for More Stringent Discharge Requirements

- This criteria was given a lower weighted percentage overall. Future treatment requirements are anticipated to be out 20+ years and treatment technologies may have evolved significantly by then.
- Alternative 1-3 MBR was discussed with the ability to meet the highest water quality due to the barrier nature of the membrane technology and given a 5.0.
- Alternative 1-1 BioP and Alternative 1-2 ChemP BNR treatment technologies were compared and BioP was given the edge, as there is more risk in process control for the chemical feed as phosphorus varies. BioP was given a 4.0 and ChemP was given a 3.0.
- Alternative 2-2 is an ESSS MBR and ChemP BNR at the WRF. The score was given to match Alternative 1-2 at 3.0.

Reliable (Bullet Proof)

- Alternative 1-3 MBR was discussed with the reliability to meet the highest water quality due to the barrier nature of the membrane technology and again given a 5.0.
- Alternative 1-1 BioP and Alternative 1-2 ChemP BNR treatment technologies were compared and BioP was given the reliability edge for similar reasons, as there is more risk in process control for the chemical feed as phosphorus varies. BioP was given a 4.5 and ChemP was given a 4.0.
- Alternative 2-2 is an ESSS MBR and ChemP BNR at the WRF. The score was given to match Alternative 1-2 at 4.0.

Process Operational Requirements

- The Operational edge was given to Alternative 1-1 –BioP BNR with a score of 4.5 as there is limited attention to chemical feed.
- The Alternative 1-3 - MBR was given the next highest rating of 4.0 as there is more PLC control for this process and much attention is needed to make sure the membranes are fully functional, but much less existing facilities to operate.
- Alternative 1-2 –ChemP BNR was the lowest at 3.0 as there is higher attention to chemical feed.

- Alternative 2-2 –ESSS MBR/ChemP at WRF was scored a 2, as operation would be required at two separate facilities.

Maintenance Requirements

- The Alternative 1-3 - MBR was given the lowest rating of 3.0 as there is more equipment and PLC controls for this process and much maintenance is needed for equipment replacement, cleaning, etc.
- Alternative 1-2 –ChemP BNR was the next lowest at 4.0 as there is higher maintenance for chemical feed equipment.
- The maintenance edge was given to Alternative 1-1 –BioP BNR with a score of 4.5 as there is limited required attention to chemical feed.

Ability for Future Expansion

- MBR was discussed with the best ability to expand due to the smaller footprint (less concrete to pour) of the membrane technology and given a 5.0. It was also noted that MBRs could be added in smaller increments.
- BioP and ChemP BNR treatment technologies were compared and both were given a 3.5 due to the similar tankage requirements.
- Alternative 2-2 is an ESSS MBR and ChemP BNR at the WRF. The score was given to match Alternative 1-2 also give a 3.5.

Resource Recovery (Green)

- MBR was discussed with the best ability to for resource recovery i.e. reuse due to the cleaner water supplied by the membrane technology and given a 4.8.
- BioP and ChemP BNR treatment technologies were compared and BioP was given the resource edge for similar reasons, as there is less chemical feed required and, also the potential to recover phosphorus. BioP was also given credit, as the bioavailability of phosphorus is limited with ChemP. It was discussed that chemical would still be required for the dewatering process. BioP was given a 3.0 and ChemP was given a 2.0.
- Alternative 2-2 was given a score of 3.5, which is higher than Alternative 1-2 as there is reuse potential at the ESSS MBR.

Ability to Handle Peak Flows

- The Alternative 1-3 - MBR was given the lowest rating of 3.5 as MBRs are a barrier technology and flow is limited to a peaking factor of 2. The impact of current weather trends with higher, more concentrated storm events occur. HDR discussed some current MBR issues at MBR plants, which has been due to a number of factors including cold climate, silt, and other constituents.
- BioP and ChemP BNR treatment technologies were compared and both were given a 4.5 due to the similar ability to pass peak hydraulic flows –only limited by piping.
- Alternative 2-2 was given a score of 3.5, which is less than Alternative 1-1 and 1-2 as there MBR technology barrier issues would exist at the ESSS MBR.

As far as reliability, all are consistent and reliable in meeting lower ammonia and nutrient levels.

Maintenance requirements are significant considerations for the screening and evaluation of the alternatives. Alternative 1 has an edge over the Alternative 2 -ChemP MLE process as biologic phosphorus removal requires less chemical.

7.4.7 Cost Weighted Non-Monetary Criteria Ranking

The objective of weighing economic and non-economic criteria is to provide a balance between making a purely economic choice with the non-economic variables that are important to the planning team and ultimately the community served. Proportioning of economic and non-economic criteria was done on a 50% allocation to economics and 50% to the non-economic evaluation. Refer to Table 7.16 for the cost weighted non-monetary criteria ranking. Scoring is a percentage with the higher percentage being more favorable.

- Alternative 1-1 Activated Sludge, BIOP BNR came out the most favorable at a higher score of 95% versus Alternative 1-2 ChemP at 92% and Alternative 1-3 - MBR at 90% and Alternative 2-2 WRF Activated Sludge, ChemP BNR with ESSS MBR at a value of 80%.
- A driving factor is that the life cycle cost difference for Alternative 1-3 compared to Alternative 1-1 is more than $70 million over the life of the project.

Table 7.16 Cost-Weighted Non-Monetary Criteria Ranking[a]

Criteria	Criteria Portion	Alternative 1-1	Alternative 1-2	Alternative 1-3	Alternative 2-2
		Activated Sludge, BIOP BNR (Million)	Activated Sludge, ChemP BNR (Base)	MBR	WRF Activated Sludge, ChemP BNR with ESSS MBR
Economic Evaluation	50%				
Capital Cost (Total Project)		$271,400,000	$242,800,000	$298,500,000	$270,200,000
O&M 20-Year Present Worth Cost		$70,060,000	$75,790,000	$94,030,000	$90,420,000
Total 20-Year Present Worth Cost		$341,460,000	$318,590,000	$392,530,000	$360,620,000
Percent of Minimum Present Worth Cost		107%	100%	123%	113%
Economic Evaluation Points		0.47	0.50	0.41	0.44
Non-Economic Evaluation	50%				
Non-Economic Weighted Score		4.22	3.60	4.24	3.16
Percent of Maximum Weighted Score		99.6%	84.9%	100.0%	74.6%
Non-Economic Evaluation Points		0.498	0.425	0.500	0.373
Total Score[a]		**96%**	**92%**	**91%**	**81%**

Note: [a] Higher Total Scores indicate that the alternative is more preferable.

7.5 Recommendations

The existing trickling filters are very efficient for BOD and ammonia removal and have served the City of Sioux Falls well in terms of permit compliance for the last 35 years. Likewise, it is a familiar technology to operations staff and reduces the impact of future biosolids production. However, fixed film is not effective for nutrient removal without significant chemical addition (methanol) in downstream aeration basins or add-on denitrification filters.

Costs for the alternatives with two phases to achieve the effluent limits for Permit #2 and #3 for both future ammonia and Level 1 nutrient control of 10 mg/l TN and 1 mg/l TP indicate the following:

- Alternative 1-2, 4-Stage Bardenpho MLE with chemical phosphorus removal is ultimately the lowest cost alternative whether it be construction cost, energy cost, chemical cost, operations and maintenance cost, or overall present value. On a total 20-year present value basis, it is approximately $22.6 million less expensive than the next alternative, which equates to $1.6 million on an annual basis.
- Alternative 1-3, MBR with chemical phosphorus removal has both the highest capital and operations and maintenance cost of all of the alternatives.
- Alternative 1-1, 5-Stage Bardenpho MLE with biological phosphorus removal has the second lowest life cycle cost and when weighed with the non-economic factors this is the highest ranked alternative.

Alternate 1-1 5-Stage Bardenpho MLE with biological phosphorus removal is recommended for expanding the activated sludge treatment for additional capacity with provisions for denitrification and phosphorus removal as it was collectively the best alternative from both a non-economic and economic standpoint.

Recommended Alternative 1-1: 5 Stage Bardenpho Biological Nutrient Removal

The 5-Stage Bardenpho Process was chosen as the alternative for upgrade of the WRF to biological nutrient removal. This provides a basis for planning for the treatment process upgrade, defining the facilities required, establishing preliminary design/sizing criteria, estimating costs, and making an initial assessment of plant site layout impacts. The 5-Stage Bardenpho process was selected for the following reasons:

- Ability to biologically remove both phosphorus and nitrogen,
- Ability to meet lower phosphorus limits as permit limits become more stringent,
- The process is nonproprietary and proven and,
- Collectively, the balance of non-economic and economic criteria was favorable.

Note costs and project scope are further refined in Chapter 10.

The long-term final recommendation is to implement the above WRF improvements to be continued through 2036 with the following action items:

- As the projected 20-year growth and resulting flows and loadings flows are approached, an East Side WRF would be reevaluated along with potential for additional equalization, a third forcemain.
- A safety factor should be applied to the modelled equalization volume to address the storm of record.

Chapter 8 – WRF Solids Handling Evaluation

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Table of Contents

Tables

Figures

Appendices

Chapter 8 Solids Handling Evaluation

8.1 Background and Purpose

Several variables impact the solids handling system. One variable is fats, oils, and grease (FOG) processing, which has been recommended as a sustainable option for the WRF. Another factor is that the existing post digestion processing has become less viable as available land is getting farther away. Finally the selected liquid process alternative has been sized as part of this Master Plan to meet the projected design loading, which increases solids handling loading rates. The purpose of this chapter of the master plan is to review the previous study recommendations for upgrades or improvements to the existing solids handling system including thickening, solids digestion, dewatering, and drying facilities and provide recommendations.

The City of Sioux Falls Water Reclamation Facility (WRF) provides secondary treatment for municipal, commercial, and industrial wastewater, based on the previously defined regional service area, using primary sedimentation, two-stage fixed-film trickling filters, activated sludge, and disinfection. Treated effluent is discharged into the Big Sioux River. In the future, the trickling filters will be phased out and additional sludge production will be used as part of the selected 5-Stage Bardenpho activated sludge process as described in Chapter 7. Solids handling facilities consist of co-settled Waste Activated (WAS) and Primary Sludge (PS). The WAS is returned ahead of the primary clarifiers and co-settled in the primary clarifiers. The co-settled solids are then sent to one of two gravity thickeners and anaerobically digested via primary digesters. Digested sludge is pumped to two biosolids lagoon cells for storage prior to land application.

In the future, the WRF plans are to dewater and thermally dry the solids thereby creating Class A biosolids, which will be compatible with public fertilizer use; any biosolids not used as fertilizer will be land applied. In addition, there are plans for acceptance of Fats, Oils and Grease (FOG) to provide for a sustainable WRF facility.

The two prior studies relevant to this Master Plan describing the recommended solids handling improvements for FOG and dewatering are as follows:

- Water Reclamation Facility FOG Receiving and Digester Complex Improvements Study (FOG Study, December 2013)
- Biosolids Management Evaluation Study for Water Reclamation Facility (Biosolids Study, Updated June 2014)

The following sections summarize the resulting master planning recommendations and associated costs, the evaluations and considerations that led to those recommendations, and identify subsequent considerations, which were reviewed, and either updated for Master Planning or recommended as future action items.

The FOG Study section is an assessment of thickening through digestion, and the Biosolids Management Evaluation Study is an assessment of post-digestion facilities through ultimate disposal.

8.2 FOG Study

This study, dated December 30, 2013, was prepared by SEH with the intent of replacing aging digester related facilities at the Water Reclamation Facility with new facilities that incorporate energy sustainability goals, support future growth, responds to potential regulatory impacts, and incorporate long-term operation and maintenance practices.

8.2.1 Costs and Components

The costs and components in this section describe the FOG Study recommendations and the status of the associated projects.

Original digester related facilities were constructed in 1982 with only minor improvements to add a new engine generator in 2009 and to replace one digester mixing system in 2010. The Study recommends $19.5 million worth of improvements (including engineering, construction administration, and City administration and legal) to be constructed in four phases over four and one-half years. The first phase was shown to begin in 2014 and the fourth phase was shown to be completed in mid-2018. These costs are in 2013 dollars.

A breakdown of the estimated costs is included in the FOG Study Table 8.1 and Figures 8.1 and 8.2 on the following pages. All except Project 5 are required to replace aging facilities. Project 5 adds a Feedstock Receiving and Processing Station to receive and co-digest FOG in the short term and to receive and co-digest food/higher solid waste materials with additional improvements in the future when the associated waste collection program is developed.

Table 8.1 Sioux Falls WRF FOG Receiving & Digester Complex Improvements Summary*

Proposed Capital Improvements	Project No.	Project Cost	Status	Remaining Project Costs
Heat Exchangers	1	$760,000	Completed	
Gas Conditioning	2	$3,290,000	In Progress	
Digester #3 Mixing & Cover	3	$2,440,000	In Progress	
Digester #2 Mixing & Cover	4	$2,440,000	In Progress	
FOG Receiving and Processing	5	$2,660,000	Remaining	$2,660,000
Secondary Digester Cover	6	$1,350,000	Completed	
Digester #1 Mixing & Cover	7	$2,440,000	In Progress	
Microturbines	8	$4,150,000	Remaining	$4,150,000
TOTAL		**$19,530,000**		**$6,810,000**

* From Study -In 2013 dollars.

The following projects are either completed or in progress:

- Project Nos. 1 and 6 - Completed

- Project Nos. 2, 3, 4, and 7 - In Progress
- Project Nos. 5 and 8 - Remaining

8.2.2 Evaluations

The FOG study found that the $2.66 million FOG receiving and processing facility had a five to twelve year simple payback and will produce $1 million to over $4 million savings over 20 years. Key assumptions in the analysis included the energy value of the increased digester gas production, an estimated $200,000 annual savings in collection system maintenance associated with keeping grease out of the collection system, a $0.10 per gallon tipping fee for FOG, and an education program, new FOG ordinance, and enforcement that redirect the "optimum" amount of the FOG from Sioux Falls food service establishments to the new receiving station.

The FOG study estimated that around 5,500 lb/day, 2 million lb/year, of FOG are generated in the WRF service area as of 2012. At 15 to 27 percent solids, this equates to 2,500 to 4,500 gallons per day of FOG waste. The FOG Study also forecasts FOG quantities to increase to just under 8,000 lbs/day, or 3,500 to 6,300 gallons per day by 2035.

The FOG Study also noted reduced sanitary sewer overflows with keeping FOG out of the collection system and reduced post digestion solids handling costs due to potentially lower solids production with the co-digestion of FOG.

The FOG Study indicates that the most immediate need is to improve digester gas quality to decrease O&M costs for energy recovery and increase capacity for the additional biogas from FOG co-digestion. Following evaluation, it recommends a bio-trickling filter over ferric chloride addition for this purpose; largely because of lower operation and maintenance costs for biological hydrogen sulfide removal and the flexibility to accommodate additional feed stocks in the future.

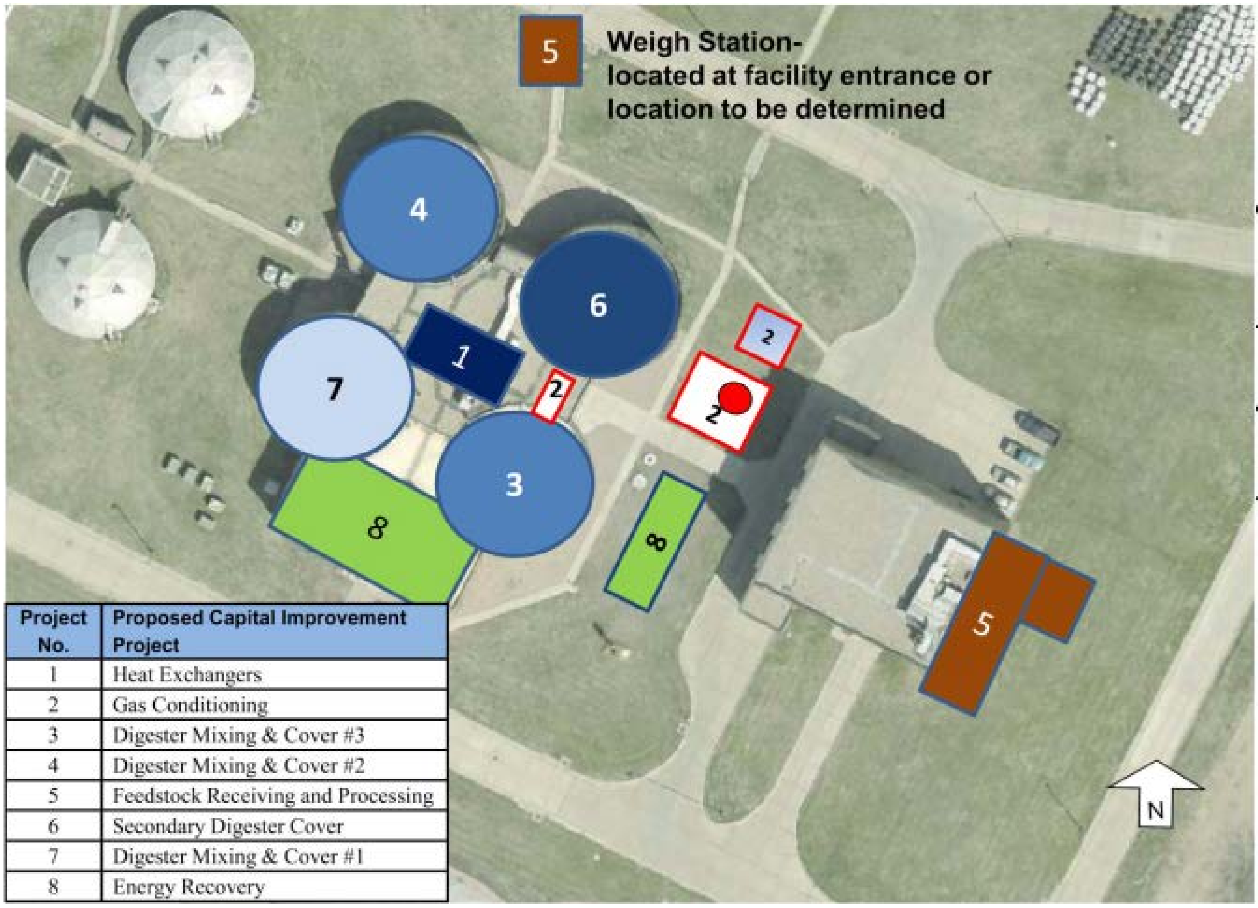
The FOG Study indicates that the next most immediate need is to replace the digester mixing system and heat exchangers to optimize co-digestion performance. Following evaluation, it recommends spiral heat exchangers over tube-in-shell heat exchangers on the basis of lower capital cost, smaller footprint, and less prone to plugging. It also recommends a high flow, moderate velocity externally pumped digester mixing system with multiple discharge nozzles, including some at the surface to break up scum, over draft tube and disk mixing systems; largely because of compatibility with the proposed floating covers, slightly lower power consumption, and reduced maintenance costs.

Additionally, the FOG study recommends micro turbines over replacing engine generators for combined heat and power. Following evaluation, this recommendation was based primarily on operational flexibility with reduced maintenance costs but also higher turndown range and less restrictive air permitting requirements. The FOG receiving and processing justification included assumptions that the micro turbines would have 95 percent generation uptime and would cost $0.023 per kilowatt-hour to operate including the associated biofilter cost.

Finally, the FOG Study recommends radial steel beam floating digester covers over fixed and membrane digester covers. This recommendation was based on floating covers being the safest and most flexible operation. However, fixed covers have been installed since the time of the study in order to increase the digester capacity and prepare for operating all digesters as primary digesters.

The following Figure 8.1 contains the FOG receiving and digester complex improvements, general site layout and respective project numbers. Refer to Figure 8.2 for the FOG receiving and digester complex below grade layout relevant to project 5.

Figure 8.1 Sioux Falls WRF FOG Receiving and Digester Complex Improvements (Figure 2)



Project No.	Proposed Capital Improvement Project
1	Heat Exchangers
2	Gas Conditioning
3	Digester Mixing & Cover #3
4	Digester Mixing & Cover #2
5	Feedstock Receiving and Processing
6	Secondary Digester Cover
7	Digester Mixing & Cover #1
8	Energy Recovery

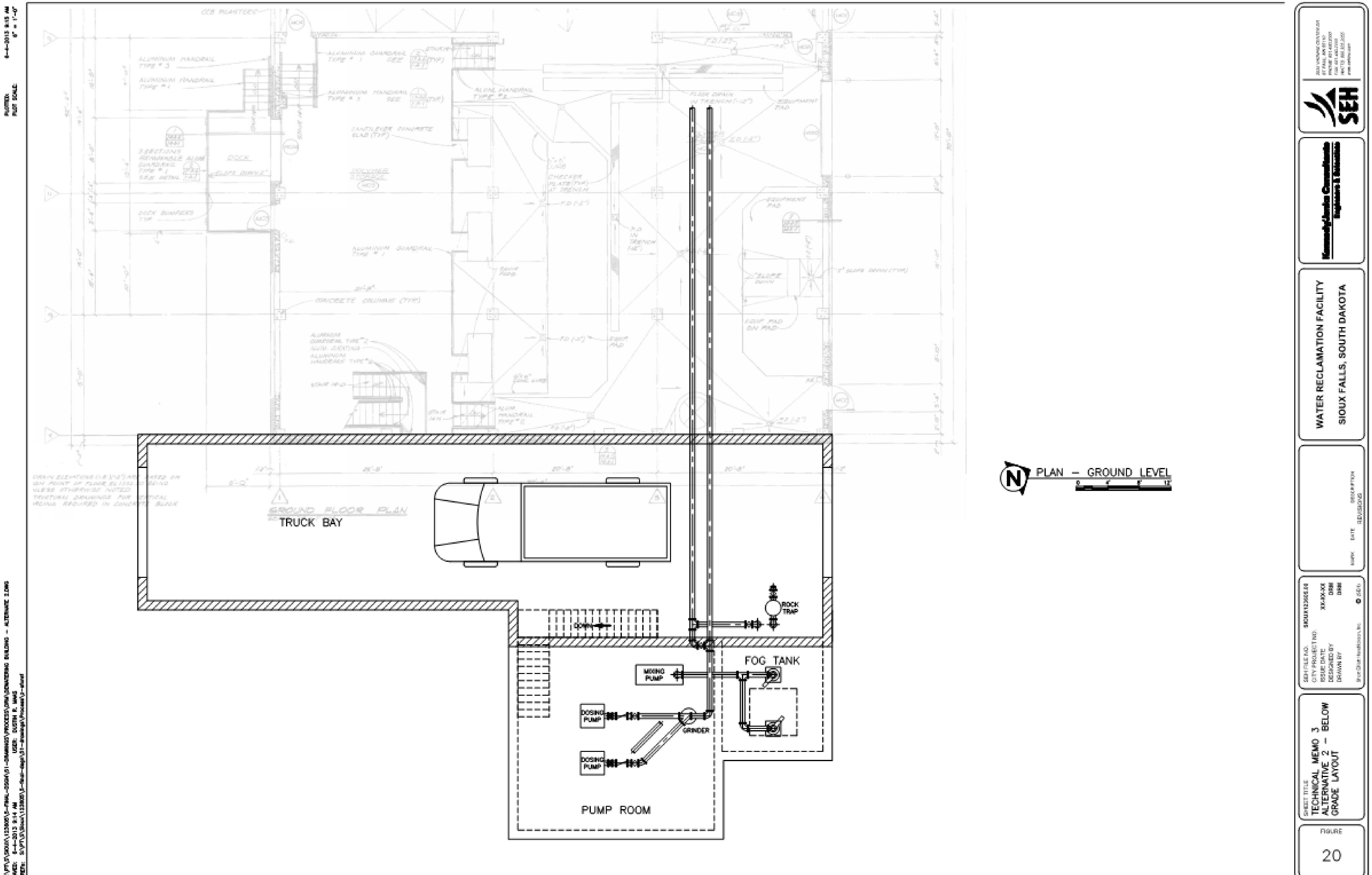


Figure 8.2 Sioux Falls WRF FOG Receiving and Digester Complex Layout

8.2.3 Existing Municipal Solids Digestion Loading Summary

Table 8.2 shows a comparison of current volatile solids (VS) to the digester from the 2013 FOG Study. As indicated in the table, June 2015 through May 2016 were wet months and the flow was up 30% from 2012. The average flow to the digesters increased by 20%. However, the volatile solids loading was down slightly due to a lower average VS content of 78.9% versus the assumed VS of 82.9%, based on 2012 plant data. The net effect is that the detention time of the digester is reduced while the VS loading has been relatively uniform.

Table 8.2 Digester Loading Comparison to FOG Study

Time Period	Average Plant Influent Flow	Average Flow to Digesters	Solids Concentration	Average VS Loading	Max. Month VS Loading
	MGD	MGD	%TS	lb VS/d	lb VS/d
2012 (FOG Study)	13.9	0.063	6.1	32,027	36,265
June 2015 – May 2016	18.1	0.075	6.1	30,258	36,577
Change (% Increase)	30%	20%	0%	-6%	1%

8.2.4 Future WRF Solids Handling Capacity Summary

The proposed master plan facility upgrades for biological nutrient removal impact the quantity and characteristics of the wastewater solids generated during treatment. Also, the upgrade would be accompanied by a significant plant expansion to accommodate master plan growth and capacity for regional and industrial loadings. The solids processes were evaluated at the master plan projected design flow conditions to determine the adequacy of the current facilities to handle the additional residuals from the projected future flows and loadings and the changes from nutrient treatment.

Based on the FOG Study, the maximum acceptable loading rate used was 0.160 lb/cf/d (160 lb/1000 cf/day), and the minimum detention time used was 20 days, the maximum allowable solids loading rates are summarized in Table 8.3. An estimate of plant influent flow rates that will result in solids production rates equal to maximum digester loading has also been estimated assuming the digester covers are replaced with fixed covers which increases the volume by 5.4% to 811,000 gallons.

The ENVision model was used by HDR to project future residuals as part of the Master Plan effort. It was calibrated at an average flow of 16 mgd to determine that assumptions used in the model were correct. Table 8.3 provides a summary of the digester feed and loading rates with Alternative 1-1, 5-Stage Bardenpho and Alternative 1-3, MBR. The solids concentration was assumed to be 5% versus 6.1% in the FOG study due to the increased WAS, as the role of activated sludge increases. Note that the total solids to the digesters from plant operational data were adjusted for a mass balance with the BOD and influent solids. It was determined that there may be some sampling discrepancies giving higher than actual thickened sludge concentration as the City was confident in the magnetic flow meter readings.

The solids concentration could still be 6% if WAS is thickened by mechanical thickening as determined in preliminary design.

From the table, the shaded/underlined values indicate values that approach recommended digestion capacity as follows:

- With three digesters, both 2026 and 2036 maximum month loading results in detention times less than 20 days.
- With three digesters, 2036 maximum month loading results in loadings greater than 160 lb/1000 cf/day.
- With four digesters, 2036 maximum month loading results in detention times slightly less than 20 days at 17 days.
- With four digesters, 2036 maximum month loading results in loadings less than 160 lb/1000 cf/day.

The quantity of FOG that can be added to the digesters was calculated utilizing the following assumptions:

- Each digester has 811,000 gallons of active volume.
- All digesters are clear of grit and scum.
- VS / TS ratio of municipal solids remains at its present average of 82.9% throughout future growth.
- FOG waste contains 1.49 pounds of grease per gallon of waste collected.
- FOG waste contains 95% volatile solids.
- 15 cubic feet of digester gas are generated for each pound of volatile solids destroyed.
- 90% of FOG waste volatile solids are destroyed and converted to digester gas.
- 62% of municipal volatile solids are destroyed and converted to digester gas.
- At present there are 2,000,000 pounds of FOG waste available per year.
- Quantities of FOG waste available will increase proportionally to plant influent flow.

Table 8.3 includes a summary of the remaining capacity for FOG for three or four primary digesters operating as follows for the recommended 5-stage Bardenpho process at a loading of 160 lb VS/1000 cf/d:

- The total capacity per digester is 17,400 lb VS/d which equates to 52,000 lb VS/d for 3 digesters and a total capacity of 69,400 lb VS/d for four digesters.
- With four primary digesters, there is approximately 8,840 lb VS/d available in 2036.
- There is capacity is available to handle FOG through 2036. Based on TM3, Table 7 of the FOG Study 5,500 lbs VS/day, 2,500-4,500 gallons per day, of capacity is required.
- With four digesters, the expected FOG is approximately 51% of the total available volatile solids loading capacity.

Note, at other facilities, digesters have been loaded at 0.20 lb VS/cf/d with blending FOG versus the recommended 0.16 lb VS/cf/d, which results a 25% increase in available capacity, Ref. *Living Innovation: EBMUD's Challenges Along the Path to Energy Self Sufficiency, Horenstein, Skoda et. al.*

8.2.4.1 Future WRF Gas Capacity Summary

The net energy remaining was checked for projected year 2026 and 2036 average day loadings. Year 2026 was limiting.

The estimated biogas generated in 2026 is 220 MMBTU/d with 40 MMBTU/d used for digester heating and 130 MMBTU/d used for thermal drying (@ 1,500 BTU/lb-water) and the remaining net energy is 50 MMBTU/d per day on an average 2026 daily basis. Natural gas may be required to supplement in the coldest days of winter.

At today's average natural gas cost per Therm at ($0.39), thermal drying cost equates to approximately $185,000 per year.

Thickener Capacity Summary

The two gravity thickeners have a surface area of 2,375 sf each, with a 2026 loading from the co-thickened primary and waste activated sludge of 41,660 lbs/day, the loading rate to one thickener would be 17.5 lbs/sf/day, which is outside the standard range of 5-16 lb/sf/day. Gravity thickener capacity will need to be increased by 2025 if a unit is maintained as standby, per the current operation.

Table 8.3 Digestion Process Evaluation Summary -2026, 2036 Capacity Requirements

			Existing	Phase 1 Expansion		Alternative 1-1, 5-Stage Bardenpho				Alternative 1-3, MBR	
			AA	2026 AA	2026 MM	2031 AA	2031 MM	2036 AA	2036 MM	2036 AA	2036 MM
Anaerobic Digester Feed[1]	lb/d		22,660	41,660	64,130	43,080	61,230	46,620	79,250	59,460	80,680
Feed Concentration	%		5%	5%	5%	5%	5%	5%	5%	5%	5%
Feed flow	mgd		0.054	0.100	0.154	0.103	0.147	0.112	0.190	0.143	0.193
Loading for 3-Digesters											
HRT @ 3 Digesters	d		45	24	16	24	17	22	13	45	24
Digester Loading Rate @ 3 Digesters	lb/1,000 cf/d			97	158	101	143	109	186	144	193
Available FOG Capacity @ 3 Digesters -160 lb VS/1000 cf/d				20,381	583	19,302	5,508	16,612	(8,507)	6,853	(9,274)
Loading for 4-Digesters											
HRT @ 4 Digesters	d		60	32	21	31	22	29	17	29	22
Digester Loading Rate @ 4 Digesters	lb/1,000 cf/d			73	119	75	107	82	140	104	141
Available FOG Capacity @ 4 Digesters 160 lb VS/1000 cf/d				37,729	17,930	36,650	22,856	33,959	8,840	24,201	8,074
Volume each	gal	811,000									

Note: 1. The digester feed rate from the plant data exceeded the influent solids loading. It was assumed that the WRF influent BOD (approximately BOD5 at 30,000 lbs/day) was correct and the existing anaerobic digester feed was adjusted to match the expected solids production based on the influent BOD loading rate.

Abbreviations:
AA - Average Annual
MM - Maximum Month
HRT – Hydraulic Residence Time
Design Criteria

- *Minimum HRT 20 days*
- *Maximum loading 160 pounds Volatile Solids per 1,000 cubic feet per day, 0.160 lb/cf/d.*

8.2.5 Digestion Master Plan Considerations

The following considerations are offered based on the fact that secondary digester cover has been replaced, the primary digester covers and mixing system are in process, the fourth digester is converted to a primary digester and the digester gas conditioning project is in design.

1. Thickening: A third gravity thickener will need to be provided by 2025 to provide for a standby unit, per the current operation, as the loading is exceeded in 2026. The project cost of the third unit is estimated at $3.3 million and should be included as part of the phase 1 liquid storage improvements. However, in the long term mechanical thickening is required which includes either drawing directly off of the thickeners or separately storing and thickening WAS based on the increase WAS with the treatment shift to activated sludge and continuing to thicken primary clarifier sludge via the gravity thickeners. Refer to Table 8.4.

Table 8.4 New Sludge Thickening Cost Estimate

Capital Cost:				
Item Description	Est. Qty	Units	Unit Price	Total Price
New Thickening and Process Piping Modifications	1	EA	$1,660,000	$1,660,000
Subtotal				$1,660,000
Undeveloped Design Detail (25%)				$415,000
Construction Subtotal W/Contingencies				$2,075,000
General Conditions, Mobilization (5%)				$104,000
Sales Tax Allowance (5%)				$109,000
Overhead & Profit (15%)				$343,000
Bonds & Insurance (2%)				$53,000
Total Construction Cost				$2,684,000
Engineering, Admin., Legal, Permitting (24%)				$644,000
Total Gravity Thickener Project Cost				$3,330,000

2. Digester Gas: Digester gas production was updated for the recommended micro turbine installation as these recommendations were made after the Biosolids Study recommendation to use the gas to dry biosolids.

3. Digester Loading: Note, at other facilities, digesters have been loaded at 0.20 lb VS/cf/d with blending FOG versus the recommended 0.16 lb VS/cf/d. A steady loading and SRT are required to maintain a stable process, but consideration should be given to allowing a larger FOG loading if FOG is received at a higher than expected rate. To successfully maintain higher loadings, FOG loading should be distributed evenly between the digesters along with the plant solids.

4. Digester Capacity: The updated estimated sizing and costs for recommended facilities not already under design or construction were reviewed as part of this Master Plan are as follows:

- The fourth primary digester is currently being converted to a primary digester and required by 2026 or sooner, depending on the level of FOG. A review projected total loading quantities and impacts on biosolids quantity loading to the Digesters is summarized in Table 8.2.

- Four digesters are adequate for the forecasted increase in sludge quantities as well as FOG.

- Thermal drying will provide additional treatment to meet Class A biosolids requirements and augments the digester time and temperature requirement.

5. Energy Recovery Improvements: Methane gas produced by anaerobic digestion can be upgraded to pipeline quality and sold to a public utility for injection into a natural gas distribution system or reused in vehicles. Upgrading the gas typically involves treatment for removal of carbon dioxide, oxygen, and hydrogen sulfide, dehydration, and compression. Moreover, based on current prices of natural gas, selling of upgraded gas to a public utility or for reuse in vehicles has become very economically viable. Given developments in the gas market and the availability of carbon credits for recovery of gas and sale to the utility, it is recommended that a study be conducted to determine the feasibility of this for the Sioux Falls WRF. The advantage the WRF has is that they are implementing a biogas conditioning system, which may meet the quality requirements.
6. Capital Improvement Items: Capital improvements for thickening and digestion are itemized in Table 8.5 (inflated to 2016 dollars from the base year at 2013):

Table 8.5 WRF FOG Receiving & Digester Complex Improvements Summary*

Proposed Capital Improvements	Study Project No.	Study Project Cost	Status	Updated Project Costs
New Gravity Thickener	N/A	N/A	Added	$3,330,000
FOG Receiving and Processing	5	$2,660,000	Remaining	$2,920,000
Microturbines	8	$4,150,000	Remaining	$4,550,000
TOTAL		**$6,810,000**		**$10,800,000**

* From Study –Updated to 2016 dollars.

7. Future Action Items: The remaining FOG Study action items are as follows:

- Ensure that revisions to City ordinance, development of an education program, and enforcement infrastructure to keep FOG out of collection system are pursued. In addition, develop plans to encourage hauling to new FOG receiving facilities.

- Monitor competitors to determine whether the assumed tipping fee of $0.10 per gallon (escalated at 3 percent per year) is competitive.

- Need to continue to assess whether there are other high strength liquid waste streams that should be also be pursued.

- Affirm FOG Study assumptions that there will be reduced post digestion solids handling costs due to potentially lower solids production with co-digestion of FOG, and that the microturbines would have 95 percent generation uptime and cost $0.023 per kilowatt-hour to operate including the associated biofilter cost. This is a key assumption in the payback and needs to be verified when the FOG sources are more fully defined.

8. Future Waste Considerations: Assuming that the City's intent is still to eventually receive and co-digest food/higher solid waste materials the WRF should do the following:

    - Develop a food / higher solid waste collection program.

    - If source(s) are available, develop an updated Basis of Design to include facilities for receiving and process food / higher solid waste.

8.3 Biosolids Study

This Study, dated June 2014, was prepared by HR Green with the primary purpose to evaluate alternatives and recommend a 20-year plan for biosolids at the Sioux Falls WRF. One of the most critical questions for the Study was whether the City should continue land applying biosolids or select a contractor for land application of biosolids. Recommendations are based on forecasts of biosolids production with anticipated growth and future nutrient removal as well as investigation of digested sludge processing and storage options. The implications of FOG Study recommendations were not considered, as there was no solids increase attributed to FOG processing.

Note that Sections 8.3.1 and 8.3.2 are a summary of pertinent information and decision making from the Biosolids Study while section 8.3.3 reflects recommendations and adjustments made for Master Planning purposes.

8.3.1 Background

The Study reviewed historic biosolids quantities from 2008 through 2012 and used 2011 quantities to estimate future biosolids quantities through 2033. The future forecast includes a 2 percent annual increase based on population growth and a 10 percent increase in 2024 based on anticipated nutrient related regulatory requirements.

The study also identified historic and current sludge handling and disposal practices, post anaerobic digestion sent to liquid biosolids storage lagoons with land application on agricultural land by City staff. Each of the two storage lagoons is an 8.4 million gallons earthen basin with clay liner for a total of 16.8 million gallons. When projected out to 2036 at updated flows and loads, the combined volume provides 205 days of liquid sludge storage versus 313 days in the 2014 study, assuming DENR approval of a reduction in minimum freeboard from three feet to two feet. Supernatant is decanted back to the WRF headworks. A dredge platform with pump provides mixing and pumping.

Liquid biosolids are hauled in three 5,900 gallon tanker trailers/semi-trucks and land applied at 95 percent agronomic rates with a four-wheel drive tractor and pull-type slurry tank with subsurface injection. Approximately 2,000 acres of agricultural land is available at 47 sites from four miles to over 16 miles from the WRF. Historically, the City is able to apply from the spring through the summer into the fall due to the mix of crop and pasture land available. More than 3,600 hours of City labor were recorded in 2011 for pumping, loading, hauling, and land application.

The Study indicates that the sludge lagoons are in good shape but identifies a number of limitations with current sludge storage and disposal practices. The limitations include the need to replace the three tanker trucks in 2018, replace the lagoon dredge in 2021, and add a second biosolids crew and second set of land application equipment by 2016. Additionally, limited mixing in the sludge lagoons makes removal more difficult, the current overall liquid sludge storage and land application practice is labor intensive, City staff desire two years of liquid sludge storage to accommodate a wet fall, and the availability of farmland near the WRF is dwindling driving up hauling costs.

The Study notes that WRF removed belt filter presses once used for sludge dewatering but the dewatering building in which they are located could be used to house new sludge processing equipment with only minimal modifications. The processing equipment was envisioned to be located on the second floor and include polymer system, feed pumps, belt filter presses or screw presses to achieve at least 18 percent solids, and screw dryers or paddle dryers to achieve at least 92 percent Class A cake solids.

8.3.2 Evaluation

The Study evaluated a total of 11 alternatives; six original and five additional variations. Both economic and noneconomic elements were considered. The economic evaluation included capital and operations and maintenance costs. The noneconomic evaluation for biosolids disposal included disposal risk, safety, biosolids beneficial reuse, public perception, and regulatory changes to biosolids reporting. The noneconomic evaluation for sludge processing and disposal included byproduct beneficial reuse, bio-gas utilization, disposal flexibility, use of existing facilities, and ease of operation. The planning period was 20 years through 2033, but storage, handling, and disposal costs were included from 2011 through 2033 resulting in alternatives comparisons for a 22 year period.

All costs were reported in 2011 dollars but escalated by 3 percent annually. Present worth costs were calculated using a seven percent rate of return. They were calculated separately for land application and processing and storage, and then combined. Present worth costs were also calculated for 10, 20, and 22 year periods.

The eleven alternatives included various combinations of City or contractor disposal, dewatered or dried biosolids, liquid or covered solid storage, and land application or landfill disposal. However, only one of the alternatives (Alternative 1) was based on City disposal; the other ten alternatives were all based on Contract disposal. Notably, the Contractor disposal alternatives include a credit for eliminating the City’s liquid biosolids land application cost assuming that the associated labor will be reassigned. Also, the solids processing alternatives include a $10 million credit calculated as the net savings to modify the existing sludge lagoons for flow equalization rather than construct new flow equalization.

Specific recommendations in the study were formulated based on four key issues.

- Economics – whether to invest in land application/disposal equipment in the near term. The evaluation shows the Contractor liquid biosolids land application option to be less expensive than the City liquid biosolids land application option.
- Disposal Risk – the current liquid biosolids land application option is dependent of farmer schedules, available farm land, weather, regulatory conditions, and lagoon storage capacity. The evaluation shows processing the biosolids can reduce or eliminate these risks.
- Transfer of Labor – the current liquid biosolids land application process will require even more labor in the future. The aging WRF will likewise require more maintenance. The study shows that labor for biosolids can be shifted to plant maintenance through contract disposal.
- Beneficial Reuse – the opportunity to beneficially reuse the existing dewatering building for solids processing, the existing sludge lagoons for flow equalization, dried solids on public ground, and land application staff for other labor needs.

Alternative 2 (store liquid sludge in existing sludge lagoons and have a contractor land apply liquid biosolids on existing land application sites) was recommended in the Study as the interim option for the first 10 years through 2021 based primarily on lowest 10 year present worth as shown below, the City's available funds at the time, transfer of labor, and beneficial reuse over that time period in spite of a lower non-economic ranking and higher disposal risk. Ten years also roughly corresponds with the anticipated need for WRF flow equalization.

Table 9-1 – Present Worth Analysis for Year 10 – With Labor Credit and Without Equalization Facility Credit

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
10-Year Total Present Worth (PW10)	$5,739,000	$3,660,000	$13,835,000	$12,433,000	$11,018,000	$13,367,000
PW10 Rank	2	1	6	4	3	5

A transition to Alternative 4B (dewater sludge to 24% solids, dry sludge to 92% solids, and store the dried cake in aboveground pad/bunker for giveaway (half) and for contracted land application (half) on existing land application sites was recommended by the Study, long term, when peak flow equalization is required and biosolids production increases due to nutrient reduction. Alternative 4B has the third lowest 22 year total present worth (see Attachment B) but the best overall non-economic ranking, transfer of labor, and beneficial reuse.

The prior Study recommendations include:

- Proceed immediately with an evaluated selection process to select a biosolids specialty contractor for a two year contract.
- Budget and proceed with sludge processing improvements as soon as funding is available.
- Conduct pilot testing of sludge processing equipment in advance of design.

8.3.3 Post Digestion Biosolids Considerations

The following considerations are offered based on review of the prior Biosolids Study for this Master Plan.

1. As part of Master Planning, the problem with the reliability of contract disposal operations of biosolids in 2014 (see item 5 in the Executive Summary of the 2014 Annual Biosolids Report) was reviewed with City staff. As a result of the issue encountered, the City will continue to operate and dispose of biosolids in lieu of contract disposal as the interim solution.

2. The Master Plan verbally reaffirmed that life-cycle costs were updated in the FOG Study recommendation for using biogas for sludge drying. The estimated biogas generated in 2026 is 220 MMBTU/d with 40 MMBTU/d used for digester heating and 130 MMBTU/d used for thermal drying (@ 1,500 BTU/lb-water) and the remaining net energy is 50 MMBTU/d per day on an average 2026 daily basis. Natural gas may be required to supplement in the coldest days of winter.

3. At today's average natural gas cost per Therm at ($0.39), thermal drying cost equates to approximately $185,000 per year.

4. The Master Plan reviewed data from the last 12 months from June 2015 to May of 2016 and the sludge quantities are in close agreement. From June 2015 thru May 2016, the Sioux Falls WRF produced approximately 3,040 dry tons of digested solids per year, which were pumped to the sludge holding cells. This is in line with the Study as the projected 2015 and 2016 were 3,086 and 3,147, respectively.

5. Based on the eventual most likely liquid stream process for nutrient reduction, the Master Plan updates the projected percent increase in biosolids assumed in the Biosolids Study. Table 8.6 includes a comparison of the Biosolids Study quantities versus the projected total loading quantities from the proposed liquid stream treatment processes. The following key observations for differences in quality and quantity are:

    - Master planning projections for biosolids are not linear, as the trickling filters will be phased out over time and ultimately not used, giving way to activated sludge.
    - Dried biosolids increase relative to the Biosolids Study by 33% in 2026 and 22% in 2036 due to a combination of the shift to the activated sludge and additional biological growth.
    - Liquid biosolids percent solids were adjusted from 6.27% to 5% solids in year 2026 due to Phase 1 liquid process improvements. Activated sludge solids (WAS) will become more predominant and WAS is more difficult to thicken via a gravity thickener than trickling filter sludge. Liquid biosolids increase relative to the Biosolids Study by 66% in 2026 and 53% in 2036 primarily due to growth.
    - When projected out to 2036 at updated flows and loads, the combined volume provides 205 days of liquid sludge storage versus 313 days in the 2014 study, assuming DENR approval of a reduction in minimum freeboard from three feet to two feet.
    - It is recommended that the expected percent solids be reduced to 15-20% for a screw press dewatering technology. This will depend on results of the screw press pilot testing.

Table 8.6 Post-Digestion Biosolids Process Capacity Summary Prorated thru 2036

Year	Dried Biosolids	Liquid Biosolids, 6.27% Solids	Dewatered Biosolids, 18% Solids	Liquid Storage	Year	Dried Biosolids	Liquid Biosolids, 5% Solids @ year 2025	Dewatered Biosolids, 18% Solids	Liquid Storage
	2014 Biosolids Study					Updated Per 2016 Master Plan			
	(dry tons)	(gallons)	(wet tons)	Days		(dry tons)	(gallons)	(wet tons)	Days
2011	2,851	10,896,772	15,837		2011		10,896,772	15,839	
2012	2,908	11,114,707	16,154		2012		11,114,707	16,156	
2013	2,966	11,337,002	16,477		2013		11,337,002	16,478	
2014	3,025	11,563,742	16,807		2014		11,563,742	16,806	
2015	3,086	11,795,016	17,143		2015		11,795,016	17,144	
2016	3,147	12,030,917	17,486	510	2016	3,147	12,030,917	17,483	510
2017	3,210	12,271,535	17,836	500	2017	3,391	12,968,375	18,837	377
2018	3,275	12,516,966	18,192	490	2018	3,634	13,900,445	20,191	352
2019	3,340	12,767,305	18,556	480	2019	3,878	14,832,516	21,545	330
2020	3,407	13,022,651	18,927	471	2020	4,122	15,764,587	22,899	310
2021	3,475	13,283,104	19,306	462	2021	4,365	16,696,657	24,253	293
2022	3,545	13,548,766	19,692	453	2022	4,609	17,628,728	25,607	277
2023	3,615	13,819,742	20,086	444	2023	4,853	18,560,799	26,960	263
2024	4,049	15,478,111	22,496	396	2024	5,097	19,492,869	28,314	251
2025	4,130	15,787,673	22,946	388	2025	5,340	25,612,875	29,668	239
2026	4,213	16,103,426	23,405	381	2026	5,584 <u>(33% Increase)</u>	26,781,691 <u>(66% Increase)</u>	31,022 <u>(33% Increase)</u>	229
2027	4,297	16,425,495	23,873	373	2027	5,622	26,964,265	31,234	227
2028	4,383	16,754,005	24,350	366	2028	5,660	27,146,838	31,445	226
2029	4,471	17,089,085	24,837	359	2029	5,698	27,329,411	31,657	224
2030	4,560	17,430,867	25,334	352	2030	5,736	27,511,984	31,868	223
2031	4,651	17,779,484	25,841	345	2031	5,774	27,694,557	32,080	221
2032	4,744	18,135,074	26,358	338	2032	5,869	28,149,705	32,607	218
2033	4,839	18,497,775	26,885	331	2033	5,964	28,604,852	33,134	214
2034	4,934	18,860,476	27,412	325	2034	6,059	29,059,999	33,661	211
2035	5,029	19,223,177	27,939	319	2035	6,154	29,515,147	34,188	208
2036	5,124	19,585,878	28,466	313	2036	6,249 <u>(22% Increase)</u>	29,970,294 <u>(53% Increase)</u>	34,716 <u>(22% Increase)</u>	205

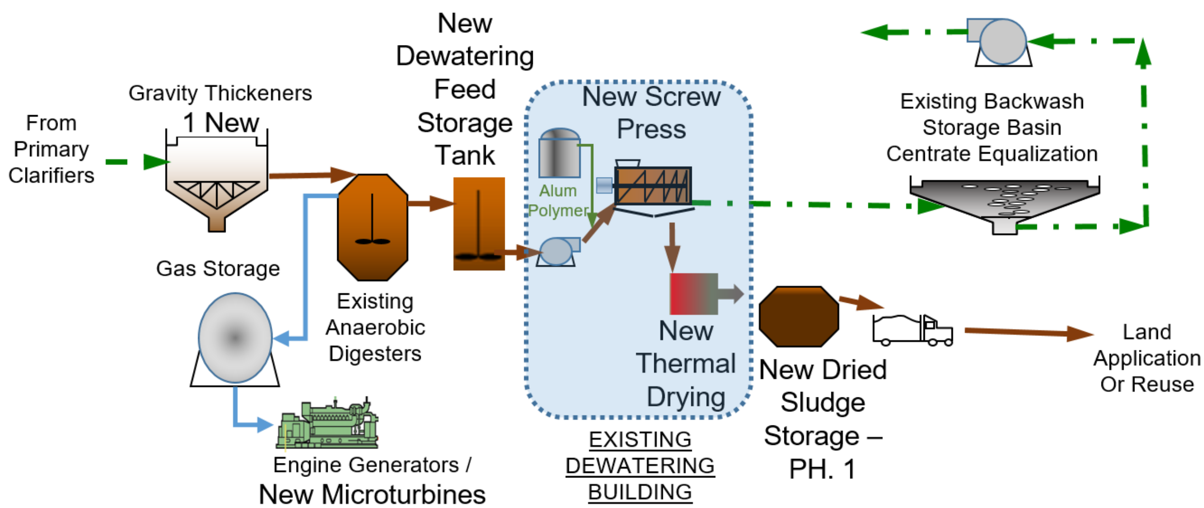
8.3.4 Recommended Biosolids Improvements

A preliminary schematic of the recommended biosolids handling process for Master Planning is shown in Figure 8.3. The recommended process type remains the same as existing through Primary Anaerobic Digestion (AD) i.e. Gravity Thickeners (GTH) followed by Anaerobic Digesters (AD). However, mechanical thickening versus gravity thickening needs to be further evaluated based on the increase WAS with the shift in treatment technology to activated sludge. The existing Biosolids Lagoons are converted to equalization and Primary Digestion the sludge would be sent to a new mixed Dewatering Sludge Feed Tank (DSFT) with a minimum of 3 days of storage at approximately 300,000 gallons. Next, polymer would be fed and an alum feed point would be provided ahead of dewatering to promote phosphorous precipitate and removal in the dewatered sludge which is then fed to the Dewatering Unit (Screw Press). The centrate would be collected and transferred to the existing backwash storage tank for aeration/equalization and ultimately returned to the head of the plant via the backwash return pumps. Dewatered sludge would be normally thermally dried with provisions to send dewatered sludge directly to storage. The recommended Biosolids Study plan is to store the dried cake in aboveground pad/bunker for giveaway (half) and for contracted land application (half) on existing land application sites.

Handling of the sidestream ammonia for Phase 1 and nutrients for Phase 2 have been included in the Biowin model scenarios and the associated capital improvement costs have been included as part of the selected treatment processes. The selected activated sludge process is sized for the anticipated recycle loads. Due to the small relative ammonia recycle loading, the benefits of sidestream treatment targeted to ammonia is limited for the selected treatment process. The current process selection equalizes the ammonia load and minimizes additional process components that would be required for the alternative patented sidestream ammonia removal processes.

The current plan recommends chemical feed for “tying up” the phosphorus as the most economical solution to address phosphorus removal along with reducing struvite accumulation in anaerobic digesters. This also improves dewaterability of anaerobically digested biosolids and reduces high phosphorus recycle loading from solids handling (up to 50% influent load). However, the phosphorus recycle content and associated challenges with solids handling for a biological phosphorus removal process warrant further consideration during preliminary design. Phosphorus handling alternatives may be considered during predesign including processes that provide Phosphorus release (P-Release) from waste activated sludge (WAS).

Figure 8.3 Preliminary Schematic for Recommended Improvements



Cost and components for the recommended alternative dewatering and drying process have been reviewed and updated to 2016 present-day costs and Master Planning recommendations and summarized in Table 8.7. The City prefers to construct the thermal drying process concurrent with the dewatering to minimize storage, hauling, and operational requirements. The resulting capital improvement project cost of $18.1 million. A detailed estimate of probable costs are included in the Appendix 8.A.

Table 8.7 WRF Biosolids Handling Improvements Cost Summary Comparison

Item Description	2014 Biosolids Study	2016 Master Plan
Site Piping Improvements	N/A	$410,000
Dewatering Feed Tank (Minimum of 3 days Storage)	N/A	$1,000,000
Dewatered Biosolids Storage Facility	$1,477,000	$2,140,000
Dewatering with Schwing Screw Press	$1,810,000	$3,440,000
Drying with Therma-Flite Dryer	$4,141,000	$4,176,000
Solids handling building standby generator and ATS	N/A	$440,000
Subtotal	**$7,428,000**	**$12,610,000**
Undeveloped Design Details (25% for Master Plan)	$1,490,000	$2,910,000
Construction Cost	$8,920,000	$14,520,000
Engineering, Admin, Legal, Permitting (24%)	N/A	$3,490,000
Total Project Cost[1]	**N/A**	**$18,100,000**

Note: 1. Does not include WAS thickening facilities cost of $3.33 million.

The recommended dewatering facility improvements include the following components.

SITE WORK:

- Centrate Site Piping: Construct required pumping and piping to existing backwash storage and other miscellaneous connections.

DEWATERING FEED TANK:

The dewatering feed tank consists of a new mixed sludge storage tank, similar architecturally to the existing digesters, with a minimum of 3 days of storage at average day flow, which equates to approximately 300,000 gallons.

DEWATERING AND THERMAL DRYING:

The rehabilitation of the existing dewatering building to accommodate solids processing facilities including:

- New of digested sludge dewatering facilities
  - Total of three (3) screw presses with one for standby.
  - This was increased from the Study recommendation of two units based on increased flow and loads.
  - Pilot testing is recommended before final selection of a solids dewatering system is made. The number of units will be refined based on final equipment selection.
- New dewatered sludge drying facilities presumed to be a Therma-Flite screw-type or equal dryer.

- New sludge feed pumps.
- New conveyors.
- New bridge crane & monorail for equipment maintenance.
- New polymer feed systems.

DEWATERED BIOSOLIDS STORAGE FACILITY:

Construction of new of dewatered and dried sludge storage facilities to be modular construction of an above-ground concrete storage tank or covered concrete pad/bunker @ 100 days storage.

8.3.5 Biosolids Improvements Costs

A summary of the costs for the biosolids handling improvements project is itemized in Table 8.8 Biosolids Handling Evaluation Estimated Total Updated Project Cost.

Table 8.8 Biosolids Handling Evaluation Estimated Total Updated Project Cost

Item Description	2016 Master Plan
Site Improvements	$410,000
Dewatering Feed Tank (Minimum of 3 days Storage)	$1,000,000
Dewatered Biosolids Storage Facility	$2,140,000
Dewatering with Schwing Screw Press	$3,440,000
Drying with Therma-Flite Dryer	$4,176,000
Solids handling building standby generator and ATS	$440,000
Subtotal	**$12,610,000**
Undeveloped Design Details (25% for Master Plan)	$2,910,000
Construction Cost	$14,520,000
Engineering, Admin, Legal, Permitting (24%)	$3,490,000
Total Project Cost	**$18,100,000**

In addition, the following items need to be planned for in the interim.

- Equalization: Construct new equalization basins to the west of the existing biosolids lagoons, due to the timing of the projects i.e. if dewatering is delayed, equalization can still be constructed.

8.4 Summary of Planning Criteria for Solids Handling

8.4.1 Digestion and FOG Planning

Master Plan capital improvement planning should include (inflated to 2016 dollars from the base year at 2013):

- Gravity Thickening, at $3.3 million and
- Item 5, FOG receiving and processing, at $2.92 million and
- Item 8, energy recovery improvements, at $4.55 million

The following considerations are offered based on the understanding that secondary digester cover has been replaced, the primary digester covers and mixing system are in process, and the digester gas conditioning project is in design.

1. At other facilities, digesters have been loaded at 0.20 lb VS/cf/d with blending FOG. A steady loading and SRT are required to maintain a stable process, but consideration should be given to allowing a larger FOG loading if it is available. To successfully maintain higher loadings, FOG loading should be distributed evenly between the digesters along with the plant solids.

2. The updated estimated sizing and costs for recommended facilities not already under design or construction were reviewed as part of this Master Plan are as follows:

   - A review projected total loading quantities and impacts on biosolids quantity loading to the Digesters is summarized in Table 8.2.

   - A review projected total loading quantities and impacts on post-digestion biosolids quantity loading is summarized in Table 8.3.

3. The remaining FOG Study action items are as follows:

   - Ensure that revisions to City ordinance, development of an education program, and enforcement infrastructure to keep FOG out of collection system are pursued. In addition, develop plans to encourage hauling to new FOG receiving facilities.

   - Monitor competitors to determine whether the assumed tipping fee of $0.10 per gallon (escalated at 3 percent per year) is competitive.

   - Need to continue to assess whether there are other high strength liquid waste streams that should be also be pursued.

   - Affirm FOG Study assumptions that there will be reduced post digestion solids handling costs due to potentially lower solids production with co-digestion of FOG, and that the microturbines would have 95 percent generation uptime and cost $0.023 per kilowatt-hour to operate including the associated biofilter cost.

4. Assuming that the City's intent is still to eventually receive and co-digest food/higher solid waste materials the Master Plan should do the following:

   - Develop a food / higher solid waste collection program.

   - If source(s) are available, develop an updated Basis of Design to include facilities for receiving and process food / higher solid waste.

8.4.2 Biosolids Handling Planning

The total project cost estimate for dewatering and thermal drying facilities complete with post digestion storage facilities was adjusted as part of this Master Plan at $18.1 million in 2016 dollars.

The remaining action items, which need to be reviewed as part of predesign for the dewatering facilities:

1. Develop preliminary design basis, layout drawings and more detailed cost estimates for the following:
   - Alternative post-digestion biosolids storage mixing options.
   - Review alternative WAS thickening options in conjunction with dewatering operation.
   - Biosolids lagoon transfer pumping.
   - New dewatering equipment options.
   - Dewatered sludge storage options.
2. Develop pilot testing protocol and pilot testing determine which equipment will be used. Additional investigation and pilot testing is recommended before a final decision is made on a solids dewatering alternative. Investigation and pilot testing would provide the following:
   - Potential for site visits to observe the alternatives evaluation in a full-scale operation at other facilities.
   - Reliability of the alternatives to consistently meet the sludge dewatering performance goals.
   - Determine the ability to operate the alternatives continuously on a 24-hour basis with minimal adjustments of the polymer and operator attention.

8.4.3 Summary of Costs

Table 8.9 gives a summary of the project cost for each solids related capital improvement project.

Table 8.9 Biosolids Handling Summary of Project Costs

Proposed Capital Improvements	Project No.	Project Cost	Begin Design (Year)	Constructed by (Year)	Comments
New Thickening	1	$3,330,000	2020	2025	Include in Phase 1 Liquid Improvements
FOG Receiving and Processing (2013 dollars)	5	$2,920,000	TBD	TBD	See FOG action items
Microturbines (2013 dollars)	8	$4,150,000	TBD	TBD	Conduct Study: Address alternative uses.
Biosolids Handling Improvements Alternative		$18,100,000	2018	2022	
TOTAL		**$28,510,000**			

In 2016 dollars unless noted.

Chapter 9 – Collection System Analysis and Improvements Alternatives

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Table of Contents

Tables

Figures

Appendices

Chapter 9 Collection System Analysis and Improvements Alternatives

9.1 Introduction

This chapter discusses the collection system analysis and improvement alternatives associated with the current 2016 Wastewater Treatment and Collection System Master Plan (WTCSMP). The objectives of this chapter are to summarize the City of Sioux Falls' (City) collection system capacity analysis for the existing system and the three target planning years (2026, 2036, and 2066) that are the focus of this WTCSMP. In addition, the 100-year (2116 planning year) is also examined but not included for Capital Improvement Program (CIP) project recommendations. The capacity analysis and improvement alternatives use the WTCSMP model discussed in detail in Chapter 5 and the associated flow projections for base sanitary flow (BSF), dry weather infiltration (DWI) allowances, and the rainfall-derived infiltration and inflow (RDII) allowances associated with the 25-year level of service. The capacity analysis is based on the City's collection system standards. The approach to achieving this goal is to evaluate the existing systems and prioritize the need for upgrades and/or replacement due to lack of potential capacity.

9.2 Capacity Analysis Criteria Review

The purposes of the conveyance system analysis are to:

1. Document the analysis of the existing collection system with existing wet weather flows and identify locations of potential capacity limitations. For this modeling effort, 2015 dry weather flow monitoring information was utilized along with the monitored wet weather events of June 2014.
2. Document the analysis of the existing collection system with development tiers associated with the planning years (2026, 2036, and 2066) based on RDII associated with the 25-year level of service.
3. Determine the likely size required for future trunk sewer extensions required to serve future development based on the projected 100-year development build-out condition.
4. Determine scenarios with which to route future trunk sewer extensions required to serve future development at each development tier.
5. Identify and characterize potential hydraulic capacity limitations of the existing collection system based on development tier wet weather flows with RDII associated with the 25-year levels of service.
6. Develop mitigation solutions based on specified criteria for areas with potential hydraulic capacity problems.

Potential capacity-limited areas were identified by analyzing the existing collection system under flow conditions associated with the planning years (2026, 2036, and 2066) against the established system analysis criteria. Characterizing the capacity- limited areas assists in developing and prioritizing improvement alternatives and recommendations.

9.2.1 Wastewater Flow and Level of Service Criteria

All capacity criteria are in reference to the 25-year level of service, which for the current 2016 WTCSMP, is the 25-year, 96-hour rainfall event which is referred to as the Design Storm. Development of the Design Storm was discussed in detail in Chapter 5.

9.2.2 Gravity Sanitary Sewer Criteria

The calibrated collection system model was used for the hydraulic analysis to locate capacity- limited areas during 25-year level of service wet weather scenarios under existing and planning year (2026, 2036, and 2066) conditions. The modeling approach for the City's collection system uses data from all the pipes and manholes that exist in the City's collection system for which data is available to develop an "all pipes" model. The benefits of an all-pipes model include increased accuracy in allocating wastewater flows to the sewer system, improved flow routing and attenuation from upper reaches of system, and simplifying the task of adding to and updating the model in the future from GIS.

To accomplish the analysis, project capacity criteria were developed based on discussions with City staff and the City of Sioux Falls Engineering Design Standards for Public Improvements (EDS). Capacity limitation identification criteria are based on the percentage of full-flow within pipes and surcharge conditions at manholes.

The criteria remain the same for existing and future build-out scenarios but differ between pipe classes. The capacity limitation identification criteria is based on the pipe class (local, collector, and interceptor), the modeled depth divided by the full flow depth (d/D), and sanitary sewer overflows (SSOs). The capacity limitation identification criteria established for the 2016 WTCSMP consist of the following:

9.2.2.1 Gravity Main Flow Criteria

1. Local System (< 15-inch diameter)
    a. Sanitary sewer overflows (SSO) are prohibited
    b. Peak flow on an average day of dry weather flow (ADWF) - flow less than a depth of 50 percent of the full pipe (0.50 d/D)
    c. Peak 25-year level of service wet weather - flow less than a depth of 75 percent of the full pipe (0.75 d/D)
2. Collector System (15-inch – 27-inch diameter)
    a. Sanitary sewer overflows (SSO) are prohibited
    b. Peak flow on an average day of dry weather flow (ADWF) - flow less than a depth of 50 percent of the full pipe (0.50 d/D)
    c. Peak 25-year level of service wet weather - flow less than a depth of 75 percent of the full pipe (0.75 d/D)
3. Interceptor System (30-inches diameter and greater)
    a. Sanitary sewer overflows (SSO) are prohibited

b. Peak flow on an average day of dry weather flow (ADWF) - flow less than a depth of 60 percent of the full pipe (0.60 d/D)

c. Peak 25-year level of service wet weather - flow less than a depth of 80 percent of the full pipe (0.80 d/D)

9.2.2.2 Gravity Main Velocity Criteria

1. Peak Hour Dry Weather (Low Velocities) and Wet Weather (High Velocities)
    a. 0 - 2 feet per second (low velocities)
    b. 2 - 14 feet per second (minimum to maximum)
    c. > 14 feet per second (high velocities)

9.2.2.3 Manhole SSO Risk Criteria

1. From Manhole Rim (Rim Down)
    a. Low – Basement Backup Potential – 8 to 3 feet (water level has a high potential of basement back-ups but low potential of MH SSO).
    b. Medium – SSO Potential - 3 to 0 feet
    c. High – SSO Likely - 0 feet

    The interceptor system has a greater 25-year level of service weather criterion since flow depths within the corresponding larger pipes are not as impacted by equal flow increases compared to the smaller pipes in the collector system. Compared to local and collector system pipes, interceptors typically have less variable flow depth versus pipe diameter (d/D) values during normal dry weather and smaller wet weather conditions.

9.2.2.4 Future Interceptor Approach

For future interceptors needed to serve new areas, the sizing was based on the following:

1. 100-year (planning year 2116) sizing
2. Reduce shallow sewers and siphons
3. Gravity sewers have a minimum depth of 7 feet to the invert where practical

For CIP projects associated with the existing system:

1. Upsize the entire pipe length if more that 60 percent of the pipe segments have a capacity limitations, based on planning year 2066 projected flows
2. Relief sewers for smaller capacity or localized capacity limitations
3. Relief sewers if less than 60 percent of the pipe segments have a capacity limitation
4. Possible parallel sewers or EQ for larger potential capacity limitations

9.2.3 Pumping Station and Force Main Criteria

As a general approach, existing pump stations were not altered to avoid creating capacity problems in the downstream collection system. To meet this objective, equalization was required within the pump station wet well, with equalization sizing discussed below. Force main sizing was based on the following:

1. Minimum velocities greater than 2 feet per second
2. Maximum velocities at the discharging pipe not exceeding 8 feet per second

9.2.4 Flow Equalization Criteria

The existing flow equalization basin on the outfall trunk was accounted for in all analyses and was increased in capacity when necessary for the planning years. Flow equalization was modeled to approximate peak day dry weather flow and/or to maintain a drain time within a few days during the 25-year, 96-hour Design Storm to minimize sizing of downstream infrastructure.

9.3 Hydraulic Capacity Analysis for Existing Conditions

Model results were compared against the analysis criteria to locate potential hydraulic limitations within the system. The model results were recorded for the Design Storm peak wet weather flow for each individual analyzed pipe to capture the worst-case loading scenario throughout the system. These model results represent the greatest stress placed on the collection pipes for each scenario. Manhole freeboard depth was derived from the model results to locate possible SSO risk.

The calibrated model for existing conditions was analyzed with the Design Storm. This section describes the results of the analysis.

9.3.1 Dry Weather

The peak ADWF impacts on the existing system was analyzed and resulted in no local or collector mains experiencing a surcharged conditions There were, however, 51 local or collector mains having a d/D greater than 0.5. These mains are provided in Table 9.1 and mapped in Figure 9.1. As noted in the table, some of these locations are a result of a pipe constriction or a back pitched pipe. Other locations may also be a result of invert elevations that have not been verified.

For existing conditions peak ADWF simulations, there were no interceptors that violated the hydraulic criteria.

This table is to provide a general reflection of dry weather and infiltration distributed over the entire segment. This information is presented to identify the model segments that are greater than the City design standards and do not necessarily require mitigation.

Table 9.1 Existing Conditions Model Results: Local/Collector Mains not meeting the Hydraulic Criteria for Peak ADWF

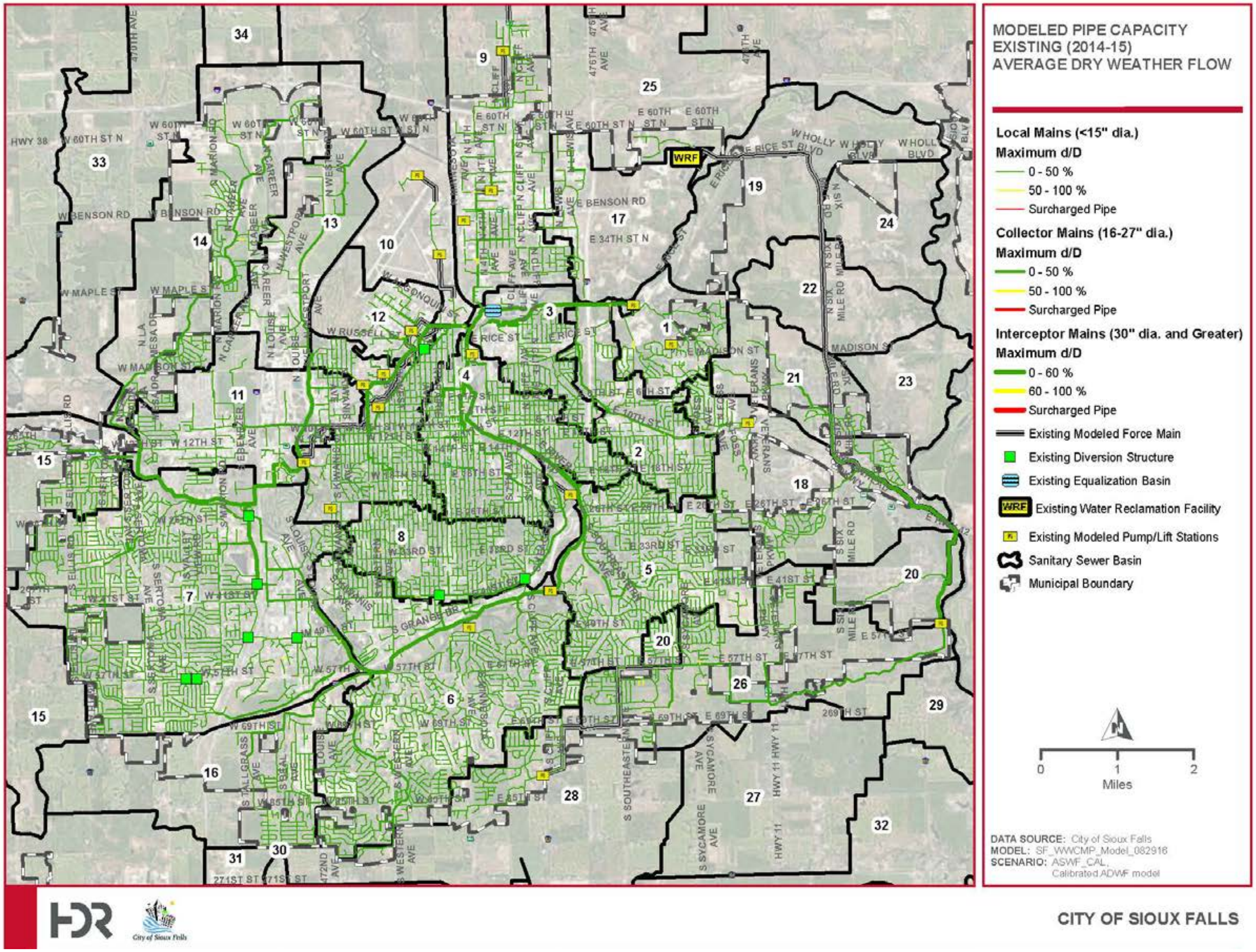
LINENUMBER	Type	Trunk Name (If Assigned in the GIS)	Length (ft)	Pipe Size (in)	Modeled Depth Divided by the Full Flow Depth (d/D)	Notes[1]
01C0008/01C0007A	TRUNK	Richmond Estates Trunk	171	8	0.99	Created by backwater
04A0007A/04A0007	SMAIN		32	8	0.93	Created by downstream bottleneck
02BC001/01C0007A	SMAIN		260	8	0.89	
16HA011B/16HA011A	SMAIN		315	8	0.77	
08A0001/04H0012	TRUNK		16	18	0.75	Pipe diameter decrease of 6 inches; Note - This will become private when flow from MHHA011G is redirected to 16EH008 in 2018
01C0007A/01C0007	TRUNK	Richmond Estates Trunk	322	8	0.69	Recommend confirming size and slope.
04AC001/04A0007	SMAIN		33	24	0.68	
09AH001/09A0013A	SMAIN		301	8	0.65	Note - Due to back water from Central Main Interceptor sewer equalization diversion.
07C0001/07B0023	TRUNK	Southwest Sanitary Sewer District	253	12	0.64	
06CA004/06CD006	SMAIN		52	8	0.62	
07HI001A/07HI001	SMAIN		180	8	0.61	
14C0004C/14C0004B	SMAIN		118	8	0.59	
05EK006A/05EK006	SMAIN		83	8	0.58	This is a private line. This is not likely capacity restricted as this only serves ten - eight or twelve-plexes.
01A0001/02A0001	TRUNK	Aspen Trunk	344	15	0.57	
17A0001/17A0001A	TRUNK		94	10	0.56	Pipe diameter decrease of 2 inches;
09C0006A/09C0006	SMAIN		40	8	0.56	Note - Potential backwater from downstream trunk sewer.
02GA001/02G0001	TRUNK MINOR	Northeast Trunk	97	10	0.56	Potential backwater from downstream trunk sewer.
01C0011/01C0010	TRUNK	Richmond Estates Trunk	45	8	0.55	
11AH006B/11AH004	SMAIN		379	8	0.55	
06CB003/06CB002	SMAIN		296	8	0.54	
26J0003D/26J0003C	SMAIN		256	8	0.54	
11AH006A/11AH006B	SMAIN		120	8	0.53	Private sewer. There are only 24 houses upstream of this. No future issue.
08FM003/08FM002	SMAIN		70	8	0.53	There are very few services upstream of this. No future issue.
04AD001/04A0015	TRUNK		138	37	0.53	Pipe diameter decrease of 16 inches;
09CB001/09C0011	SMAIN		301	8	0.53	

Table 9.1 Existing Conditions Model Results: Local/Collector Mains not meeting the Hydraulic Criteria for Peak ADWF

LINENUMBER	Type	Trunk Name (If Assigned in the GIS)	Length (ft)	Pipe Size (in)	Modeled Depth Divided by the Full Flow Depth (d/D)	Notes[1]
11AK002/11E0011	TRUNK MINOR		211	12	0.53	
01BK002/01BK001	SMAIN		93	8	0.52	
07BK002/07BK001	SMAIN		187	8	0.52	
26HA007A/26HA007	SMAIN		388	8	0.52	Negative slope as defined in 02/06/16 SF GIS
26HA008A/26HA008	SMAIN		383	8	0.52	Negative slope as defined in 02/06/16 SF GIS
07BK001/07BG005	TRUNK MINOR		300	10	0.52	Negative slope as defined in 02/06/16 SF GIS
11AK004A/11E0014	SMAIN		249	8	0.52	
11AK001/11E0010	TRUNK MINOR		90	12	0.52	Potential backwater from downstream trunk sewer.
08GO002/08GO001	SMAIN		329	8	0.52	Negative slope as defined in 02/06/16 SF GIS.
01BK003/01BK002	SMAIN		89	8	0.52	
04A0005A/04A0005	SMAIN		109	8	0.52	Private sanitary sewer. There are only a hand full of townhouses upstream of this. No future issues.
08ED001D/08ED001C	SMAIN		203	8	0.52	Potential backwater from downstream trunk sewer.
08ED001A/08ED001D	SMAIN		169	8	0.52	
08G0002A/08G0002	SMAIN		62	8	0.51	
12BL003/10A0011A	SMAIN		39	8	0.51	Potential backwater from downstream trunk sewer.
08GO003/08GO002	SMAIN		139	8	0.51	
12BF001/12B0008	SMAIN		452	8	0.51	
07HI001C/07HI001A	SMAIN		20	8	0.51	Private sanitary sewer. There are only one building upstream of this. No future issues.
04A0010A/04A0010	SMAIN		280	8	0.51	
10A0005A/10A0005	SMAIN		182	8	0.51	

Note: 1. This information is presented to identify the model segments that are greater than the City design standards and do not necessarily require mitigation.

Figure 9.1 Existing Conditions Average Dry Weather Flow Capacity Analysis



9.3.2 Wet Weather

The wet weather RDII impacts of the Design Storm on the existing system was analyzed and resulted in several areas with potential hydraulic limitations across local, collector, and interceptor sewer mains. Hydraulic analysis of the existing system using the 25-year level of service was performed to assess the current state of the City's sanitary collection system. Potentially hydraulically limited pipelines and problem areas are discussed in detail with respect to existing and future flows in Section 9.5.

The model results for the existing collection system under the 25-year level of service are mapped in Figure 9.2. The corresponding flow condition is also provided to show what pipelines may have limited conveyance capacity or are impacted by backwater conditions. Often pipes that are surcharging due to backwater conditions will no longer surcharge once capacities in the downstream system are increased.

Below is a list of notes regarding the capacity analysis for the existing conditions 25-year level of service:

- There were a number of potential capacity limitations noted in Basin 17. However since this basin was not served by a flow monitor, it could not be specifically calibrated. RDII parameters for this basin were first assigned based on flow characteristics from Basin 1. These flows where then increased, along with other non-monitored flows, serving the outfall trunk to reflect flow rates estimated at the Brandon lift station. The planning team agreed that, the recommendation is to monitor Basin 17 during a wet weather storm event to support future model validation of this basin.
- There was only one interceptor pipe length where potential surcharging was observed. This interceptor was a portion of the Central Main Interceptor, immediately upstream of the equalization basin on the Outfall Trunk. Of note, flow characteristics for the Central Main Interceptor at this location are heavily influenced by the flow rates and head generated by the diversion structure to divert flows to the equalization basin.
- Potential surcharges also occur along the Richmond Estates Trunk in Basin 1. This trunk line receives back water from the Brandon Road Pump station which causes the surcharges, which is confirmed with the downstream flow monitor serving this basin. However, this backup does not create the surcharges in the Richmond Estate Trunk. The backup could, however, impact calibration and subsequent RDII assumptions.
- A high concentration of potential surcharging also occurs in Basin 11 along the Hayward Sewer District Trunk west of South Ebenezer Avenue. This area should be investigated further with local flow monitoring.
- The majority of other pipe segments with potential capacity limitations are isolated and may be caused by flat slopes, back pitched pipes, backwater from a major interceptor, or depressed inverts (the invert into a manhole is lower than the invert out of a manhole such as what occurs along the Southside Interceptor east of Cliff Road).

RDII loading for the 25-year level of service was mapped for each of the major sanitary basins to illustrate the RDII contributions from different areas within the collection system. Figure 9.3 illustrates as a percentage of sanitary flow. Figure 9.4 illustrates as a flow per the sum of diameter times the length of pipes within the basin. The relative distribution of RDII loading is the same for all future wet weather scenarios, with only the magnitude increasing.

Figure 9.2 Existing Conditions Peak Wet Weather Design Storm Flow Capacity Analysis

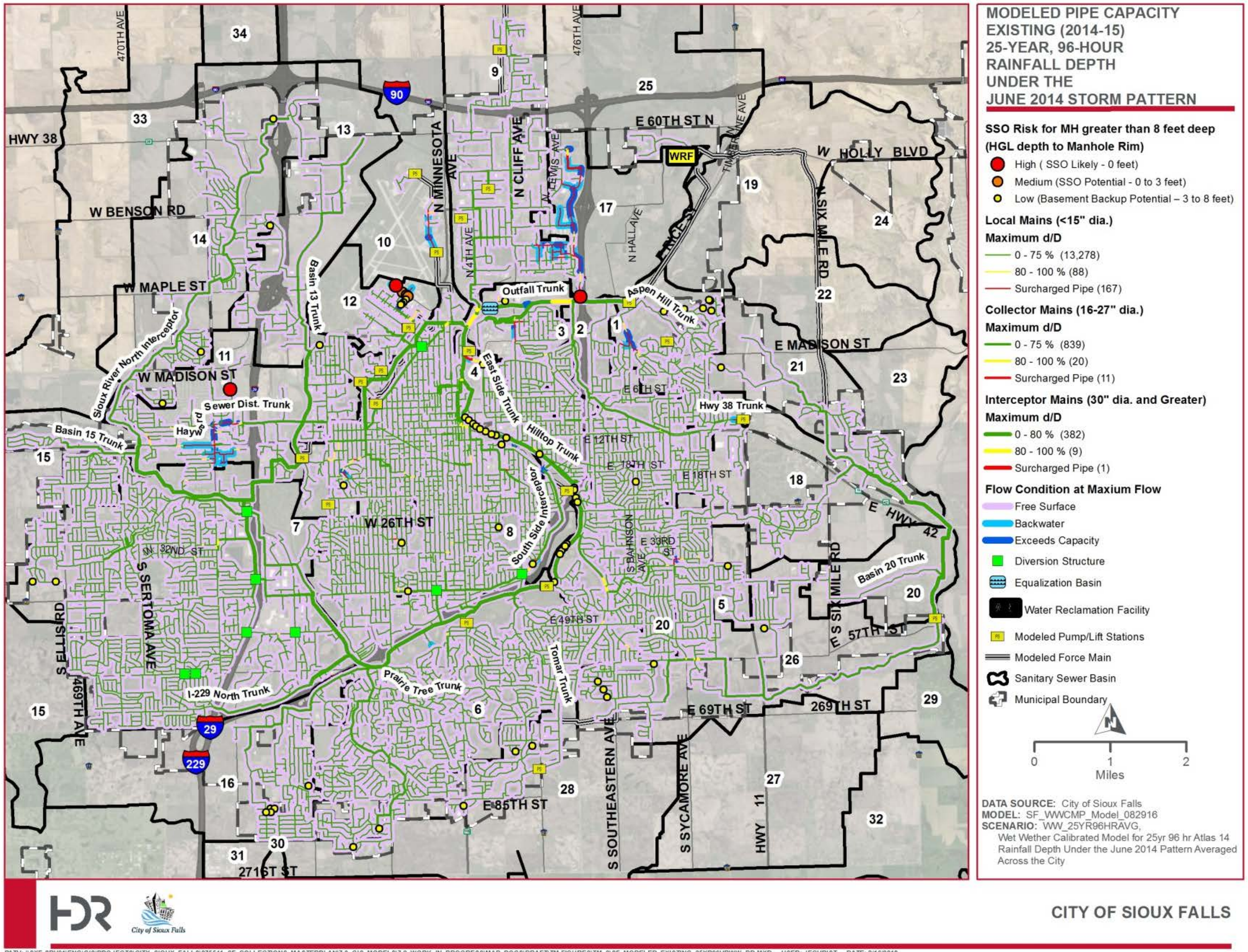


Figure 9.2 Existing Conditions Peak Wet Weather Design Storm Flow Capacity Analysis

Figure 9.3 Existing Conditions RDII Loadings per Major Sanitary Basin for the 25-Year Level of Service (as a Percent)

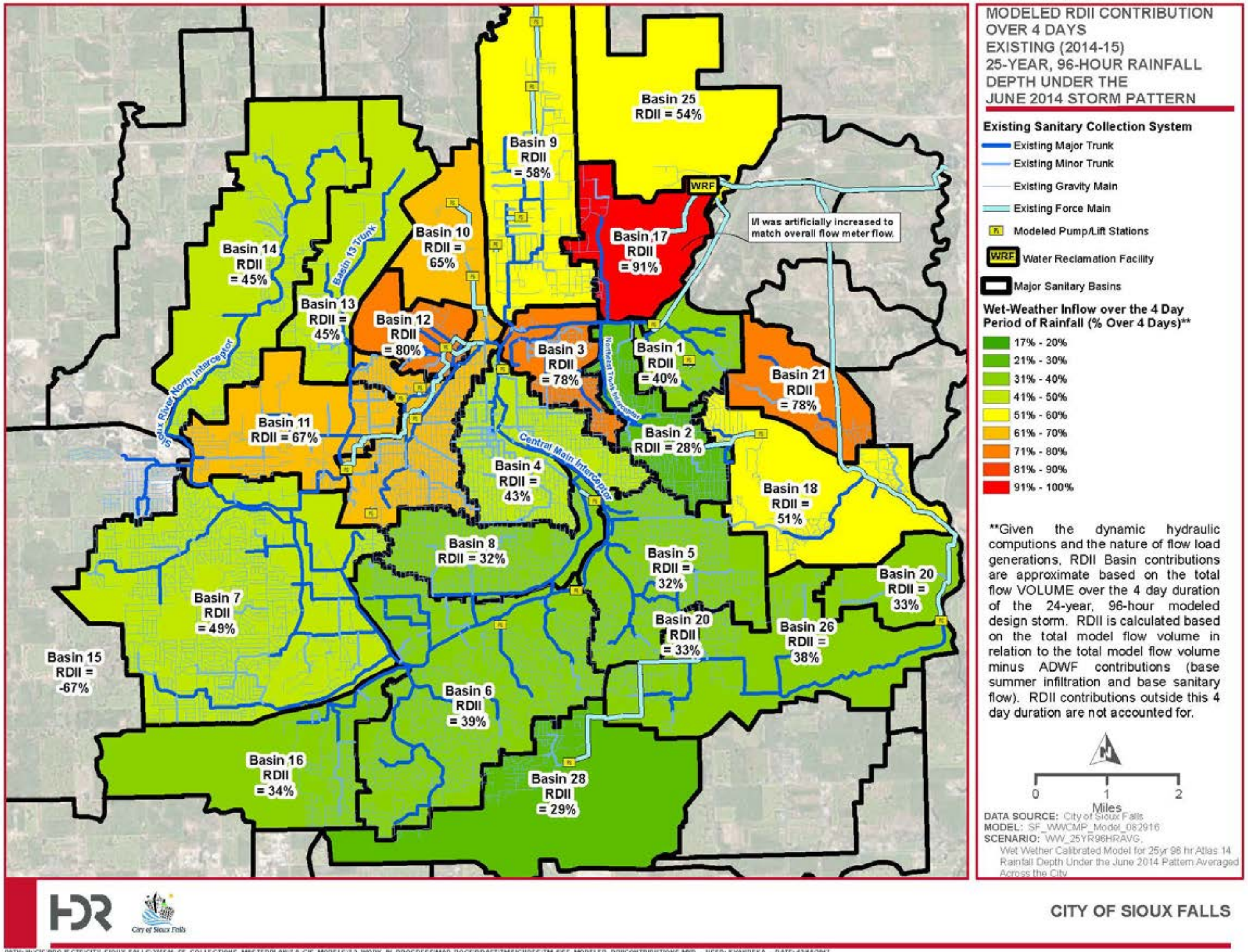
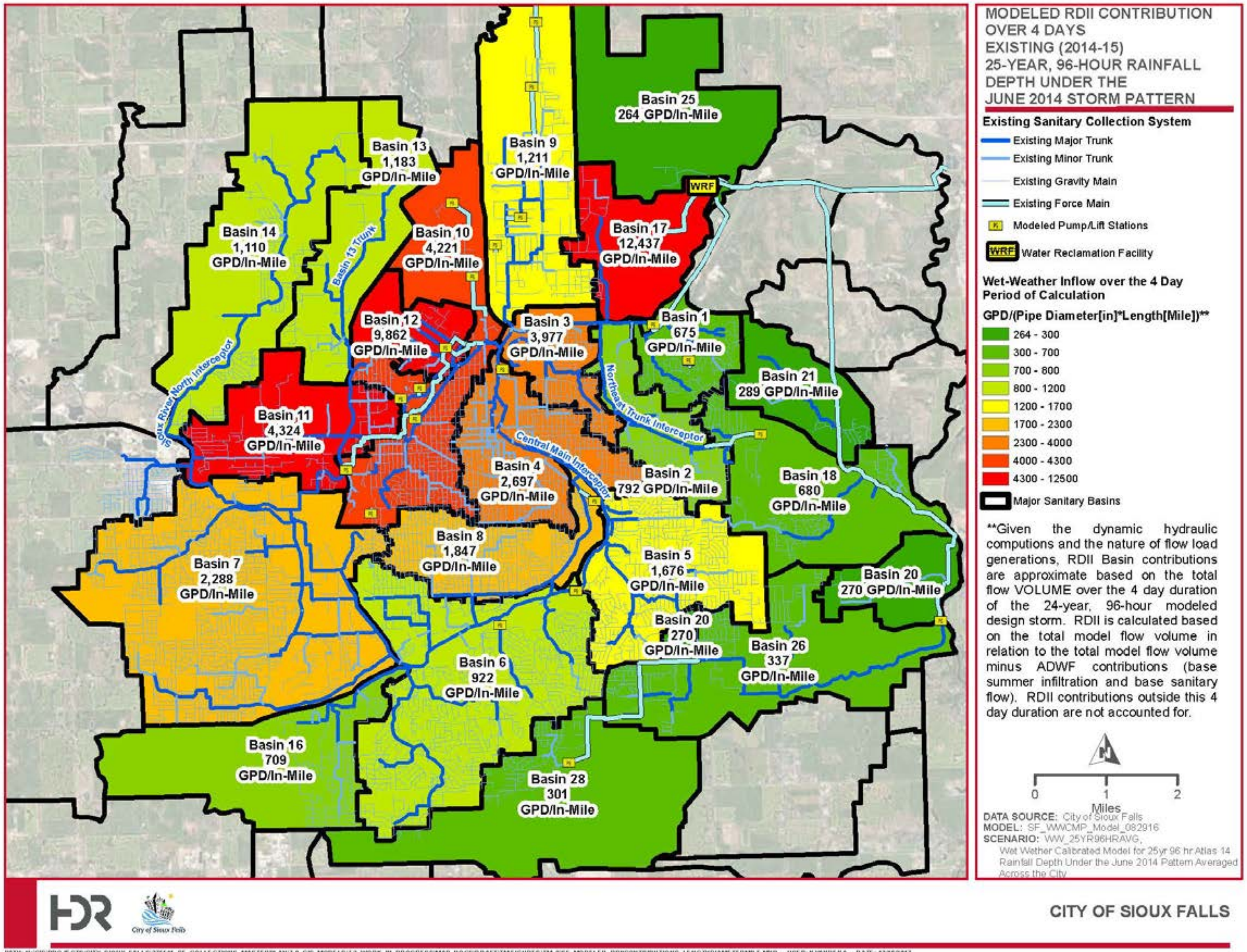


Figure 9.4 Existing Conditions RDII Loadings per Major Sanitary Basin for the 25-Year Level of Service (GPD/[Conduit Diameter-in*Length-mile])



9.4 Hydraulic Capacity Analysis for Ultimate Build-out (2116) Conditions

Future conditions modeling was performed for the 2026, 2036, 2066, and 2116 planning years. Future BSF flow development was developed for each planning year for each major sanitary sewer basin and allocated using the contributing Thiessen polygon area to the junctions throughout that basin. Flow development for each planning year is described in Chapter 3. Future infiltration and RDII allowances are described in Chapter 5. Future trunk sewer extension development is also discussed in Chapter 5.

For this WTCSMP, future trunk sewer extensions to serve new development expansion are sized to convey flows for the 2116 (100 year) planning year. CIP projects associated with current service areas are sized based on the 2066 planning year; where the 2026 and 2036 planning years aid in prioritization and scheduling. Table 9.2 summarizes the metrics of each planning year.

Table 9.2 Design Metrics Associated with Each Planning Year

Planning Year	Number of Years into the Future	Planning Range	Associated Development Tiers	Design Metric
2015	-	Immediate (2016-2021)	-	Immediate needs to the Collection system
2026	10 year	Near-Term (2022-2026)	Tiers 1 and 2	Prioritize improvements within the preferred alternative for the CIP
2036	20 year	Mid-Term (2027-2036)	Tiers 1, 2, and 3	Prioritize improvements within the preferred alternative for the CIP
2066	50 year	Long-Term (2037-2066)	Tiers 1, 2, 3, and 4	Determine a preferred alternative and size major facilities (EQ, pumping, etc.) and CIP for the existing drainage system to serve both local and development expansion flows
2116	100 year	Long-Range	Tiers 1, 2, 3, 4, and 5	Size future trunk sewer extensions to serve 100 year development expansion

9.4.1 2116 Model Results

Figure 9.5 presents the conceptualized sanitary collection system for the full 100-year build-out. This section briefly discusses the 2116 model results in terms of ADWF and then in terms of wet weather RDII for the 25-year, 96-hour Design Storm.

9.4.1.1 2116 Peak Dry Weather Flow

Figure 9.6 presents the capacity analysis associated with the 2116 peak dry weather flow. As shown in this figure, the majority of the existing system has the capacity to handle future projected peak flow.

Figure 9.5 2116 (Tier 5, 100-Year Build-out) Base Model Facilities for the Entire WTCSMP

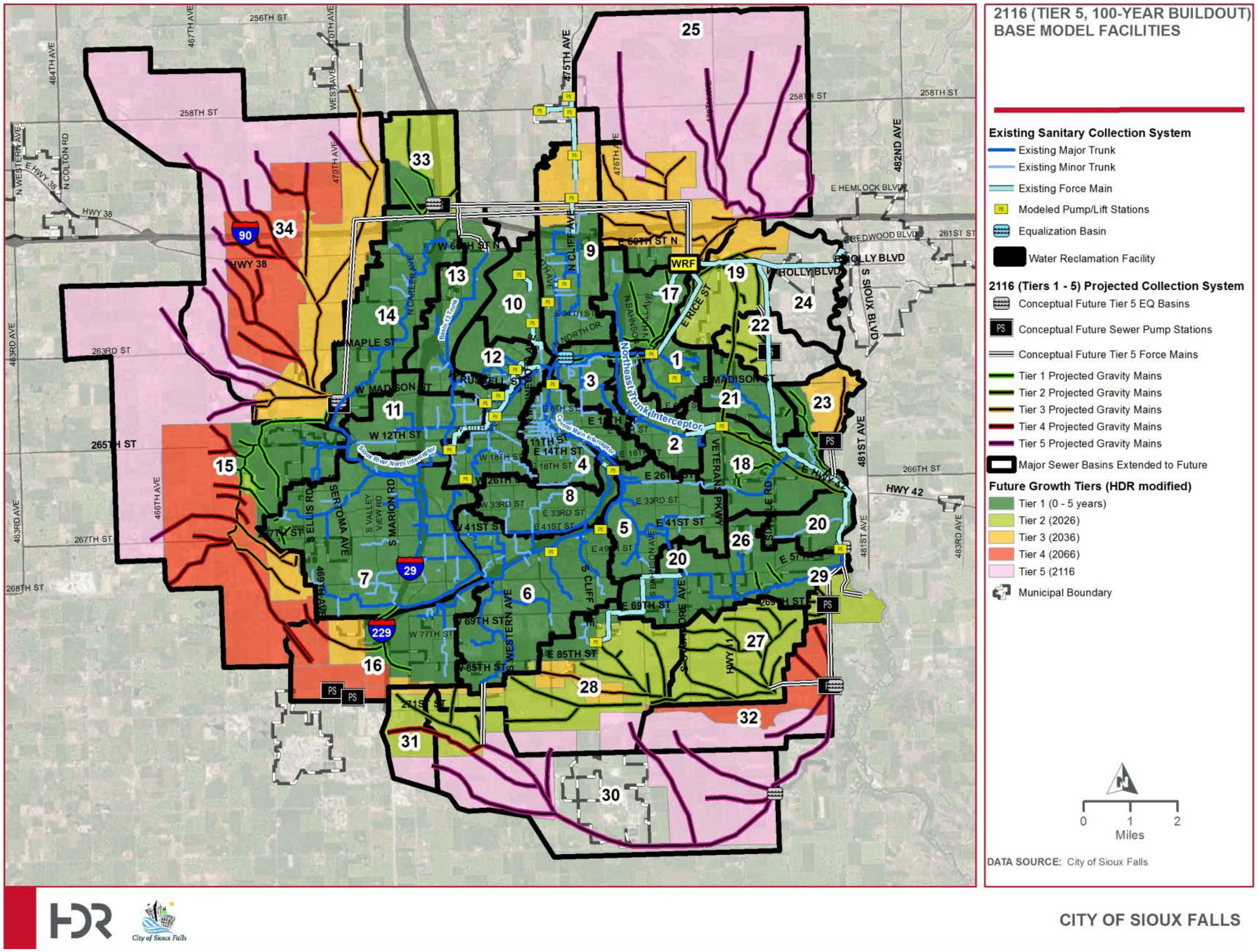
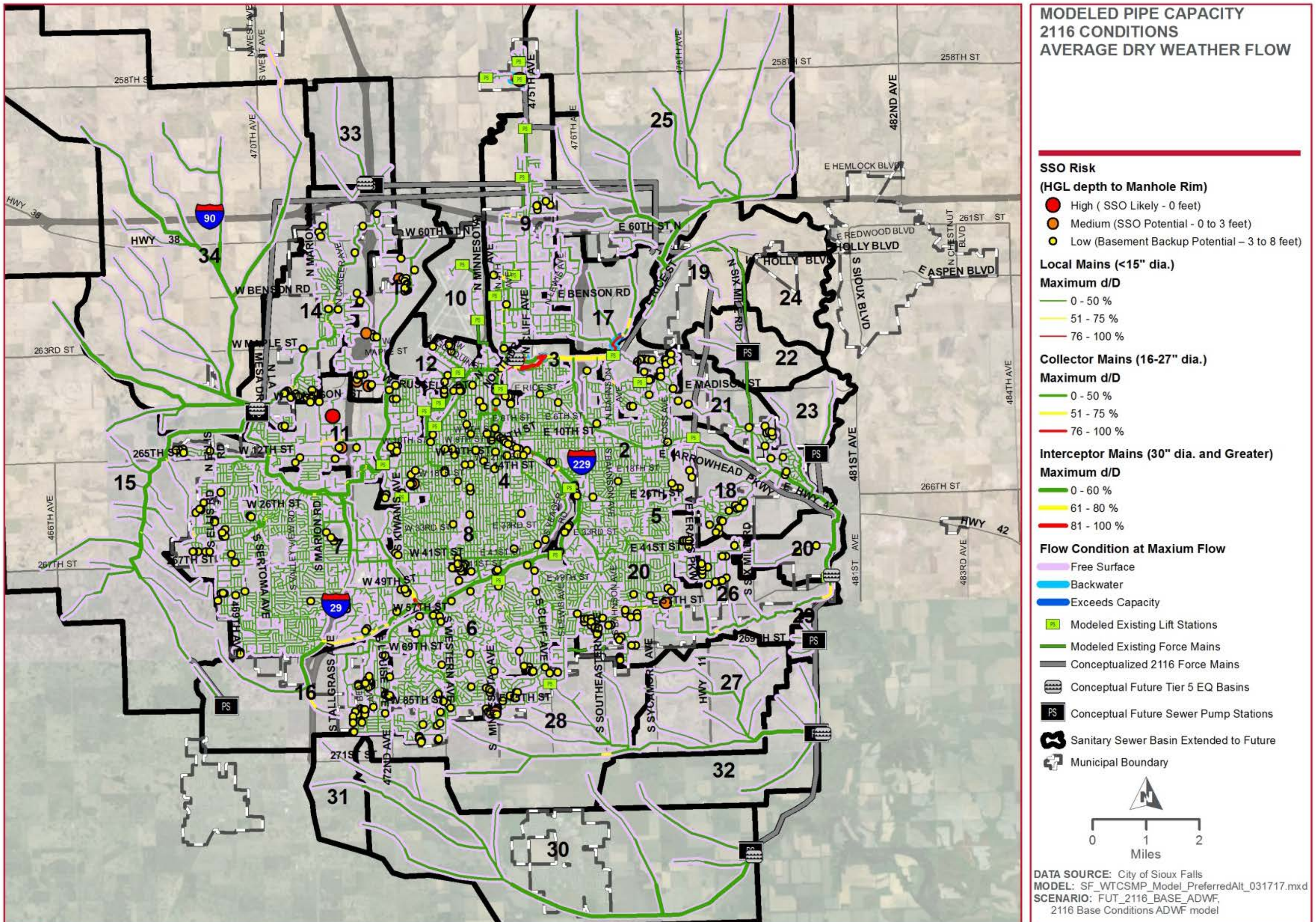


Figure 9.6 2116 (Tier 5, 100-Year Build-out) Base Model Conditions Average Dry Weather Flow Capacity Analysis



CITY OF SIOUX FALLS

9.4.1.2 2116 Peak Wet Weather Flow

As stated in Table 9.2, the 2116 planning year is used to size trunk sewer extensions for new areas. The resulting trunk sewer sizes are mapped in Figure 9.7 (northeastern part of the City; Basins 17, 19, 22, 23, 24 and 25), Figure 9.8 (southern part of the City; Basins 27, 28, 29, 30, 31, and 32), Figure 9.9 (western part of the City; Basins 15 and 16), and Figure 9.10 (northwestern part of the City; Basins 33 and 34).

Figure 9.11 presents the capacity analysis associated with the 2116 25-year RDII. As observed by comparing the 2116 wet weather flow results in Figure 9.11 to the existing wet weather flow results in Figure 9.2, there are many more capacity limited areas when future flows are applied to the existing system. It should be noted that for the 2116 planning year, most future sewer extensions are not directed into the existing system. As such, the potential capacity limitations identified are primary the result of local projected future flow increases due to infill development.

Figure 9.7 2116 (Tier 5, 100-Year Build-out) Base Model Projected Pipe Sizes for Projected Pipe Sizes for Trunk Sewer Extensions in Basins 17, 19, 22, 23, 24, and 25

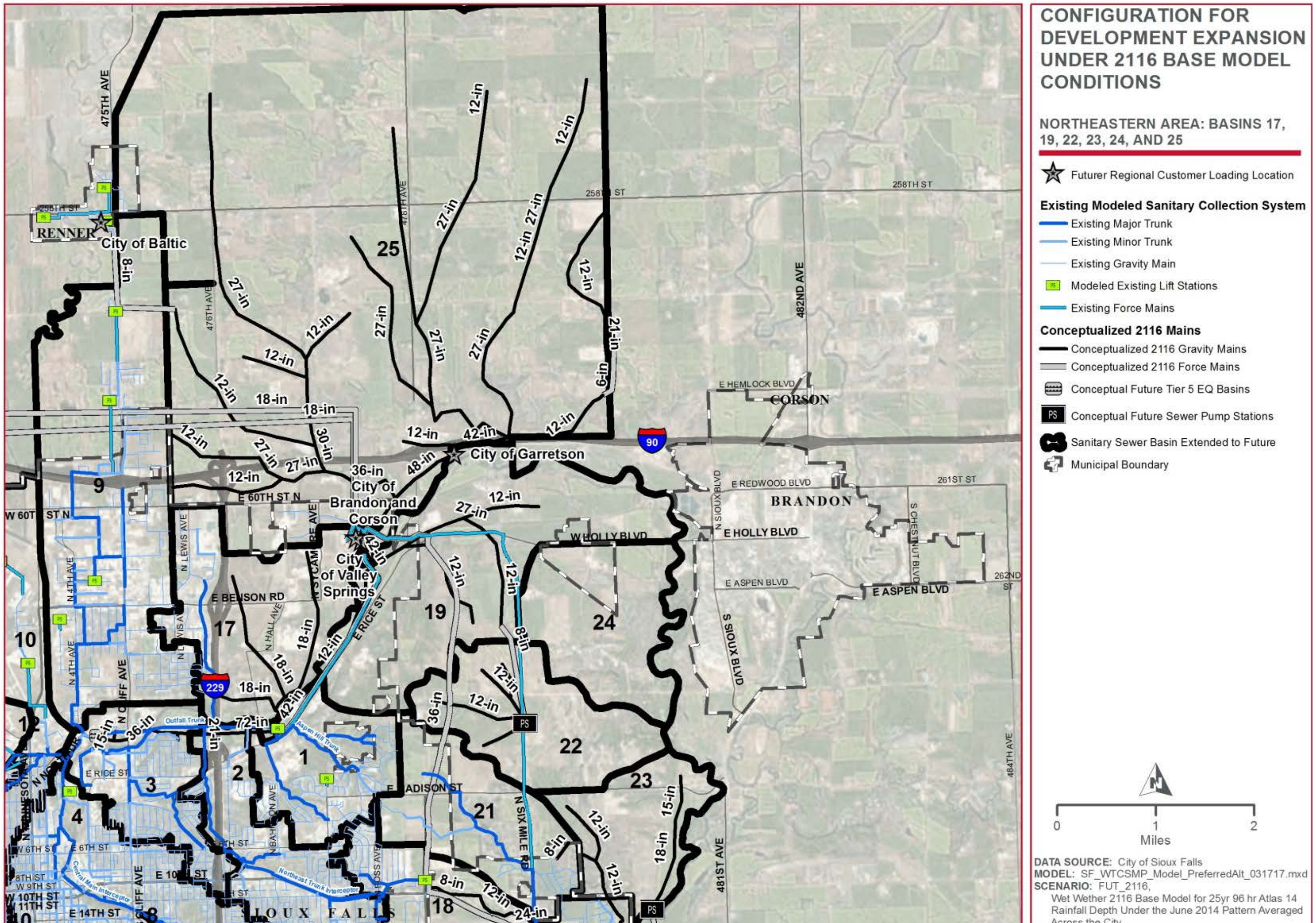


Figure 9.8 2116 (Tier 5, 100-Year Build-out) Base Model Projected Pipe Sizes for Trunk Sewer Extensions in Basins 27, 28, 29, 30, 31, and 32

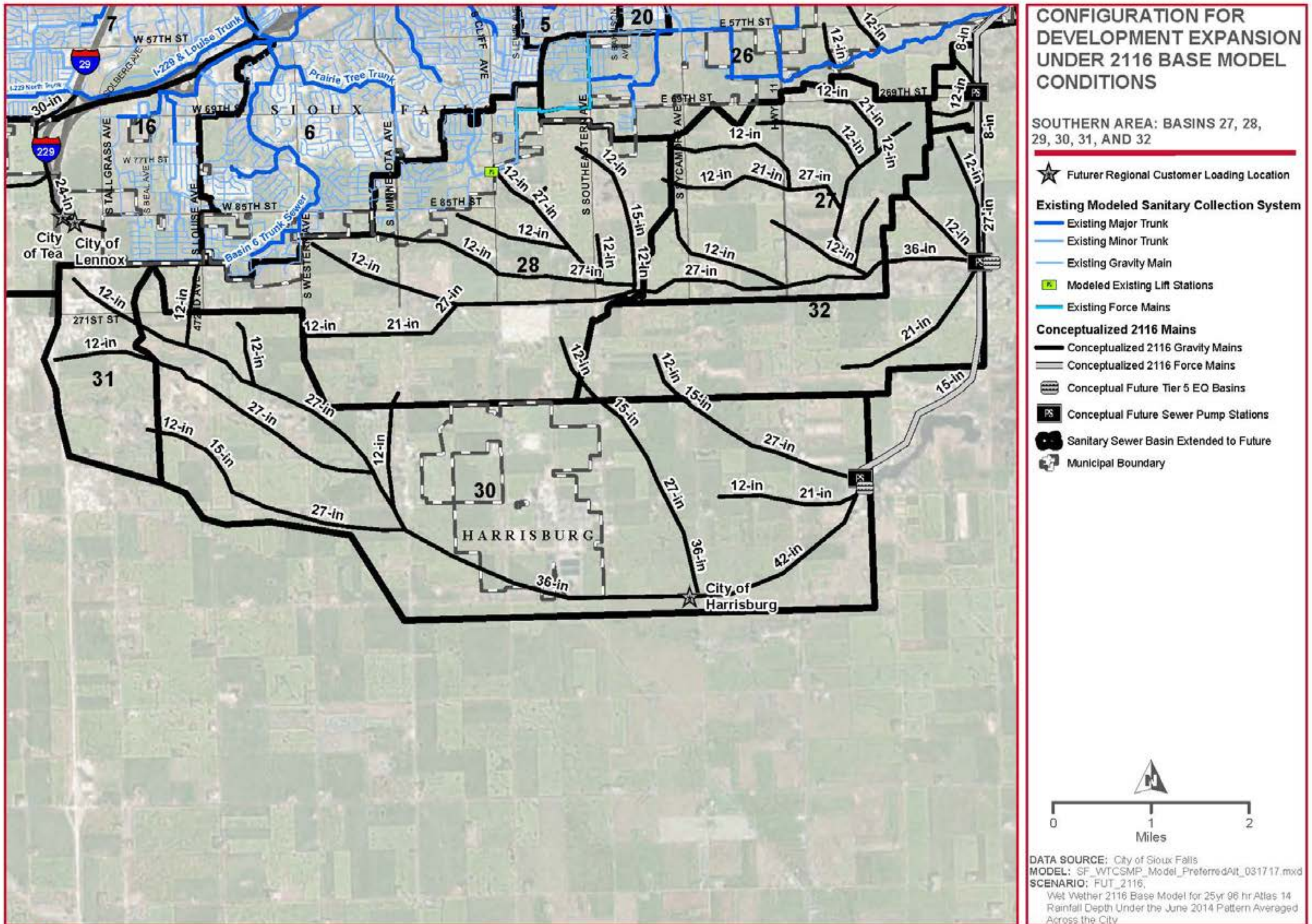


Figure 9.9 2116 (Tier 5, 100-Year Build-out) Base Model Projected Pipe Sizes for Trunk Sewer Extensions in Basins 15 and 16

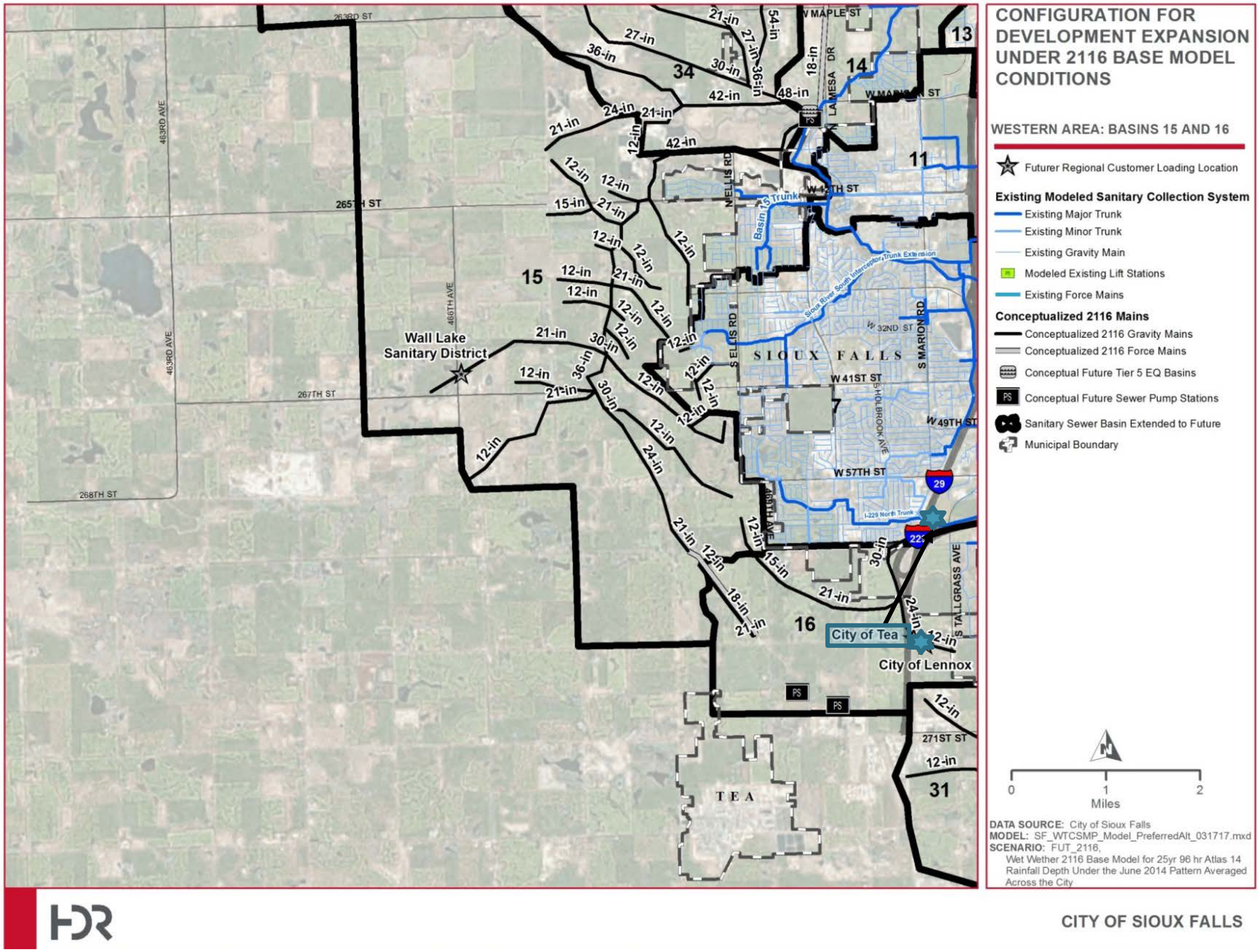
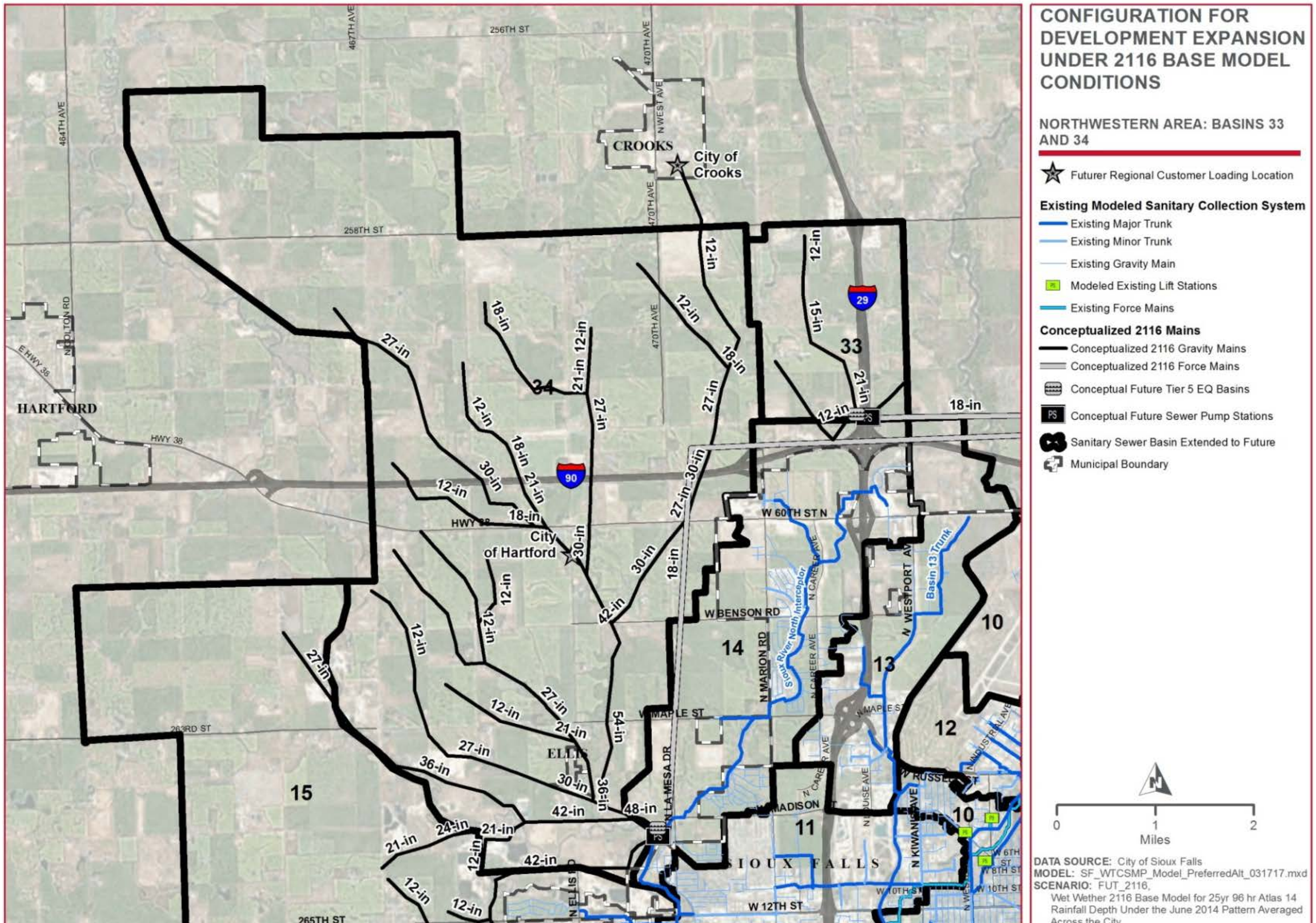
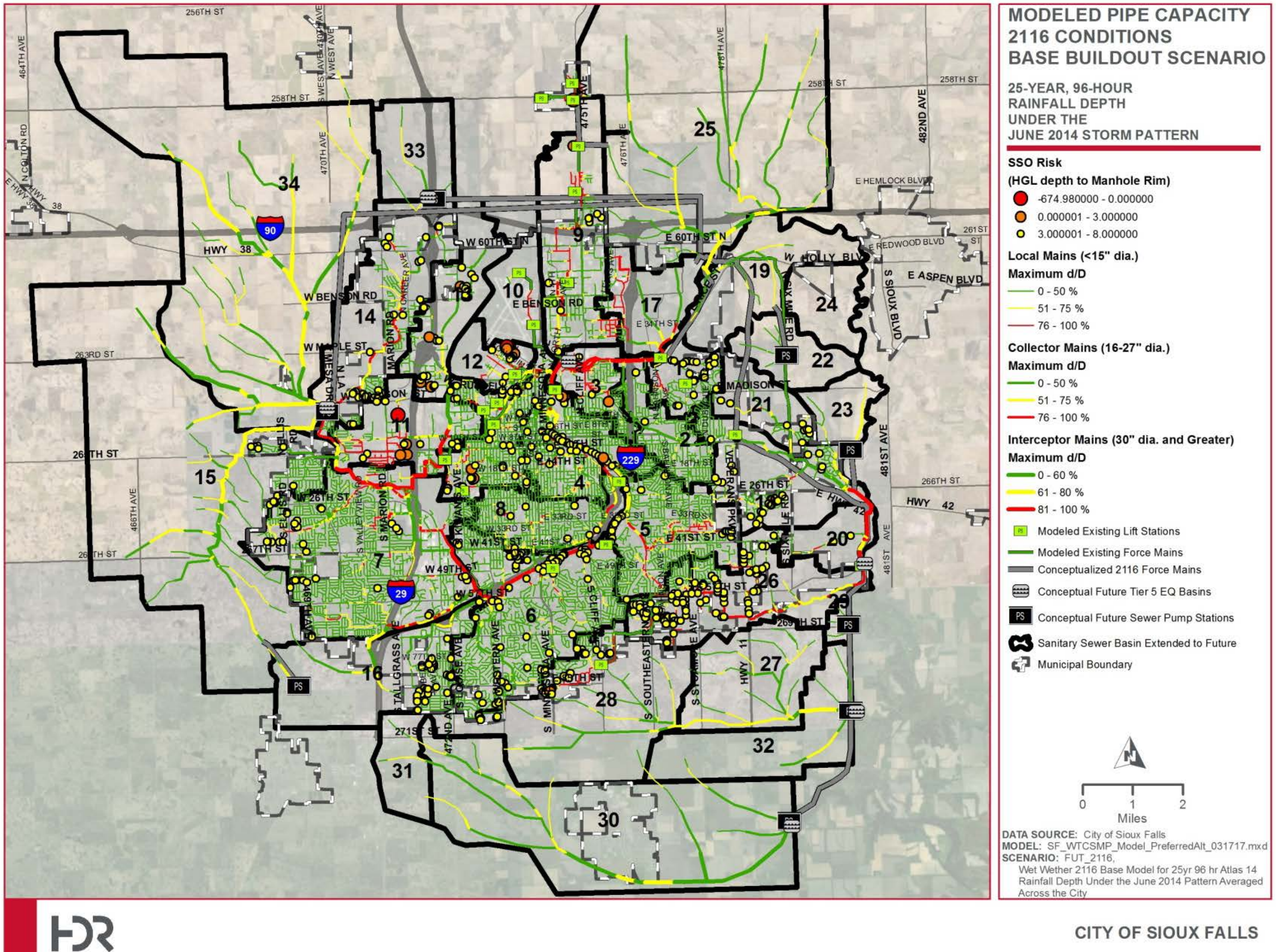


Figure 9.10 2116 (Tier 5, 100-Year Build-out) Base Model Projected Pipe Sizes for Trunk Sewer Extensions in Basins 33 and 34



CITY OF SIOUX FALLS

Figure 9.11 2116 (Tier 5, 100-Year Build-out) Base Model Peak Wet Weather Design Storm Flow Capacity Analysis



PATH: \\SXF-SRV01\ENG\GIS\PROJECTS\CITY SIOUX FALLS\275541 SF COLLECTIONS MASTERPLAN\7.0 GIS MODELS\7.2 WORK IN PROGRESS\MAP DOCS\DRAFT\TM FIGURES\TM 9\SF MODELED 25YR96HRWW DD FUT2116 BASE.MXD - USER: JECHRIST - DATE: 2/16/2018

9.4.2 Inverted Siphons

It is the City's desire to not construct inverted siphons for future trunk sewers. Therefore, conceptual future trunk extensions were established to minimize future river crossing. In addition, it is the City's intension to bypass the Basin 17A inverted siphon under the Big Sioux River just west of I-229 by diverting future flows to the future Basin 17 trunk main that goes directly to the Brandon Road Pump Station. Portions of the trunk main that will receive this future flow have already been constructed.

While it is the City's general policy to not construct new inverted siphons, the siphons on the outfall trunk are the exception. The City is in the process of constructing a fourth siphon on the Outfall Trunk. This fourth siphon is 36-inch diameter HDPE (31.511 inner diameter) and it is along the same alignment as the current three parallel siphons.

9.4.3 Pumping Stations and Force Mains

As a general practice, the current capacities of existing force mains were assumed to not increase under future conditions, with increases to future flows mitigated through equalization at the current wet wells. This assumption and approach is intended to minimize flow increases in existing downstream trunk sewer mains and other infrastructure so that they do not have to be bypassed or replaced.

Future pump stations and force mains are anticipated throughout the future conditions trunk sewer extensions due to topography and/or routing future flows into or around the existing collection system. Many of these force mains are conceptualized to be several miles in length and require the capacity to carry high volumes of wet weather flow. Future pump stations that are anticipated to be constructed by the 2066 planning year are sized for 2066 (50 year) projected flows.

For 2116, the following basins, at a minimum, will require pump stations:

- Basins 15 and 34
- Basin 22
- Basin 23
- Basin 25
- Basin 29
- Basin 30
- Basin 32
- Basin 33 (foundation park)

9.4.4 Flow Equalization Facilities

Future conditions scenario modeling includes increasing the size of the existing flow equalization (EQ) facility on the outfall trunk at Cliff and Chambers where the Big Sioux River diversion reenters the Big Sioux River. Under existing conditions the equalization facility serves to handle peak flows in excess of the Brandon Pumping Station (BRPS). For future conditions scenario modeling, the function of the flow EQ facility is increased to relieve capacity limitations on the future alignment of the Outfall Trunk.

Flow equalization facilities are assumed at most of the force mains serving future trunk sewer extensions, where interim flow connections into existing sewer mains are conceptualized, and where large volumes of future flow are anticipated to discharge into the existing collection system. Flow equalization facilities are conceptualized to reduce required future lift station capacities and force main sizes due, in part, to the long lengths (several miles in several instances) of these force mains.

For 2116, the following basins, at a minimum, will require permanent EQ:

- Basins 15 and 34 (consolidated EQ between the two basins)
- Basin 33 (foundation park)

The following additional areas could be considered for EQ to minimize the size of downstream facilities:

- Basin 22
- Basin 23
- Basin 29
- Basin 30
- Basin 32

9.4.5 Satellite Treatment Facilities

Satellite treatment facilities are a final option to serve future growth and eliminate the need for several mile long high capacity force mains. Logical places to consider future satellite WRFs are shown below. The evaluation of satellite treatment facilities is further discussed in Chapter 7.

- On the west side of the City to serve development expansions in basins 15, 34, and 14.
- On the southeast side of the City to serve development expansions to east and south including basins 27, 28, 29, 30, 31, and possibly the ESSS.

A comprehensive review of treatment versus pumping flows to the existing WRF are included in Chapter 7 *Appendix 7.B – Eastside Sanitary Sewer System Treatment at PS 240, Pump Station and Force Main Evaluation.*

Based on the monetary and nonmonetary weighted decision making, pumping to and expanding the existing WRF was preferred over the PS 240 Satellite MBR. Therefore, the final recommendation is to implement Existing WRF improvements to be continued through 2036 with a second forcemain to the WRF. Following are action items:

- The force main alignment and associated right-of-way needs to be further evaluated as part of preliminary design.
- A safety factor should be applied to the equalization volume to address the storm of record.
- The second forcemain will provide capacity for 20 - 50 years. As the new second force main capacity is approached, a new East Side WRF would be reevaluated along with potential for additional PS 240 equalization and a third force main.

9.5 Hydraulic Problem Area Identification and Characterization for the Existing Collection System

For the purpose of determining potential peak flows, the InfoSWMM model was used to evaluate modeled conduits to determine if 25-year Design Storm RDII can be conveyed through the system while satisfying hydraulic criteria.

The findings of the hydraulic capacity analysis were separated into two categories for characterization and prioritization: Type A and Type B problem areas. These two categories are defined below.

- Type A problem areas represent a series of potentially capacity limited pipes that are hydraulically connected to one another. For Type A pipelines , the system wide criteria is a modeled peak wet weather flow level exceeding 75 percent d/D for the collector and local systems (less than or equal to 27-inch diameter) and 80 percent d/D for the interceptor systems (30-inches diameter and greater).
- Type B problem areas represent isolated potentially capacity limited pipes that are not hydraulically connected to other problem locations. For Type B pipelines, the system wide criteria is a modeled peak wet weather flow level exceeding 75 percent d/D for the collector and local systems (less than or equal to 27-inch diameter) and 80 percent d/D for the interceptor systems (30-inches diameter and greater).

9.5.1 Hydraulic Improvement Alternatives for Type A Problem Areas

Hydraulic improvement alternatives associated with Type A problem areas will be discussed following the description of the identified problem. While numerous potential problem areas have been identified and discussed for both existing and future (2066) conditions, not all problem areas require a CIP project hydraulic improvement alternative. Qualifications for developing hydraulic improvement alternatives are the following:

1. **Type A Areas with a High Degree of Confidence.** Type A Areas that were served by a flow monitor for ADWF and RDII calibration. Type A areas that were not served by a flow monitor used in calibration have a high degree of uncertainty associated with flow loads, especially wet weather flow contributions. Changes in RTK values associated with RDII have a large impact on resulting flow rates associated with the Design Storm level of service. Therefore, only Type A areas that are contained within a flow monitoring basin and have calibrated flow characteristics will have an improvement alternative developed. Type A areas that are not based on calibrated flow data have a low degree of confidence in the model results and therefore carry the recommendation of obtaining flow monitoring data that captures a significant wet weather event. These locations represent watch areas.
2. **Type A areas that have pipe diameters greater than 18-inch diameter.** Type A areas that have sewer mains that are part of the Collector/Interceptor system with diameters equal to or greater than 18 inches in diameter. This does not include local mains with diameters of 15-inch diameter or less. This is due to the following:

a. The trend of less accurate or missing invert and diameter data for the local mains that could cause inaccurate or misleading results and therefore misidentify potentially hydraulically limited areas.

b. The local system is further away from the calibration points and therefore represents reduced model accuracy.

c. For future planning scenarios, future flows are estimated for each basin for each planning year with these flows being distributed evenly within that basin. Given this approach, the model results become more valid within the Collector/Interceptor system as flow allocations converge.

The potential hydraulic capacity problem areas of the previous section were grouped into three tiers to establish which areas are analyzed as a potential CIP project area, which areas should be monitored as targets for potential inflow and infiltration (I/I) reduction, and which areas require further flow monitoring and study. These tiers are defined as follows:

- Tier 1 project areas address Type A problems and have the highest priority and represent areas of high model confidence and pipes that have diameters 18 inches and greater. Tier 1 project areas are analyzed as a potential CIP project area.
- Tier 2 project areas address Type A problems but have lower priority compared to Tier 1 project areas and represent areas of medium model confidence and pipes that have diameters of less than 18 inches. Tier 2 project areas should be monitored, potentially surveyed, and are targets for potential I/I reduction
- Tier 3 project areas address Type A problems but have the lowest priority compared to Tiers 1 and 2 project areas and represent areas of low model confidence. Tier 3 project areas require further flow monitoring and study prior to CIP project recommendations.

Tier 1 project areas are considered high priority improvements as they identified to resolve larger hydraulic capacity limitations and are anticipated to have a high benefit to the collection system.

For Tier 1 project areas, existing and future (2066) potential hydraulic capacity limitations are analyzed separately. Existing condition hydraulic improvement alternatives are developed to satisfy the 0.8 d/D hydraulic criteria for the Collector/Interceptor system for existing flows and then to not surcharge under future (2066) condition flows. Existing condition hydraulic improvement alternatives only focus on the extent of the existing conditions hydraulically limited areas. If upstream/downstream pipes have future capacity limitations, only pipes that are under capacity under current conditions are altered for short term improvements (next 1-10 years). Future (2066) condition hydraulic improvement alternatives are developed to prevent surcharging under future (2066) condition flows.

The remainder of this section discusses the Tier 1 hydraulic improvements.

9.5.2 Collection System Optimization Approach

The general approaches to developing hydraulic improvement alternatives are outlined as follows:

1. Use available existing available capacity first.
    a. Optimize diversion operations when downstream capacity is available

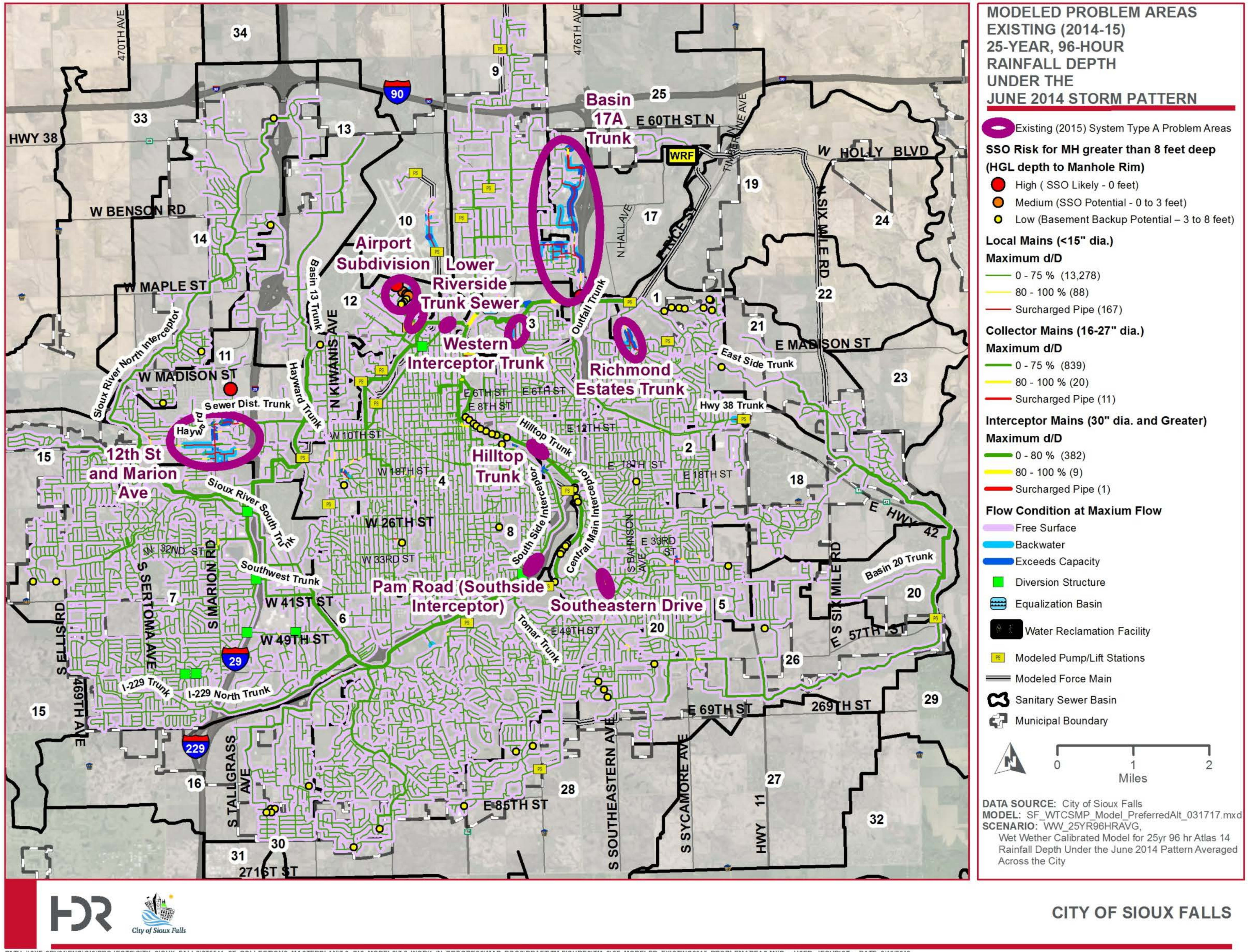
2. Use relief sewers and EQ wisely.
    a. Relief sewers can be used when there are relatively short segments of future capacity constraints. For this WTCSMP, to simplify modeling, pipes are only modeled as being upsized. However, only individual segments are upsized to reflect areas where a relief sewer could be applicable.
    b. EQ upstream of large areas of future capacity constraints and EQ at pump stations that are creating backups to reduce downstream impacts to the existing system.
    c. Pipe upsizing or parallel interceptors where large areas of future flows can be conveyed using gravity.
3. Consider additional treatment location(s) where costs of paralleling/replacing sewer are too extensive from a life cycle perspective.

The above approach is used for addressing the Type A, Tier 1 problem areas that have an associated improvement alternative developed.

9.5.3 Existing Collection System Type A Problem Areas

Model results for existing conditions indicate a number of areas that demonstrate Type A conditions. These areas are identified and named in Figure 9.12. This section describes each of these areas. A number of these locations were not served by a flow monitor, meaning that ADWF and RDII calibration could not be contrasted with actual data, requiring the basin flow loading characteristics be estimated from basins of similar age and land use. In the absence of actual contrasting data, it is recommended these problem areas be flow monitored prior to consideration of a CIP project. The 2066 model results and projected conditions for these existing identified Type A problem areas follow the descriptions of the existing conditions, in the subsequent subsection.

Figure 9.12 Existing Collection System Type A Problem Areas



9.5.3.1 Basin 17A Trunk (Lewis Road)

The Basin 17A Trunk Sewer capacity limitations appear to be extensive under Design Storm conditions. Modeled pipe surcharges occur along East 54th Street, North Hainje Avenue, North St. Paul Avenue, East 39th Street North, and North Potsdam Avenue in Basin 17. Modeled surcharges were also observed to extend into the developments to the west. A majority of the Basin 17A trunk sewer surcharges are associated with small pipe diameters, flat pipes, and high modeled RDII. The range in pipe diameters is from 8- to 18-inch for approximately 23,590 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risks. Key points about this line are the following:

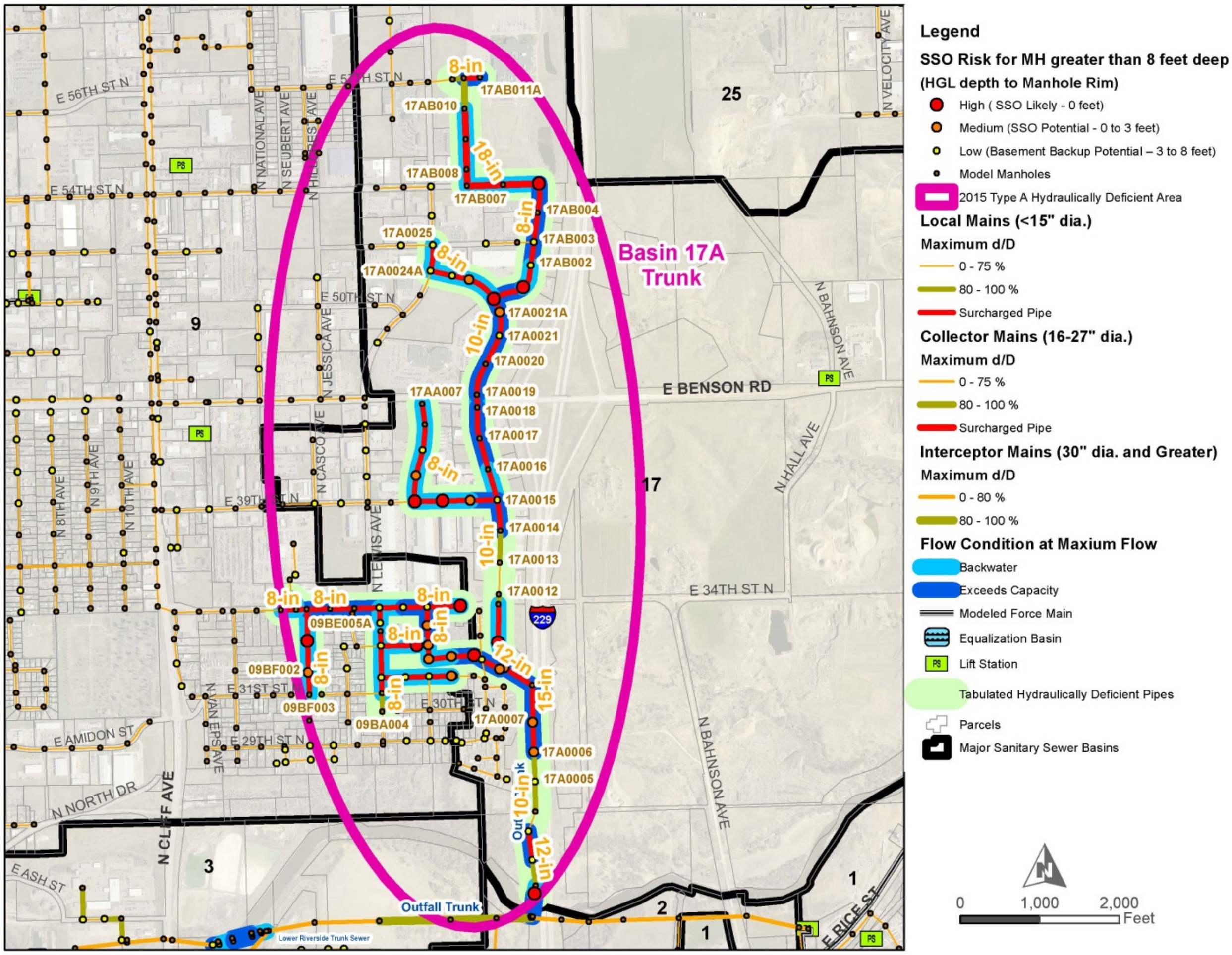
- Modeling suggests that almost the entire line surcharges under design storm condition.
- This area is not served by a flow monitor for ADWF calibration and therefore BSF is based only on winter water use and the diurnal is based on Basin 1.
- This area is not served by a flow monitor for RDII calibration. RDII assumptions were first assigned based on RTKs from Basin 1 and then adjusted for flows estimated at the WRF
- There is a low degree of confidence associated with modeling results due to the lack of wet weather calibration data.
- Recommend collecting additional flow meter data for future calibration.

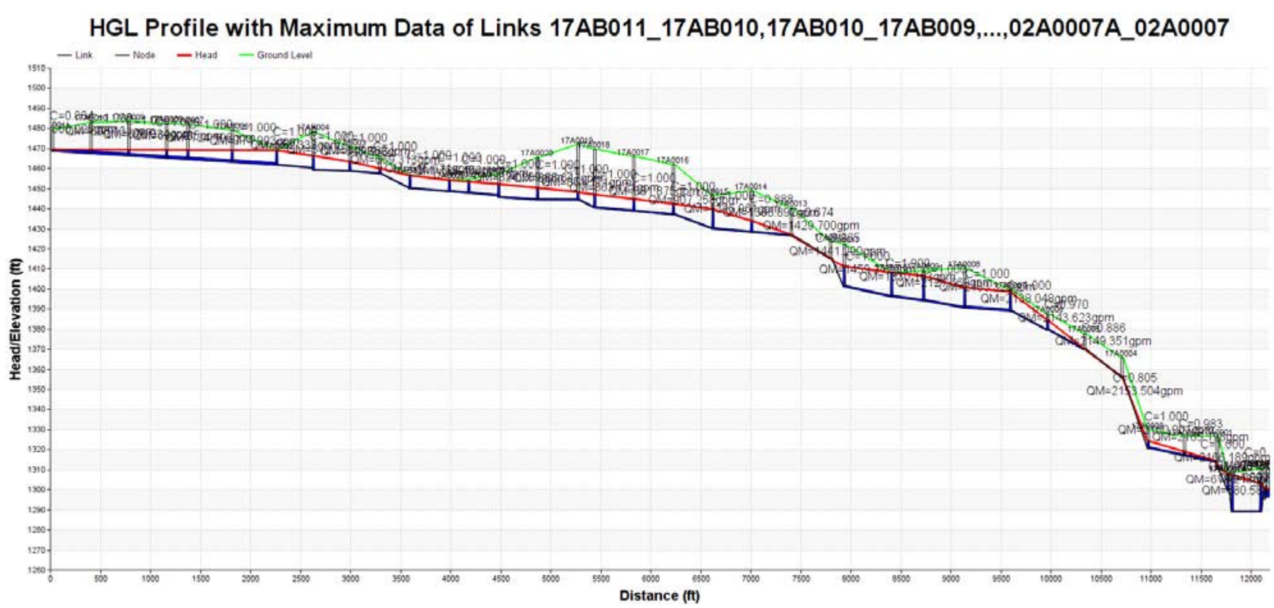
Table 9.3 summarizes the potential capacity limited pipes in this problem area. Figure 9.13 provides a map for this Type A area and a representative modeled profile along this trunk line.

Table 9.3 Existing Conditions Under Capacity Pipes for the Basin 17A Trunk (Lewis Road) Type A Problem

	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	4,660	PVC, RCP, VCP
	10	4,800	Truss White (PVC)
	12	1,120	PVC
	15	470	PVC
	18	390	PVC
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	8,800	PVC, Truss White (PVC), VCP
	10	660	PVC, DIP, Truss White
	12	810	PVC
	18	1,880	PVC

Figure 9.13 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Basin 17A Trunk Type A Problem Area





9.5.3.2 Basin 17A Trunk (Lewis Road) 2066 Conditions

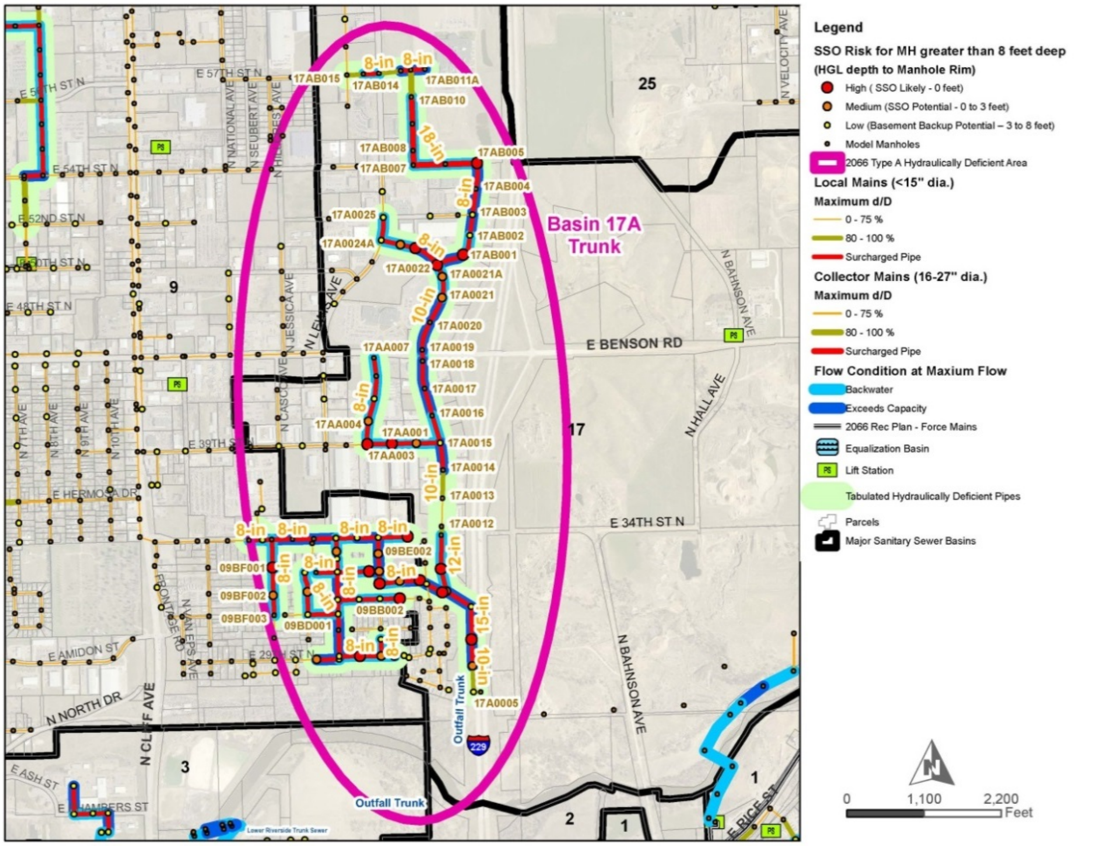
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand slightly under 2066 projected conditions. The same general notes for this problem area are the same as the existing description. The range in pipe diameters is from 8- to 18-inch for approximately 25,830 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risks.

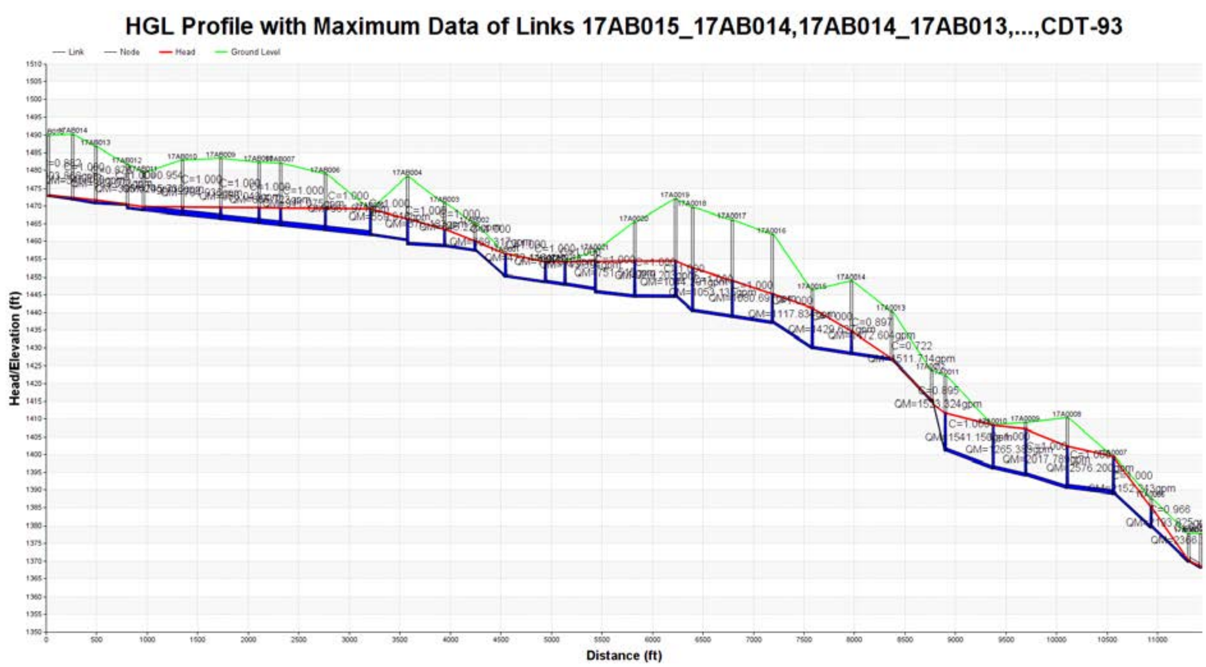
Table 9.4 summarizes the 2066 capacity restricted pipes in this problem area. Figure 9.14 provides a map for this Type A area and a representative modeled 2066 profile along this trunk line.

Table 9.4 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Basin 17A Trunk (Lewis Road)Type A Problem Area

Descriptions	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	6,630	PVC, RCP, VCP
	10	3,680	PVC, Truss White (PVC)
	12	420	PVC
	15	470	PVC
	18	390	PVC
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	10,500	PVC, Truss White (PVC), VCP
	10	1,050	PVC, Truss White (PVC), DIP
	12	810	PVC
	18	1,880	PVC

Figure 9.14 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Basin 17A Trunk Type A Problem Area





9.5.3.2.1 Recommendation

Collect additional flow meter data for this sanitary sewer section to provide for more accurate modelling. I/I flow was increased in this area to balance the entire system with actual flow metering from other basins.

9.5.3.3 Lower Riverside Trunk Sewer

The Lower Riverside Trunk Sewer is primarily along North Cliff Avenue and East Walnut Street in Basin 3 and surcharges for the Design Storm conditions with the following assumptions:

- The model reflects the 10-inch sewer to the east which was connected directly to the Outfall sewer in 2017.
- Updated flow meter data was used as the stockyard area was removed.
- For calibration purposes, permitted flow is not included for John Morrell under existing conditions. The permitted flow of 400,000 gpd is added in the 2026, 2036 and 2066 model to reflect the potential wastewater point load discharge.

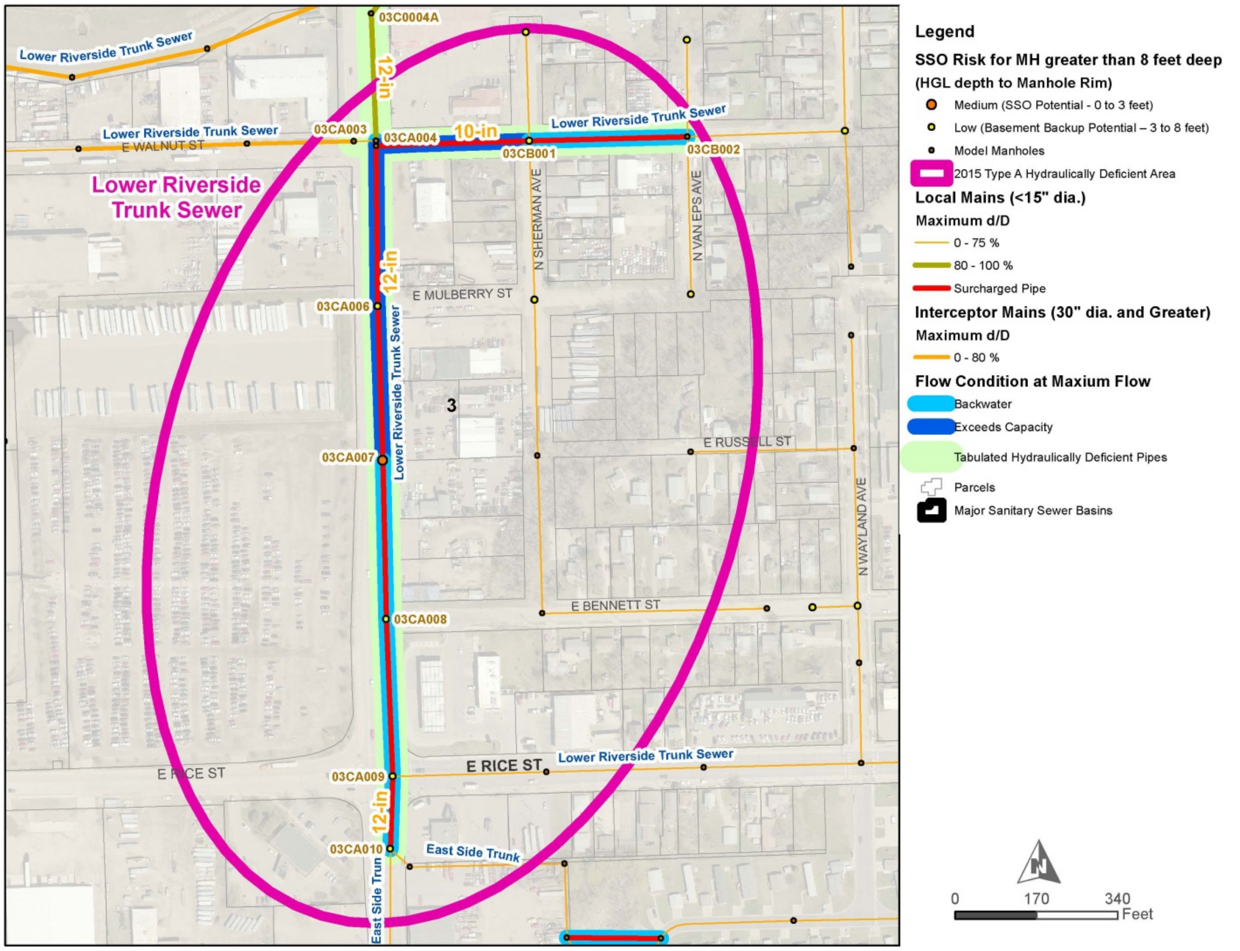
A flow monitor at manhole 03C0003 (Figure 9.15) was used to calibrate this area under existing conditions and therefore the capacity findings for these pipes have a higher level of confidence for the Design Storm conditions. The range in pipe diameters is from 10- to 15-inch for approximately 2,460 feet with the GIS not indicating that pipe lining has taken place.

Table 9.5 summarizes the capacity restricted pipes in this problem area. Figure 9.15 provides a map for this Type A area and a representative modeled profile along Cliff Ave.

Table 9.5 Existing Conditions Under Capacity Pipes for the Lower Riverside Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	10	320	VCP
	12	930	PVC, Truss White (PVC)
	15	50	PVC
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	10	330	VCP
	12	830	PVC, Truss White (PVC)

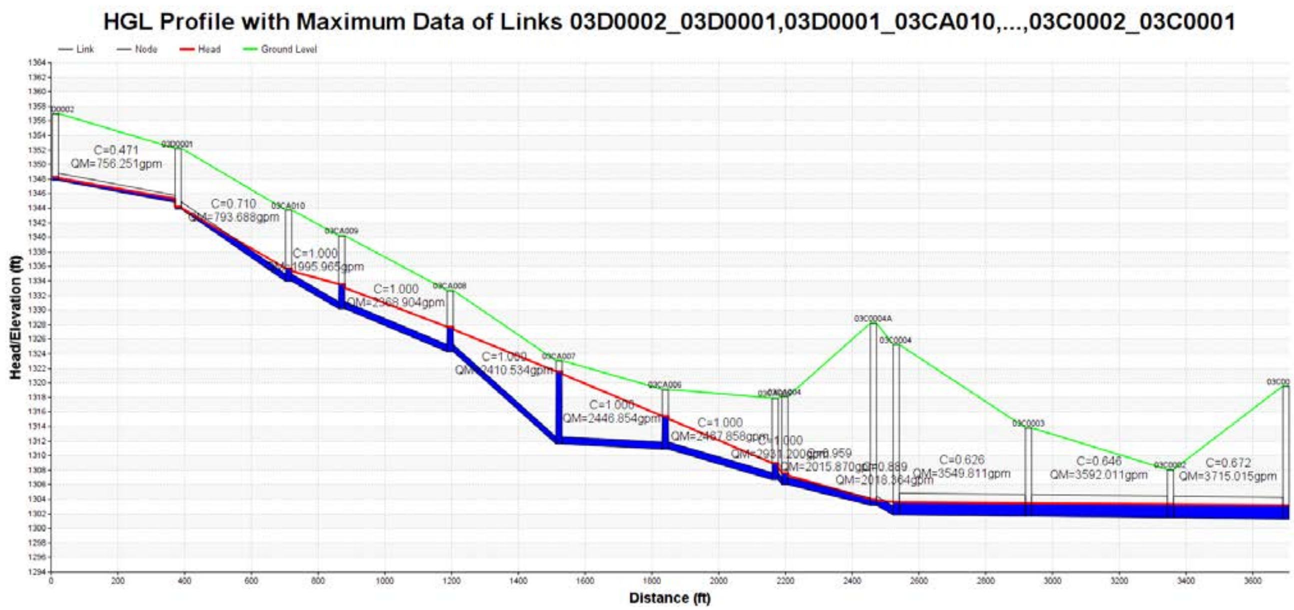
Figure 9.15 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Lower Riverside Trunk Sewer Type A Problem Area



9.5.3.4 Lower Riverside Trunk Sewer 2066 Conditions

This hydraulically limited area was identified as an existing Type A problem area. There is a need to monitor degree of surcharge and necessary repairs. Note, however, that there is no appreciable change in flow from 2013 to 2066 due to growth. Primary impact is permitted point load discharge from John Morrell which is not currently utilized.

Model results indicate surcharging but no potential for SSO risks. It may be appropriate to consider flow monitoring at the most critical manholes shown in the hydraulic profile.



9.5.3.5 Lower Riverside Trunk Sewer Recommendations

The Lower Riverside Trunk Sewer project area is hydraulically limited in both existing and future conditions. Portions of this area that have pipe inverts below the inverts of the future Outfall Trunk Sewer are not included in this recommendation. Under existing conditions, all the hydraulically limited pipes are directly connected to one another, therefore only pipe upsizing was evaluated. Given the location of this area in the collection system, diversions were not considered a viable alternative. Table 9.6 summarizes the hydraulic improvement pipe sizes associated with this project area.

Table 9.6 Lower Riverside Trunk Sewer Existing Improvements

Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size (ft)
21-inch	657
24-inch	332
36-inch	47
TOTAL	**1,036**

The problem area extents for 2026 and 2036 are similar to the problem extent for 2066. There is a need to monitor degree of surcharge and determine necessary repairs. Note, however, that there is no appreciable change in flow from 2013 to 2066 from growth. Primary impact is permitted point load discharge from John Morrell which is not currently discharging to the City. The problem area remains if John Morrell is removed from the model. This trunk sewer should continue to be monitored.

9.5.3.6 Hilltop Trunk

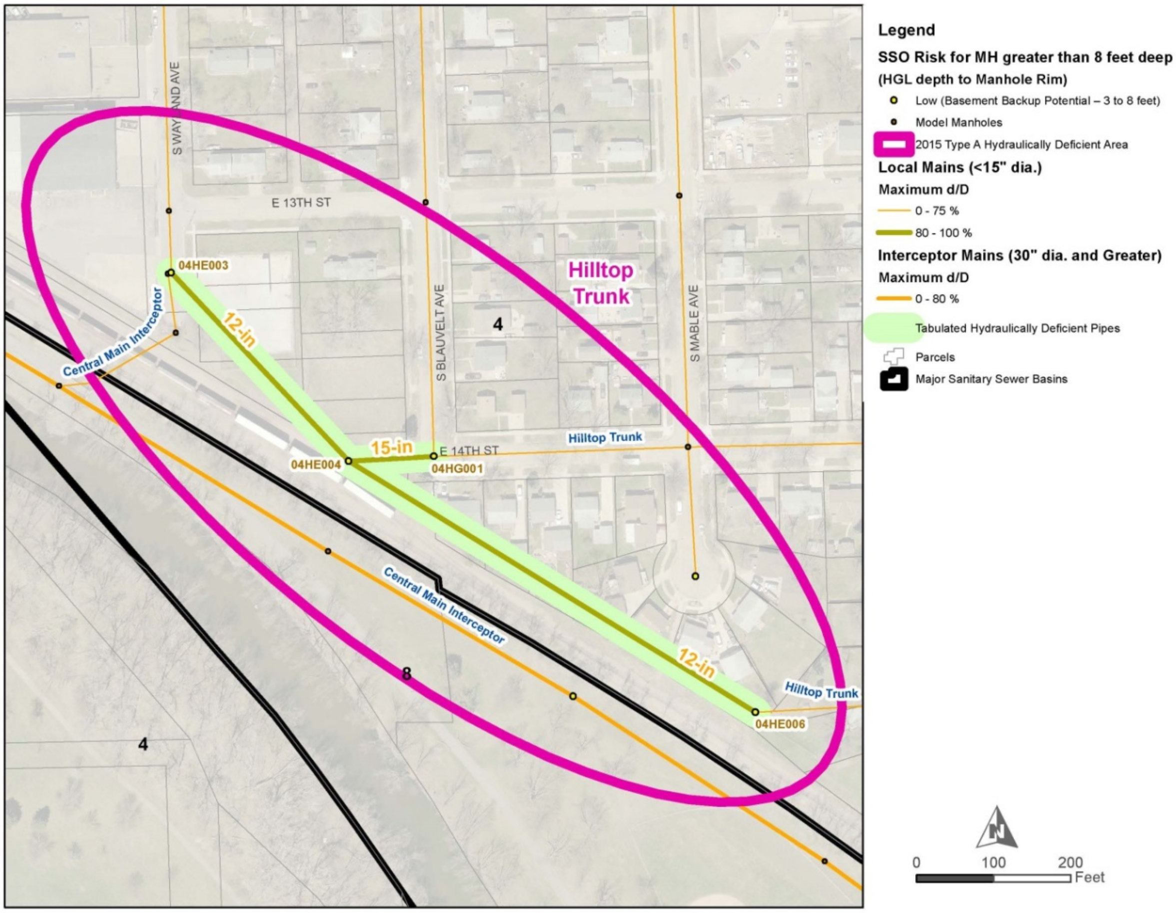
The Hilltop Trunk discharges directly into the Central Main Interceptor in Basin 4. The Hilltop Trunk exceeds the 75 percent local and collector system d/D Criteria from East 15th Street to South Wayland Avenue for the Design Storm conditions. The range in pipe diameters is from 12- to 15-inch for approximately 1,070 feet. The GIS indicates that portions of this area were CIP lined in 1988. This trunk line was not specifically monitored for wet weather flows but was part of the Central Main Interceptor calibration for the flow monitors at manholes 05A0002 and 04A0004.

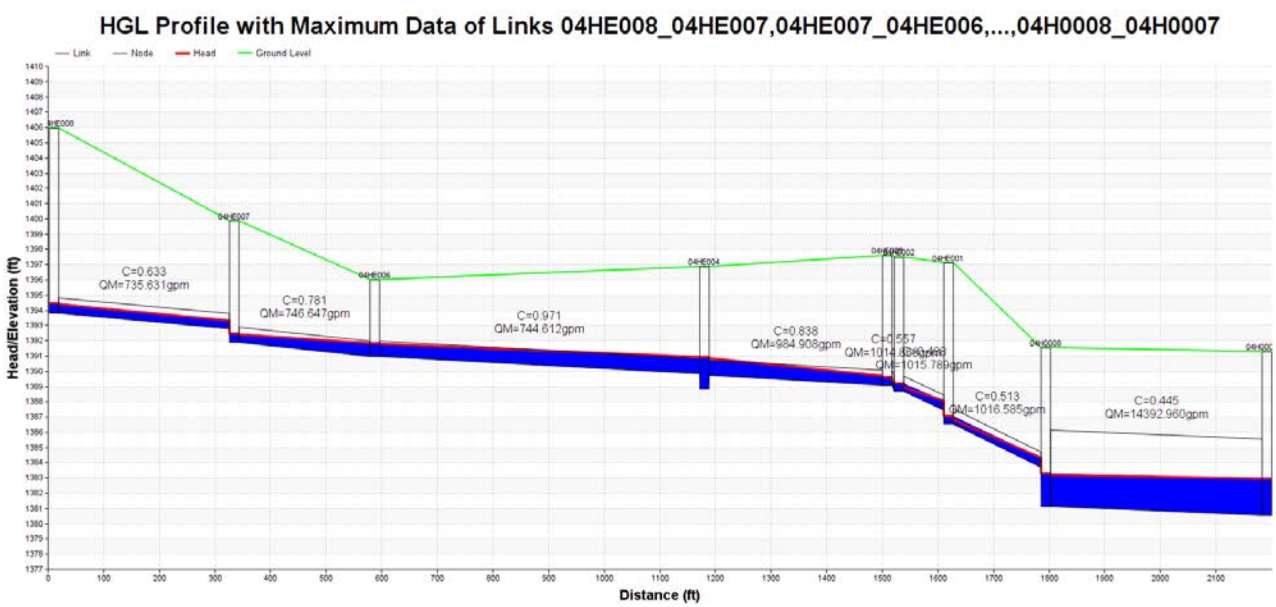
Table 9.7 summarizes the capacity restricted pipes in this problem area. Figure 9.16 provides a map for this Type A area and a representative modeled profile from East 15th Street to the Central Main Interceptor.

Table 9.7 Existing Conditions Under Capacity Pipes for the Hilltop Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	12	960	VCP	1955
	15	110	VCP	

Figure 9.16 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Hilltop Trunk Sewer Type A Problem Area





9.5.3.7 Hilltop Trunk 2066 Conditions

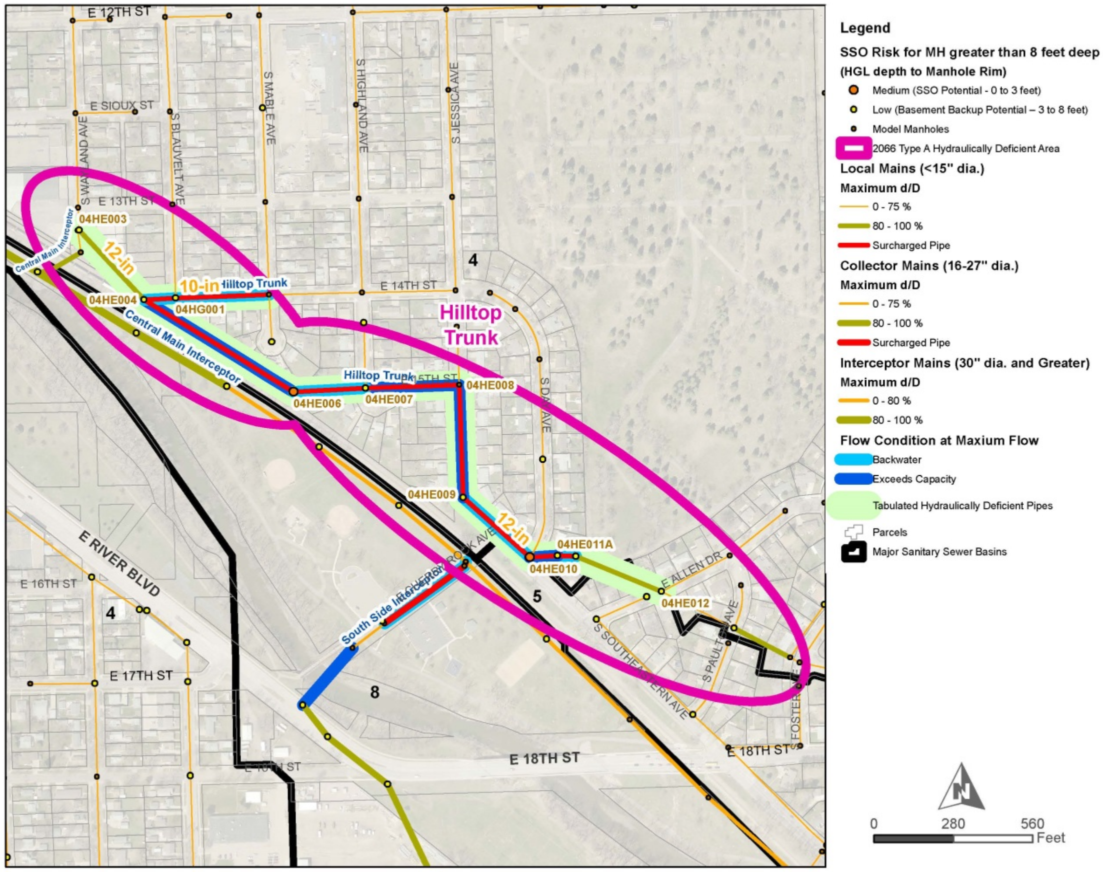
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand and become exacerbated under 2066 projected flow increases and conditions. The same general notes for this problem area are the same as the existing description. The range in pipe diameters is from 10- to 15-inch for approximately 3,190 feet. Model results also indicate the potential for a SSO risk.

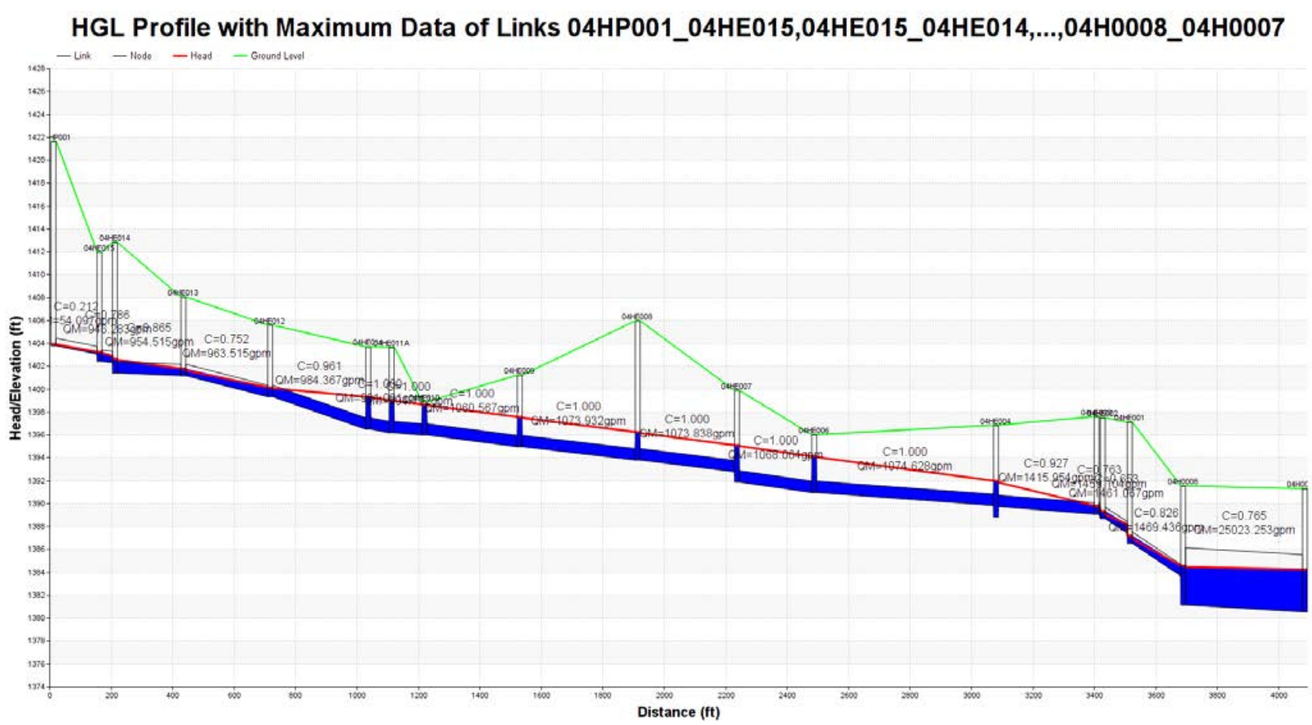
Table 9.8 summarizes the capacity restricted pipes in this problem area. Out of the problem pipes listed in Table 9.8, the GIS indicates 875 feet of VCP pipe was lined in 1988. Figure 9.17 provides a map for this Type A area and a representative modeled 2066 profile from East 15th Street to the Central Main Interceptor.

Table 9.8 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Hilltop Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	12	2,110	Truss White (PVC), VCP	1955
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	10	330	VCP	
	12	640	VCP	1955
	15	110	VCP	

Figure 9.17 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Hilltop Trunk Sewer Type A Problem Area





9.5.3.7.1 Recommendation

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.5.3.8 Richmond Estates Trunk

The Richmond Estates Trunk in Basin 1 surcharges for the Design Storm conditions as a result of under capacity pipes. There are approximately 3,770 feet of under capacity 8-inch pipes with the GIS not indicating that pipe lining has taken place. Model results indicate the potential for SSO risks. Key points about this line are the following:

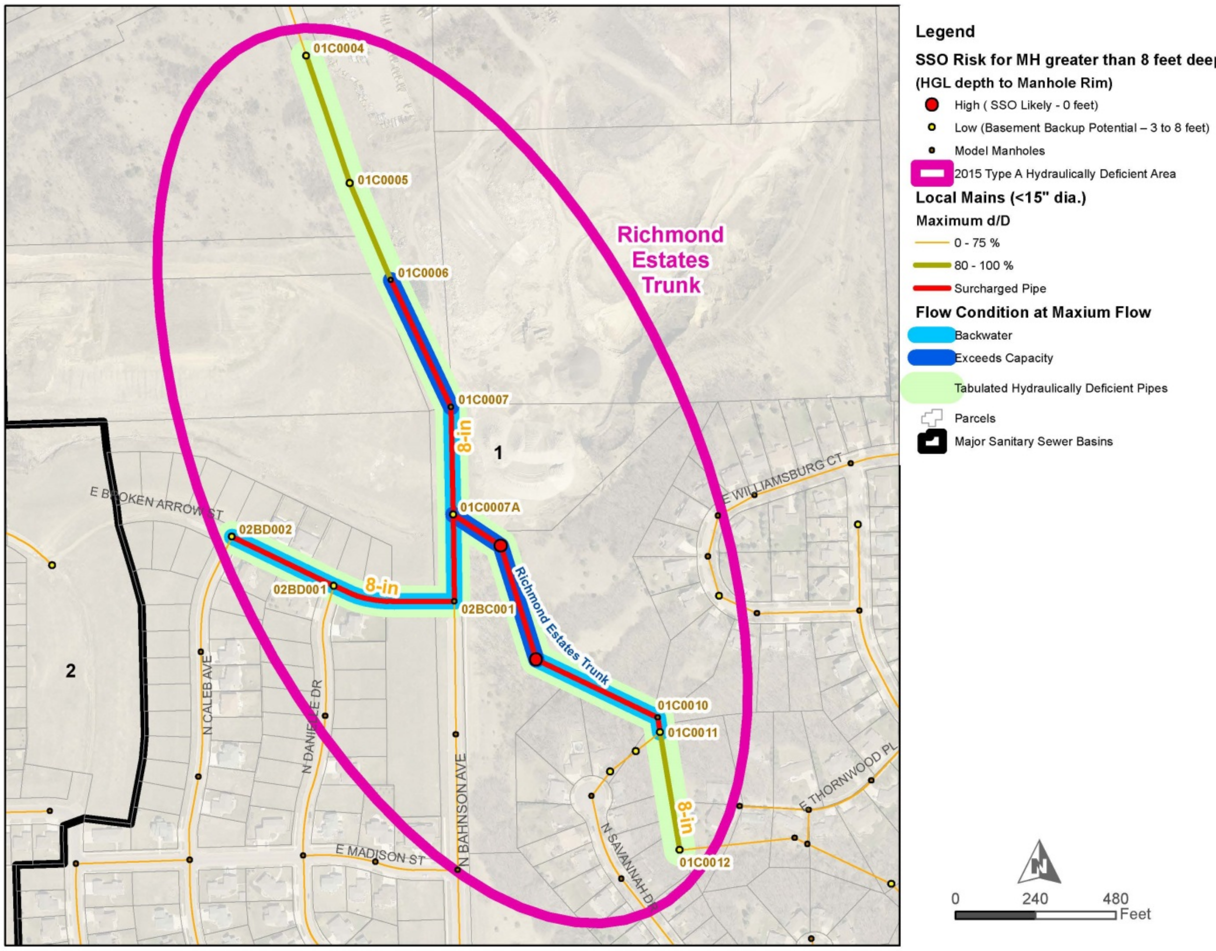
- There are a couple of pipe segments that are deep and go under a hill.
- The downstream flow monitor received backwater from the Brandon Road pump station for the calibration event and impacted calibration for this line.
- Most of the under capacity pipe segments are currently on undeveloped land.
- Survey data was collected in 2016 on a number pipes from manhole 01C0011 to 01C0007A
- Pipe segments from manhole 01C0010 to 01C0007A could be an overflow problem

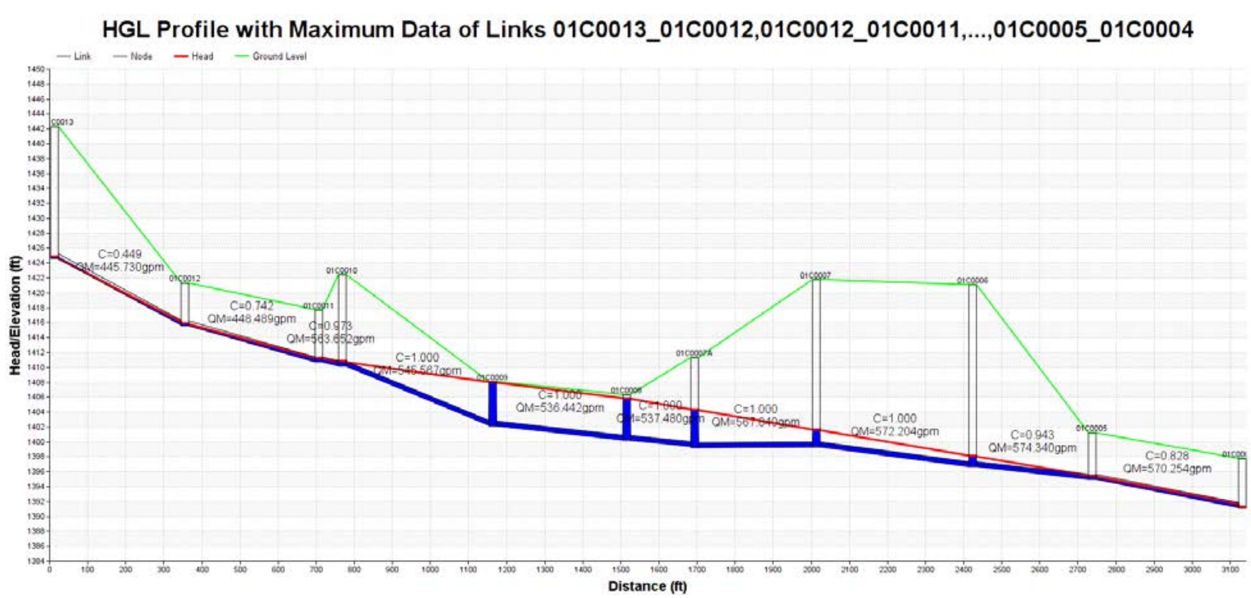
Table 9.9 summarizes the capacity restricted pipes in this problem area. Figure 9.18 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.9 Existing Conditions Under Capacity Pipes for the Richmond Estates Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	2,030	PVC, Truss White (PVC), RCP	
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	1,740	PVC, Truss White (PVC)	2004, 2005

Figure 9.18 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Richmond Estates Trunk Sewer Type A Problem Area





9.5.3.9 Richmond Estates Trunk 2066 Conditions

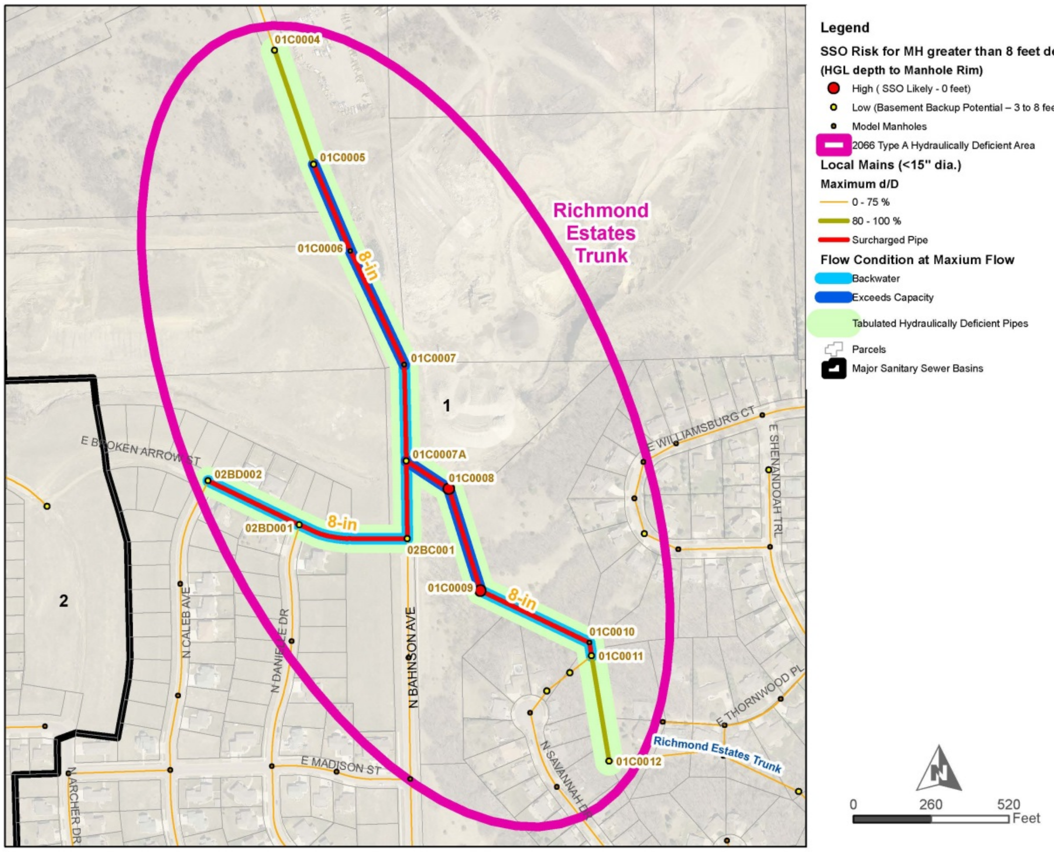
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand under 2066 projected conditions. The same general notes for this problem area are the same as the existing system description. The pipe diameters are 8-inch for approximately 3,770 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risk.

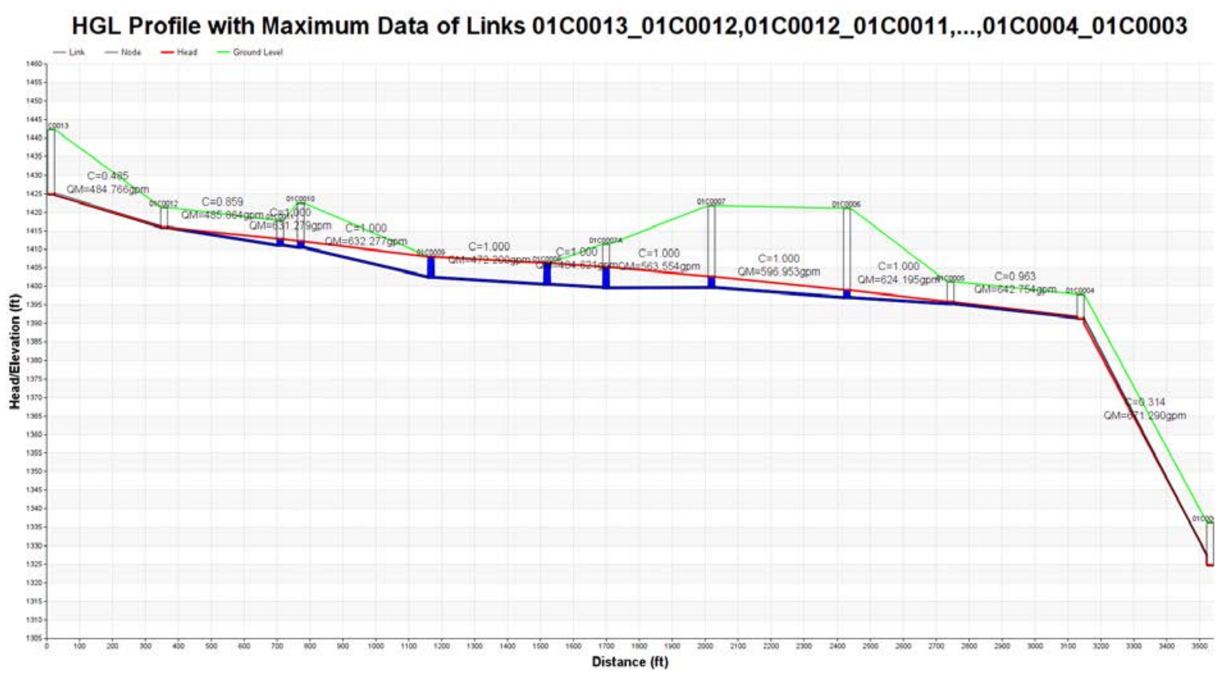
Table 9.10 summarizes the capacity restricted pipes in this problem area. Figure 9.19 provides a map for this Type A area and a representative modeled 2066 profile along this line.

Table 9.10 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Richmond Estates Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	2,030	RCP, Truss White (PVC)	
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	1,740	PVC, Truss White (PVC)	2004, 2005

Figure 9.19 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Richmond Estates Trunk Sewer Type A Problem Area





9.5.3.10 Richmond Estates Trunk Recommendations

The Richmond Estates trunk project area is hydraulically limited in both existing and 2066 conditions. Under existing conditions, all the hydraulically limited pipes are directly connected to one another and therefore only pipe upsizing was evaluated.

Because portions of this pipe alignment run under a hill (manholes 01C0007 to 01C0005), evaluations were made to avoid altering these pipes. However, model results indicate that these pipe segments are part of the problem and will need to be upsized or paralleled to keep the line from surcharging. There is also a back-sloped pipe along this alignment based on the City's GIS, however removing this back slope (creating a positive slope along the entire alignment) did not solve the hydraulic capacity limitation. Prior to implementing the CIP project, it is recommended to extend the existing survey downstream of 01C0007 and to flow monitor this location to determine specifically if backups are occurring.

Given the location of this area in the collection system, diversions were not considered a viable alternative. However, parallel pipes were evaluated but given the back pitched pipe, the parallel pipe needed to alleviate the hydraulic limitation is the same size and extent as pipe upsizing.

Table 9.11 summarizes the hydraulic improvement pipe sizes for 2066 associated with this project area, which are the same as existing, 2026, and 2036 flow conditions. Some of the pipes in and will require associated invert and slope adjustments to make the diameter work.

Table 9.11 Richmond Estates Trunk Sewer Tiers 1-4, 50-Year Build-out (2066) Improvements

Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size (ft)
12-inch	1,990
TOTAL	**1,990**

9.5.3.11 Southeastern Drive

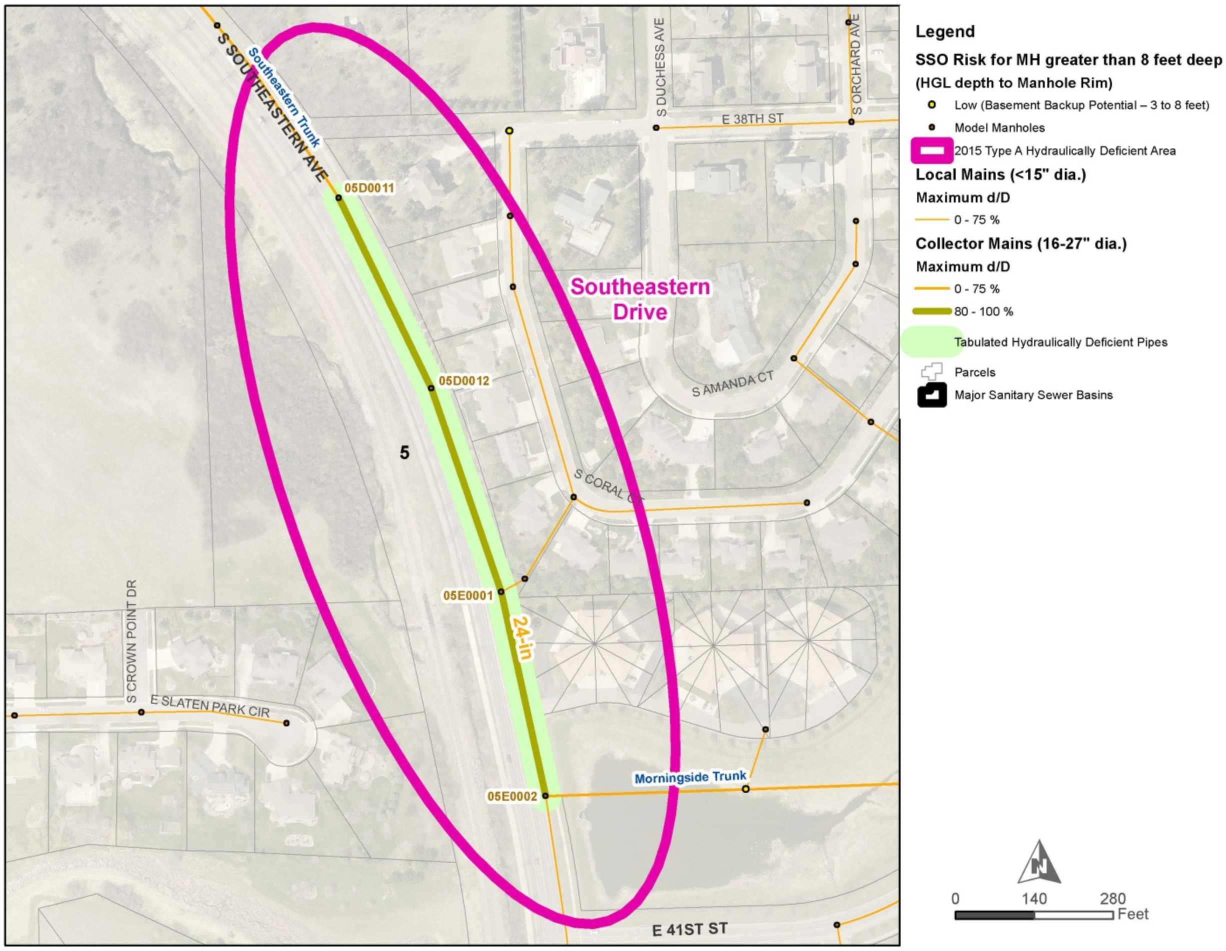
The collector system main along South Southeastern Avenue in Basin 5 from East 41st Street to East 38th Street exceeds the 75 percent collector system d/D Criteria for the Design Storm conditions. There are approximately 1,130 feet of under capacity 24-inch pipes with the GIS not indicating that pipe lining has taken place. A flow monitor located just downstream at manhole 05D0010 (Figure 9.20) was used to calibrate to existing conditions and therefore the capacity limitations for this pipes have a higher level of confidence for the Design Storm conditions.

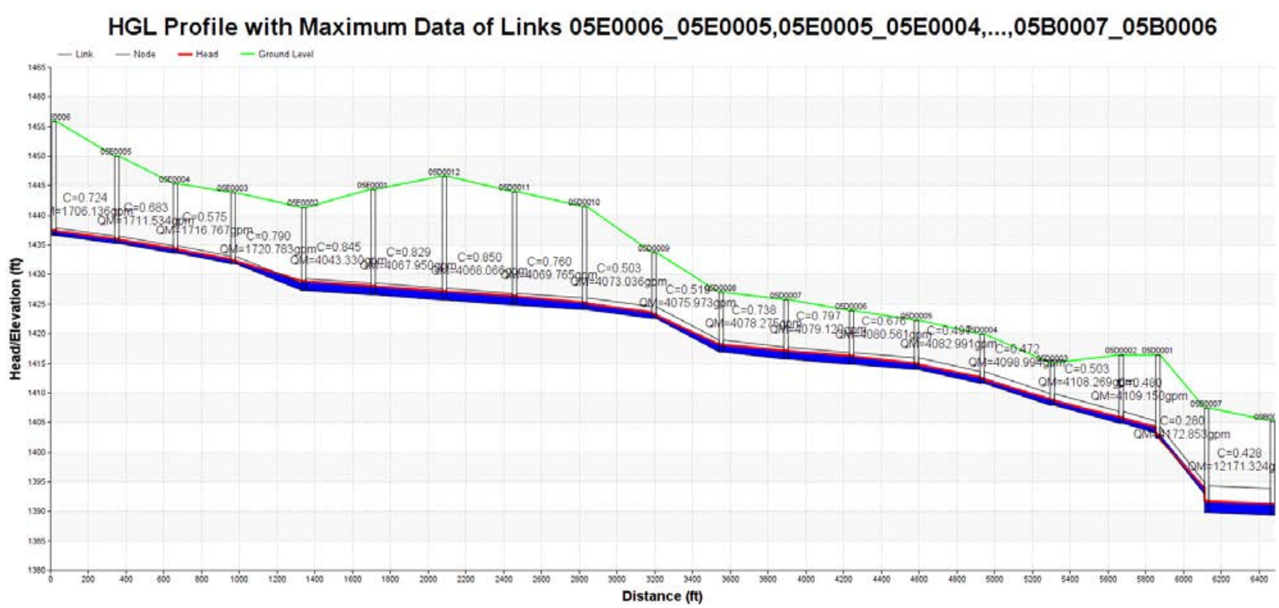
Table 9.12 summarizes the capacity restricted pipes in this problem area. Figure 9.20 provides a map for this Type A area and modeled profile from East 15th Street to the Central Main Interceptor.

Table 9.12 Existing Conditions Under Capacity Pipes for the Southeastern Drive Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	24	1,130	RCP

Figure 9.20 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Southeastern Drive Type A Problem Area





9.5.3.12 Southeastern Drive 2066 Conditions

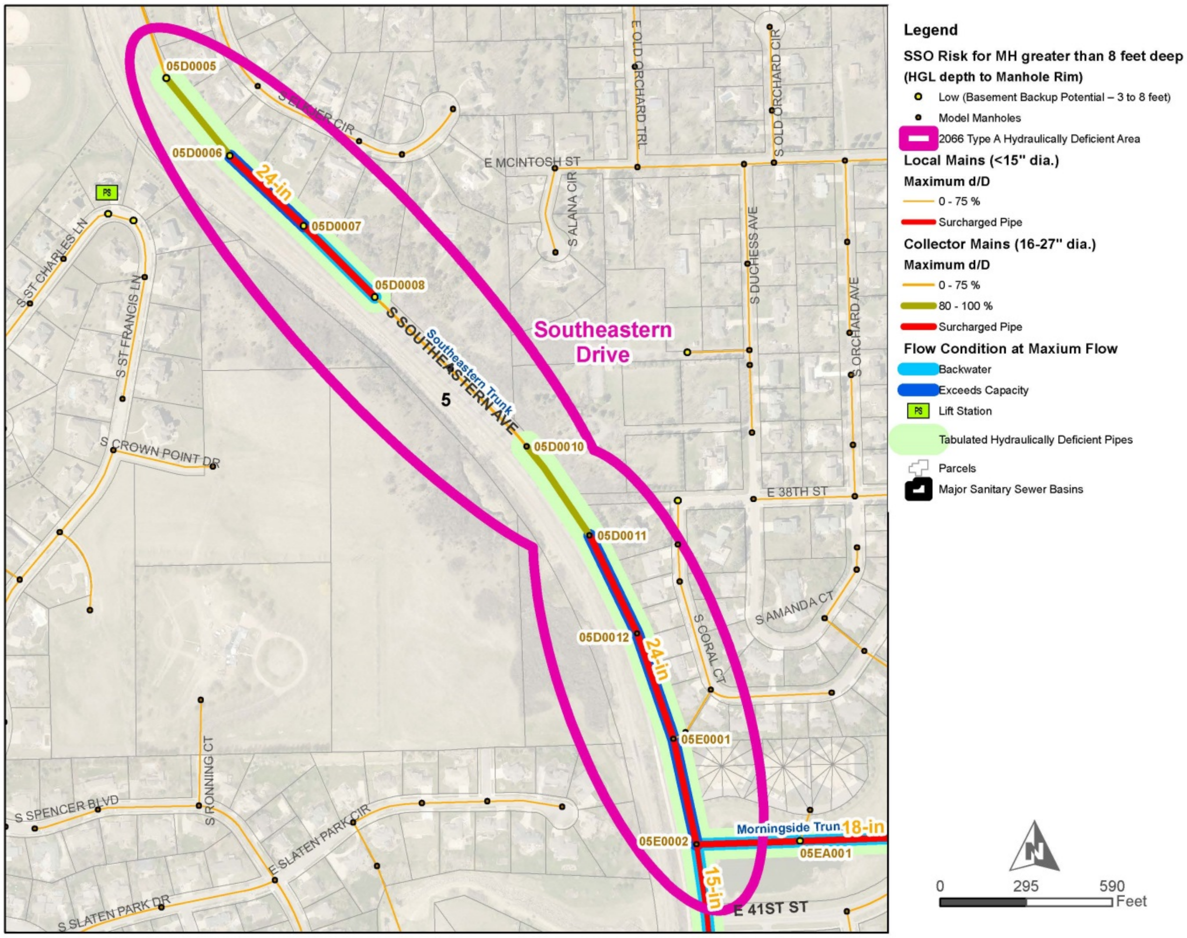
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand under 2066 projected conditions. The same general notes for this problem area are the same as the existing system description. The range in pipe diameters is from 15- to 24-inch for approximately 3,640 feet with the GIS not indicating that pipe lining has taken place.

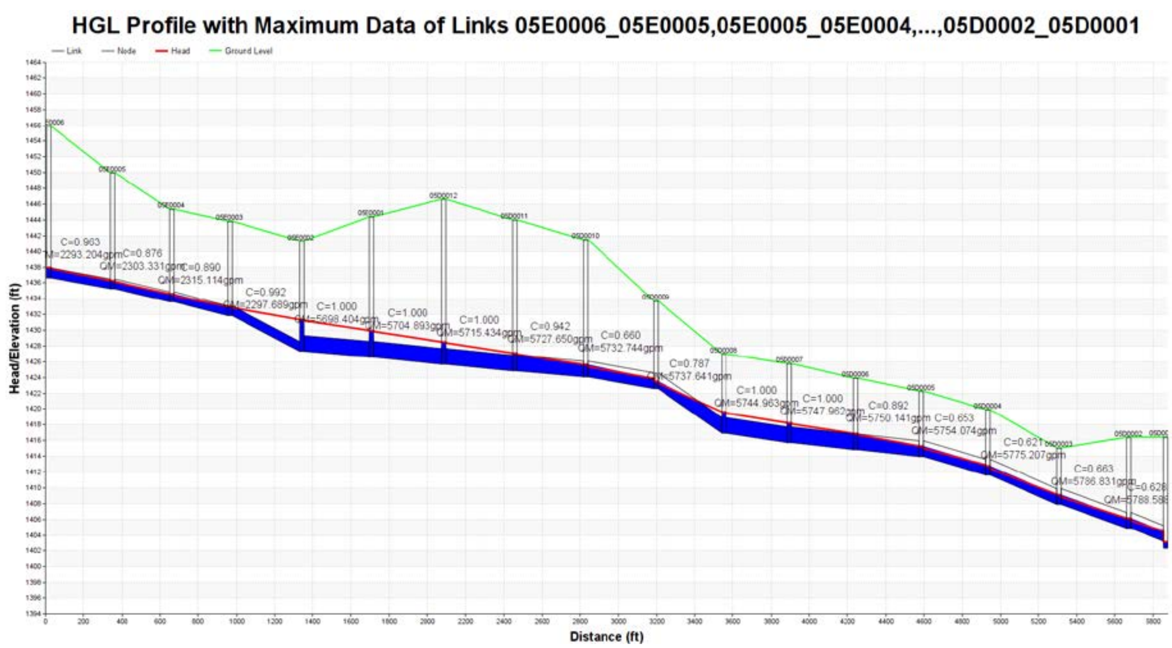
Table 9.13 summarizes the capacity restricted pipes in this problem area. Figure 9.21 provides a map for this Type A area and the modeled 2066 profile from East 15th Street to the Central Main Interceptor.

Table 9.13 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Southeastern Drive Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	24	2,200	RCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	15	380	VCP
	18	710	PVC
	24	350	RCP

Figure 9.21 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Southeastern Drive Type A Problem Area





9.5.3.13 Southeastern Drive Recommendations

The Southeastern Drive project area is hydraulically limited in both existing and 2066 conditions. Under existing conditions, all the hydraulically limited pipes are directly connected to one another and while pipe surcharging is not predicted, the pipes do not satisfy the 0.8 d/D wet weather criteria. Given the location of this area in the collection system, diversions were not considered a viable alternative. Table 9.14 summarizes the hydraulic improvement pipe sizes associated with this project area.

Table 9.14 Southeastern Drive Existing Improvements

Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size (ft)
27-inch	1,128
TOTAL	**1,128**

Table 9.15 summarizes the hydraulic improvement pipe sizes for 2066 associated with this project area. The problem area extents for 2026 and 2036 are similar to the problem extent for 2066. All of the pipes presented in Figure 9.21 are directly connected to each other, however, the solutions do not upsize downstream pipes that are smaller in size but have greater capacity due to slope. If the decision is made to upsize all of the pipes to 27-inch to the Central Main Trunk, 1,880 feet of additional pipe would need to be added to this project area.

Table 9.15 Southeastern Drive Sewer Tiers 1-4, 50-Year Build-out (2066) Improvements

Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size (ft)
27-inch	2,926
TOTAL	**2,926**

Alternatively, a lining project for the Southeastern Drive project area was also examined. For modeling purposes, it was assumed that pipe lining reduces the Manning's roughness coefficient down from 0.013 (concrete) to 0.009 (CIPP lining) and a diameter reduction from 24-inch to 23.29-inch inner diameter[1]. Under these assumptions, 2066 hydraulic capacity limitations are reduced to four pipe segments that would potentially surcharge, however it is within acceptable levels.

Pipe lining solves the hydraulic capacity limitations and is the recommended CIP project.

9.5.3.14 Pam Road (Southside Interceptor)

The Southside Interceptor northeast of the East Pam Road and South Cliff Avenue intersection (near Lincoln High School) surcharges slightly and exceeds the 75 percent collector system d/D Criteria for the Design Storm conditions. The under capacity pipes result from the sump condition in the pipe profile (Figure 9.22) backing up flow. The range in pipe diameters is from 16- to 18-inch for approximately 1,065 feet in Basin 8 with the GIS not indicating that pipe lining has taken place. Key points about this line are the following:

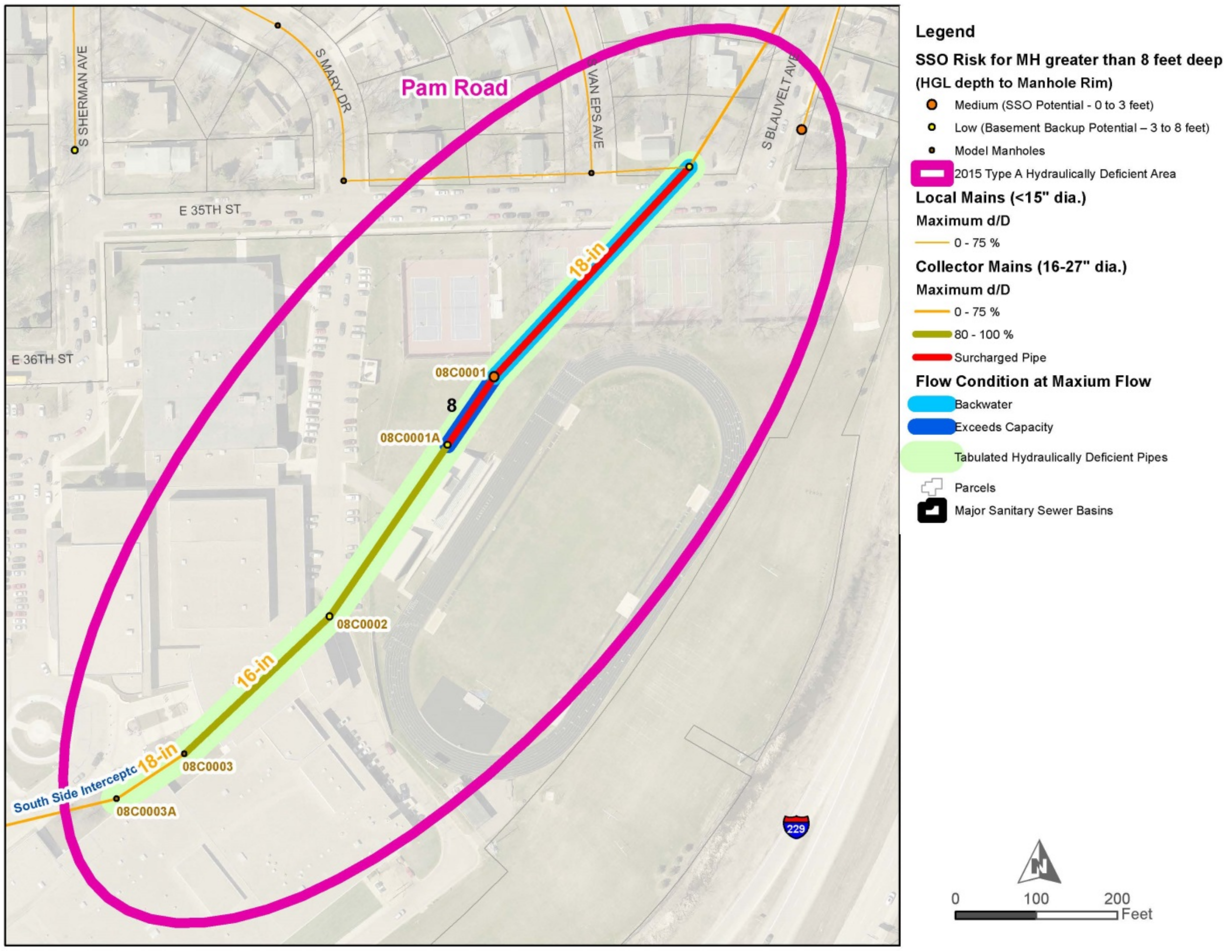
- There is a diversion structure at the intersection of East Pam Road and South Cliff Avenue that sends overflow to the south to the Sioux River South Interceptor Trunk. There is a bench in the diversion structure that controls this flow.
- This Type A Problem Area is part of the calibration for flow monitor 06A0004 on the Sioux River South Interceptor and 04A0004 on the Central Main Interceptor.
- Survey data was collected in 2016 on a number pipes from manhole 08C0002 to 08B0012

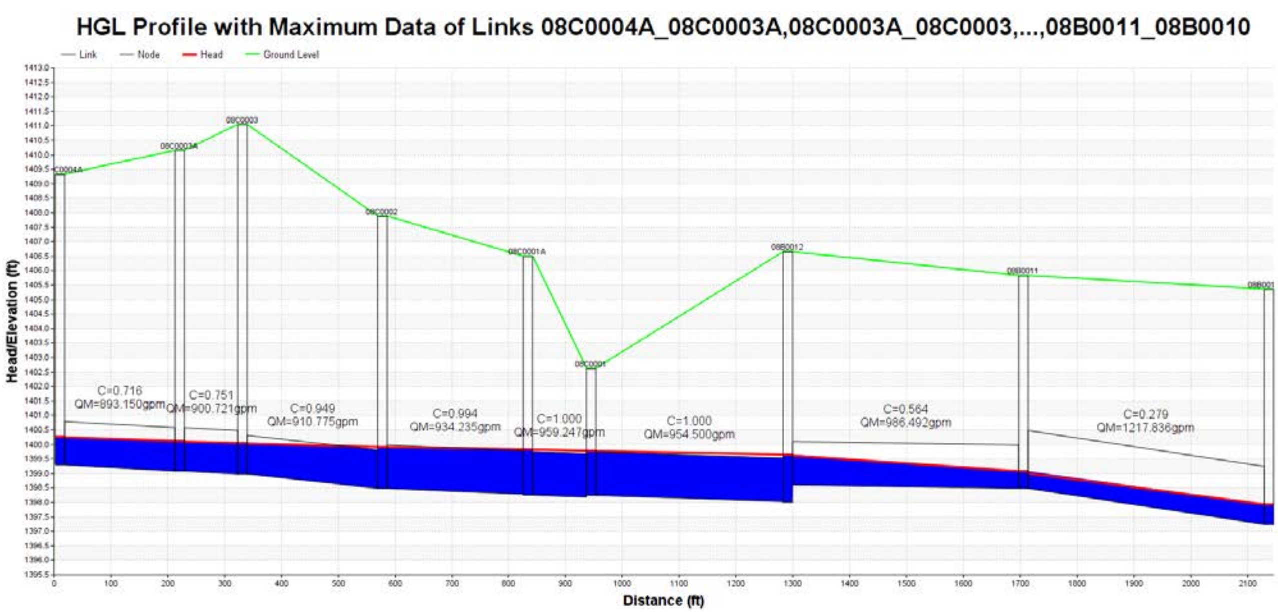
Table 9.16 summarizes the capacity restricted pipes in this problem area. Figure 9.22 provides a map for this Type A area and modeled profile along the Southside Interceptor.

Table 9.16 Existing Conditions Under Capacity Pipes for the Pam Road (Southside Interceptor) Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	18	710	VCP-Lined
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	18	355	VCP-Lined

Figure 9.22 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Pam Road (Southside Interceptor) Type A Problem Area





9.5.3.15 Pam Road (Southside Interceptor) 2066 Conditions

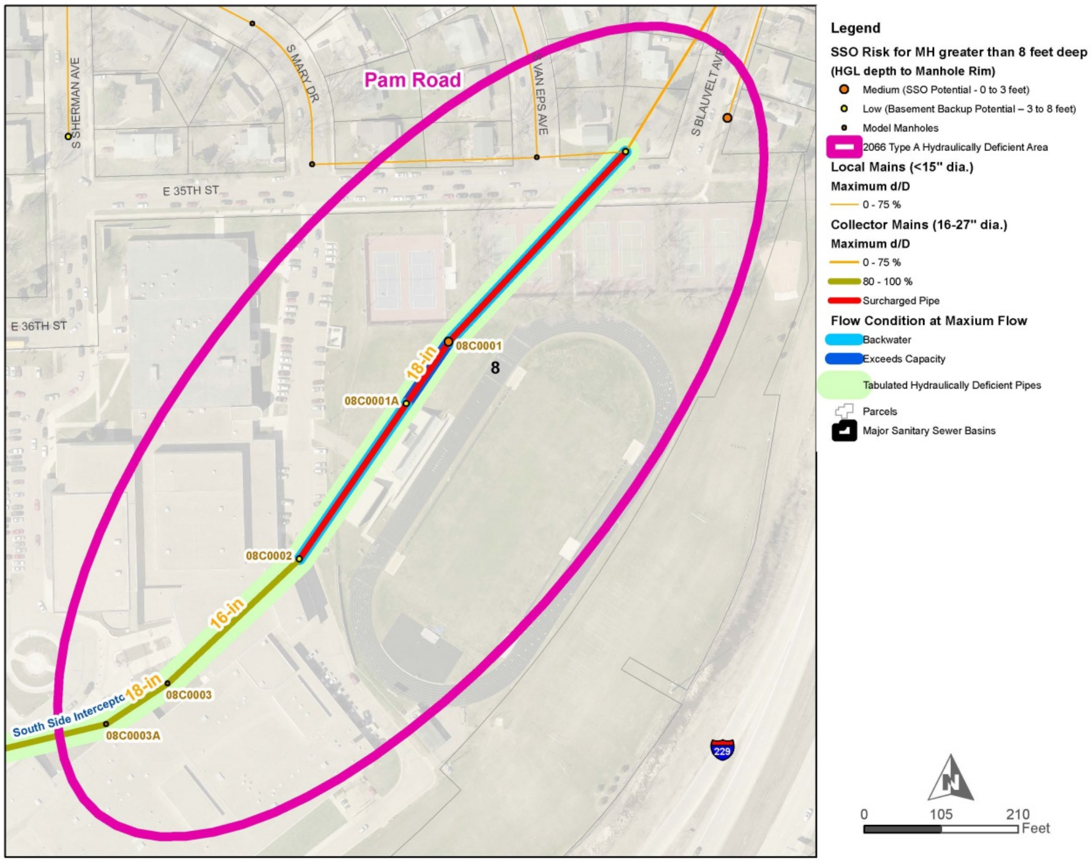
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand under 2066 projected conditions. The same general notes for this problem area are the same as the existing system description. The range in pipe diameters is from 16- to 18-inch for approximately 1,290 feet with the GIS not indicating that pipe lining has taken place.

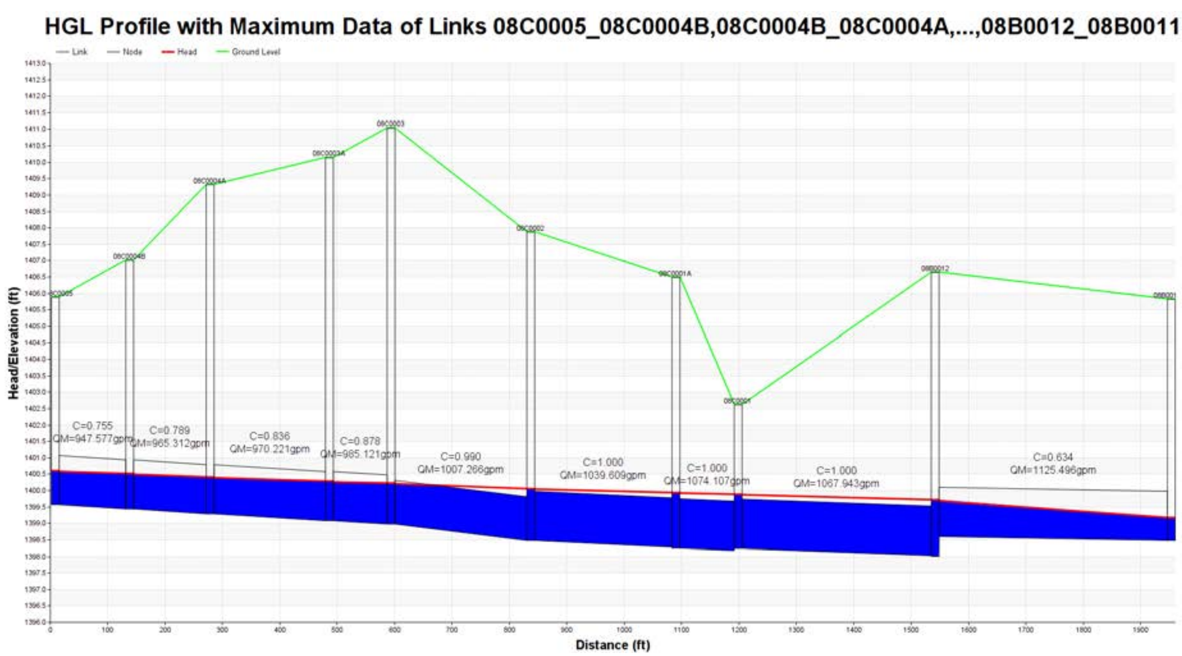
Table 9.17 summarizes the capacity restricted pipes in this problem area. Figure 9.23 provides a map for this Type A area and the modeled 2066 profile along the Southside Interceptor.

Table 9.17 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Pam Road (Southside Interceptor) Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	18	670	VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	18	620	VCP

Figure 9.23 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Pam Road (Southside Interceptor) Type A Problem Area





9.5.3.16 Pam Road Improvements (Southside Interceptor)

Flow can be relieved at Duluth. Surcharging to be investigated via survey along profile. No impact to adjacent services. The hydraulic limitations for this pipe appear to be a sump condition in the pipe profile. It is recommended this segment be surveyed and continue to be monitored.

9.5.3.17 Western Interceptor Trunk

Where the Western Interceptor Trunk, the Western Interceptor Relief Trunk, PS 203 force main, and PS 215 force main converge at the intersection of North Main Avenue and West Walnut street in Basin 10 there are several pipes that exceed the 75 percent collector system d/D Criteria and 80 percent interceptor system d/D Criteria for the Design Storm conditions. There are several pipes in this area that have minimal slope and therefore are capacity limited for the modeled flow rates. The Western Interceptor downstream of this location to the point where it discharges into the Central Main has capacity for existing modeled wet weather conditions.

The range in pipe diameters is from 24- to 36-inch and total approximately 560 feet in Basin 10 with the GIS not indicating that pipe lining has taken place. Key points about this line are the following:

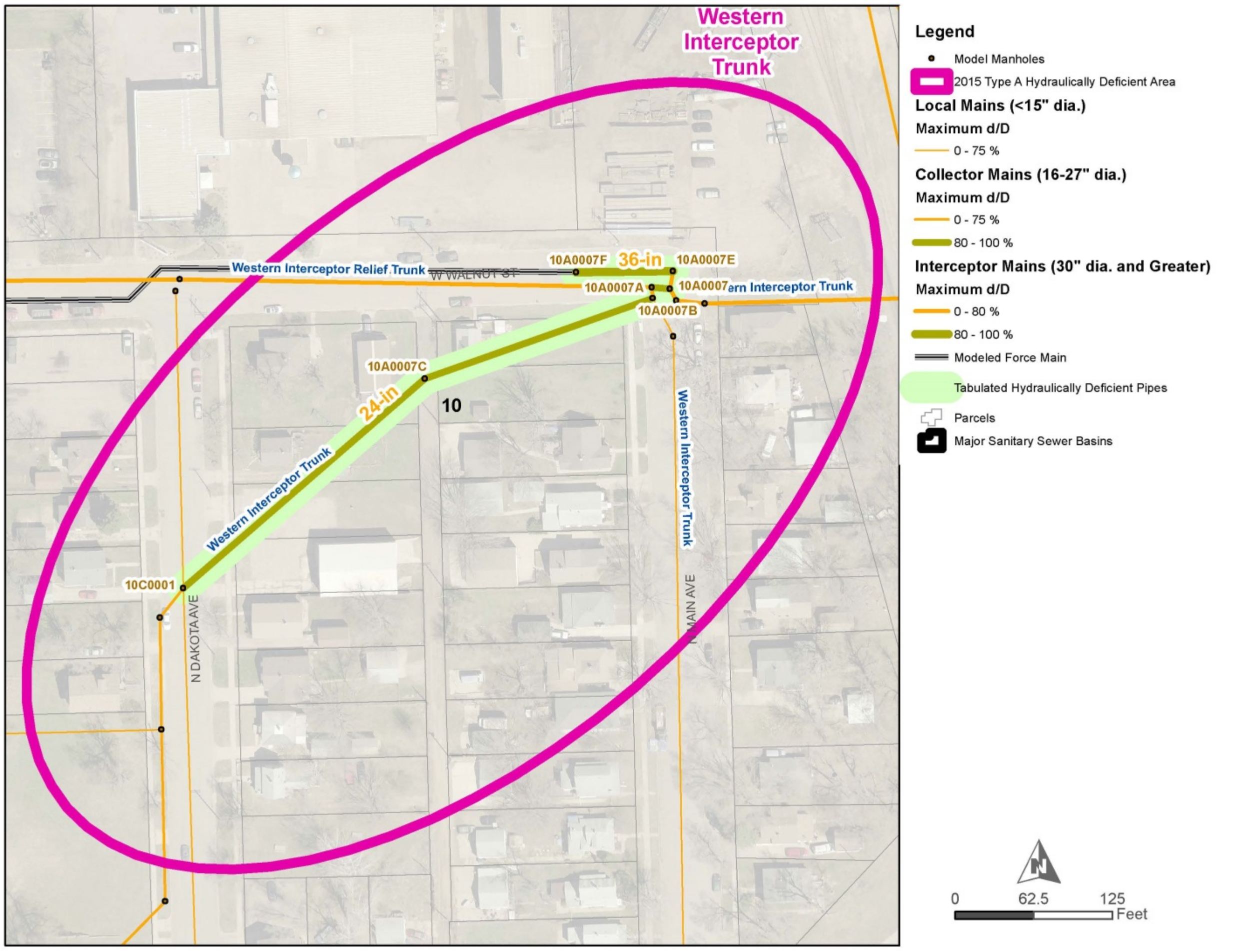
- This area is not served by a flow monitor for ADWF and therefore DWI characteristics are assumed similar to Basin 4.
- This area is not served by a flow monitor for wet weather calibration and therefore RDII characteristics are assumed similar to Basin 4 and adjusted based on estimated flows through the Outfall Trunk Sewer.
- There is a low degree of confidence associated with modeling results due to the lack of wet weather calibration data.
- This area receives flow both from PS 215 and PS 203.
- The Western Interceptor Trunk and the Western Interceptor Relief Trunk converge at this location.
- Survey data was collected in 2016 for the pipes in this area.

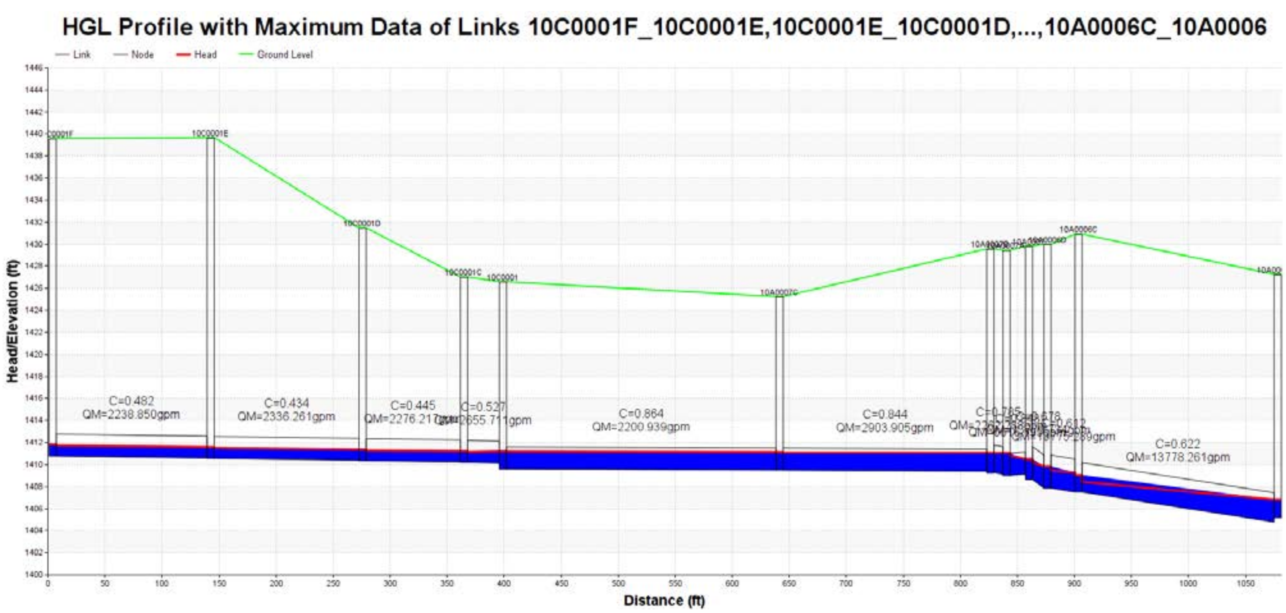
Table 9.18 summarizes the capacity restricted pipes in this problem area. Figure 9.24 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.18 Existing Conditions Under Capacity Pipes for the Western Interceptor Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	24	460	VCP
	30	10	PVC
	36	90	PVC, RCP

Figure 9.24 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Western Interceptor Trunk Sewer Type A Problem Area





9.5.3.17.1 Recommendations

The model confidence for this area is low which means the basin data is not available. No CIP projects are identified. Flow monitoring including the capture of a significant wet weather event is recommended."

9.5.3.18 Western Interceptor Trunk 2066 Conditions

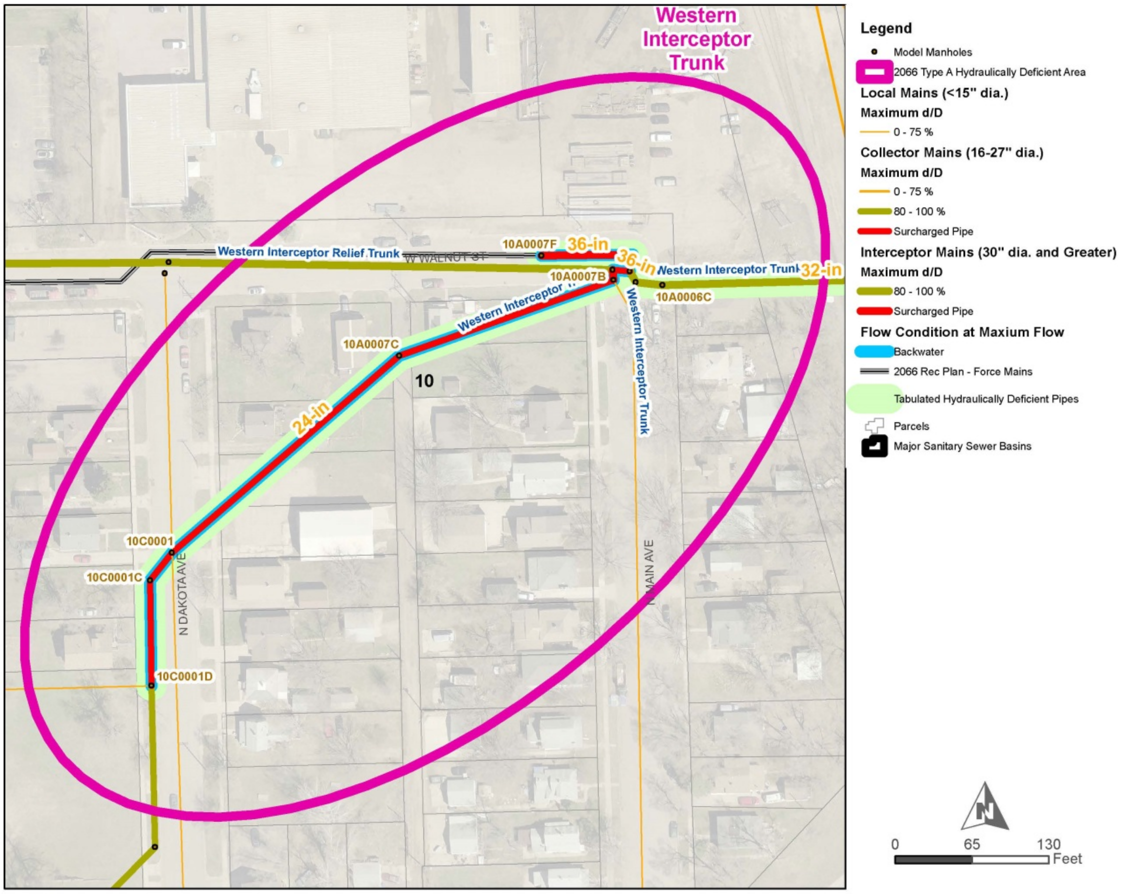
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand under 2066 projected conditions. The same general notes for this problem area are the same as the existing system description. The range in pipe diameters is from 24- to 36-inch for approximately 910 feet.

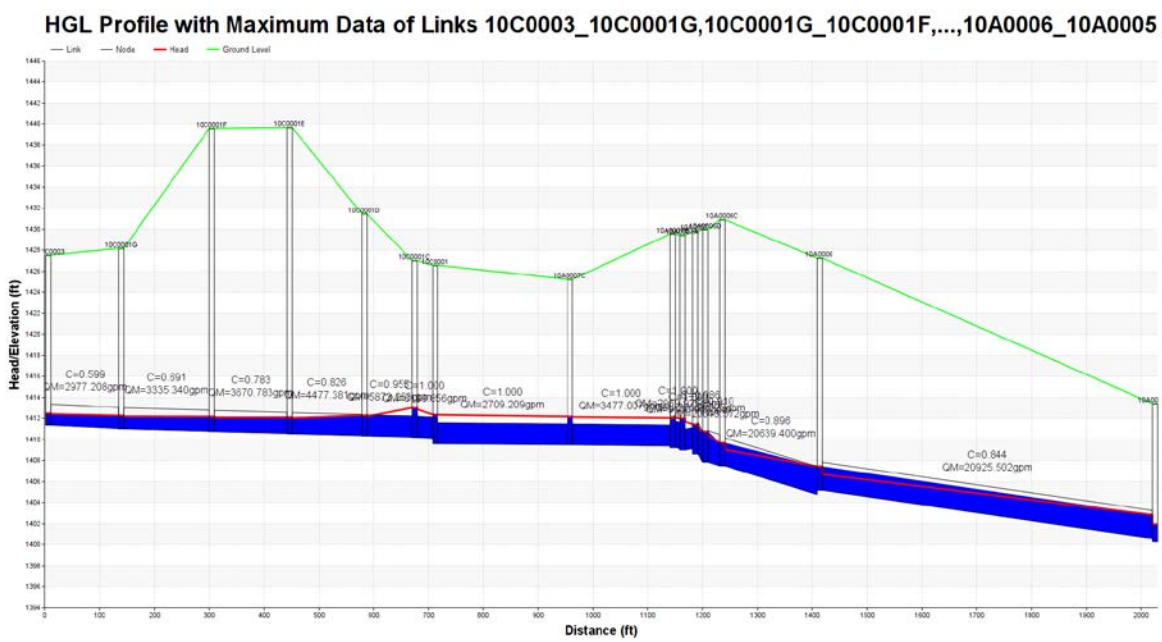
Table 9.19 summarizes the capacity restricted pipes in this problem area. One of the problem pipes listed in Table 9.19, the GIS indicates that 30 feet of VCP pipe was lined with HDPE in 1983. Figure 9.25 provides a map for this Type A area and a representative modeled 2066 profile along this line.

Table 9.19 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Western Interceptor Trunk Sewer Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	24	450	VCP	
	32	180	HOBAS	2010
	36	50	PVC, RCP	
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	24	140	PVC, VCP	1912, 2014
	30	10	PVC	
	36	80	RCP	

Figure 9.25 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Western Interceptor Trunk Sewer Type A Problem Area





9.5.3.19 Airport Subdivision

The airport addition subdivision is an industrial area just south of the airport that has several pipes that do not have capacity to carry existing conditions wet weather flow and result in numerous pipe surcharging and SSOs. The range in pipe diameters is from 8- to 21-inch and total approximately 5,510 feet in Basin 12 with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risks. Key points about this line are the following:

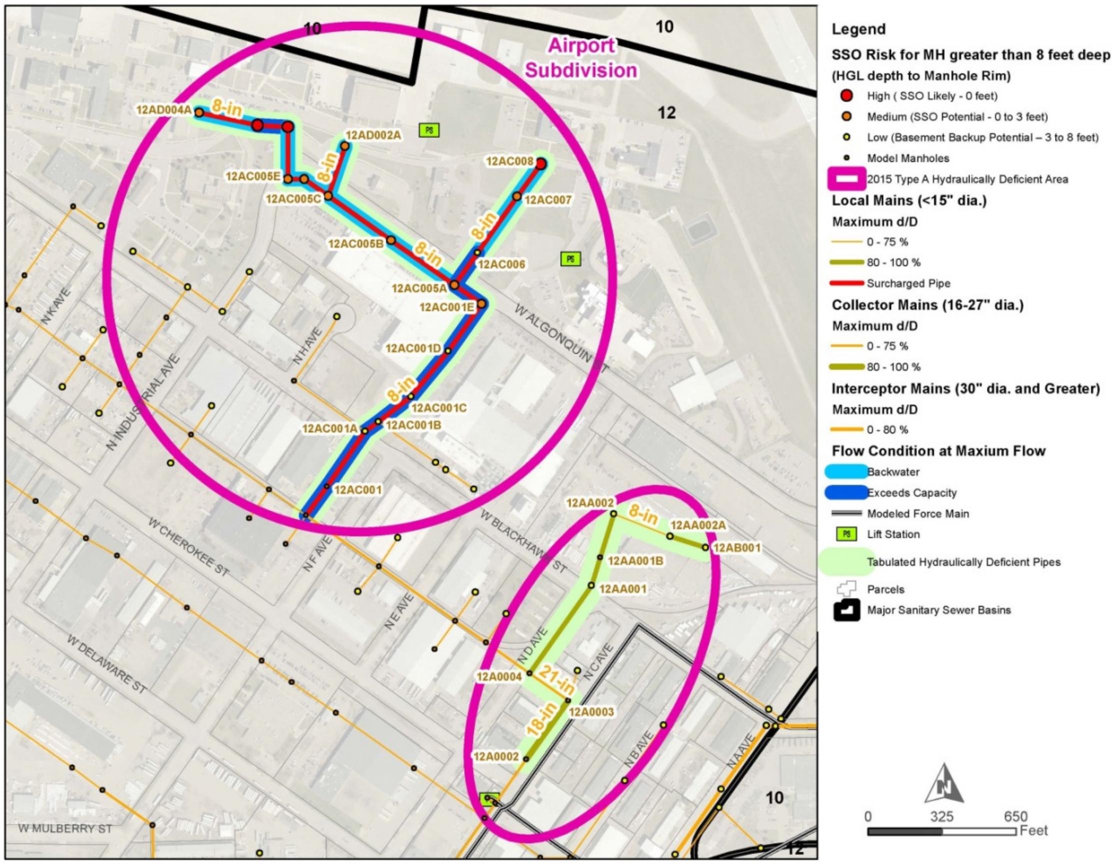
- This area is not served by a flow monitor for ADWF and therefore DWI characteristics are assumed similar to Basin 4.
- This area is not served by a flow monitor for wet weather calibration and therefore RDII characteristics are assumed similar to Basin 4 and adjusted based on estimated flows through the Outfall Trunk Sewer.
- There is a low degree of confidence associated with modeling results due to the lack of wet weather calibration data.
- The surcharging pipes are a headwater area in the system, meaning that there are no other areas or sewers contributing flow to this location.

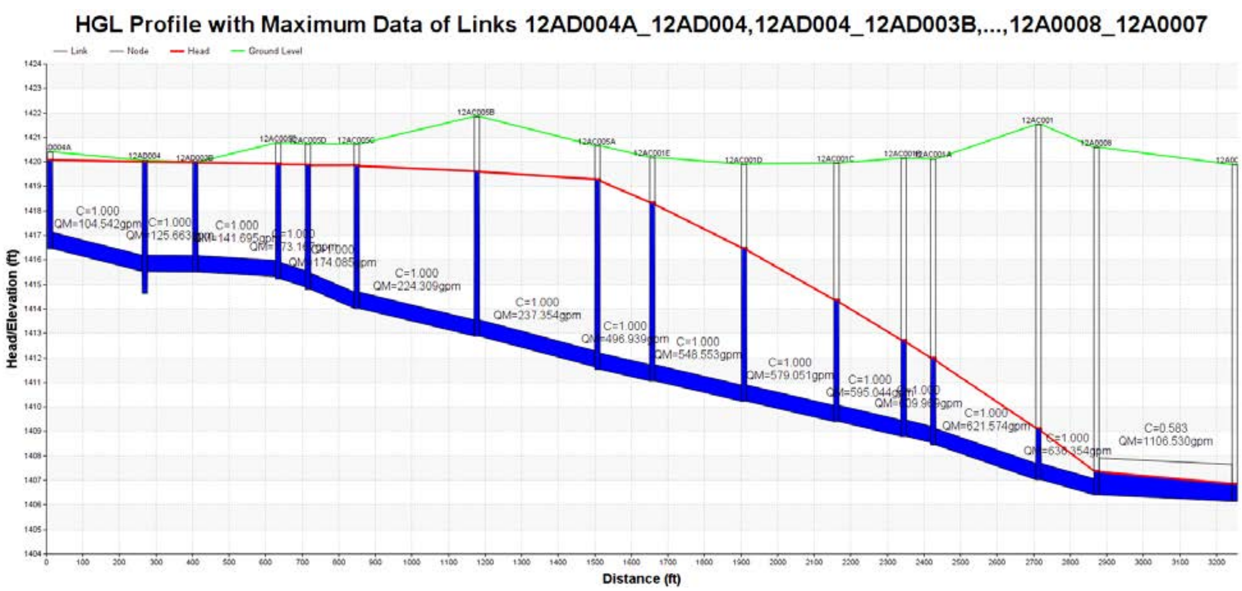
Table 9.20 summarizes the potential capacity limited pipes in this problem area. Figure 9.26 provides a map for this Type A area and a representative modeled profile in this area.

Table 9.20 Existing Conditions Under Capacity Pipes for the Airport Addition Subdivision Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	2,900	CIP, PVC, VCP	1942, 2013
	18	320	VCP	
	21	210	VCP	
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	2,080	CIP, PVC	1942, 2011

Figure 9.26 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Airport Addition Subdivision Type A Problem Area





9.5.3.20 Airport Subdivision 2066 Conditions

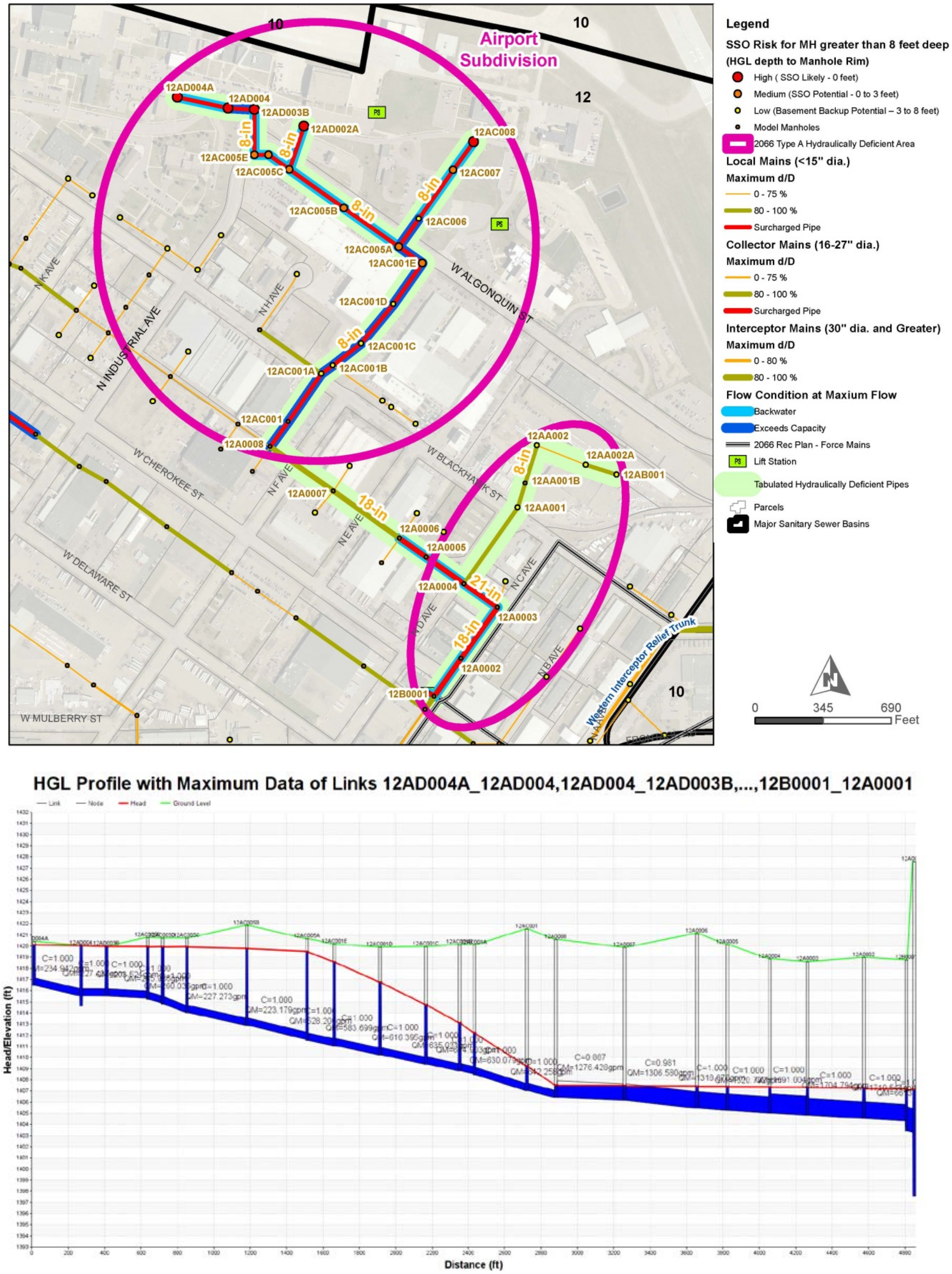
This hydraulically limited area was identified as an existing Type A problem area that is projected to expand under 2066 projected conditions. The same general notes for this problem area are the same as the existing system description. The range in pipe diameters is from 8- to 21-inch for approximately 6,950 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risk.

Table 9.21 summarizes the capacity restricted pipes in this problem area. Figure 9.27 provides a map for this Type A area and a representative modeled 2066 profile in this area.

Table 9.21 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Airport Addition Subdivision Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	2,900	CIP, PVC, VCP	1942. 2013
	18	800	VCP	
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	2,080	CIP, PVC	1942. 2011
	18	960	VCP	
	21	210	VCP	

Figure 9.27 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Airport Addition Subdivision Type A Problem Area



9.5.3.20.1 Recommendations

The model confidence for this area is low which means the basin data is not available. No CIP projects are identified. Flow monitoring including the capture of a significant wet weather event is recommended.

9.5.3.21 12th St and Marion Rd

The 12th St and Marion Ave area is a mixed use residential, commercial, and industrial area south of the West 12th Street and South Marion Road intersection and served by the Hayward Sewer District Trunk. There are numerous local system pipes along West 14th Street, West 15th Street, West 16th Street, South Marion Road, South Ebenezer Avenue, and South Watson Avenue that are in a surcharged condition. The range in pipe diameters is from 8- to 12-inch for approximately 13,660 feet in Basin 11 with the GIS not indicating that pipe lining has taken place. Key points about this line are the following:

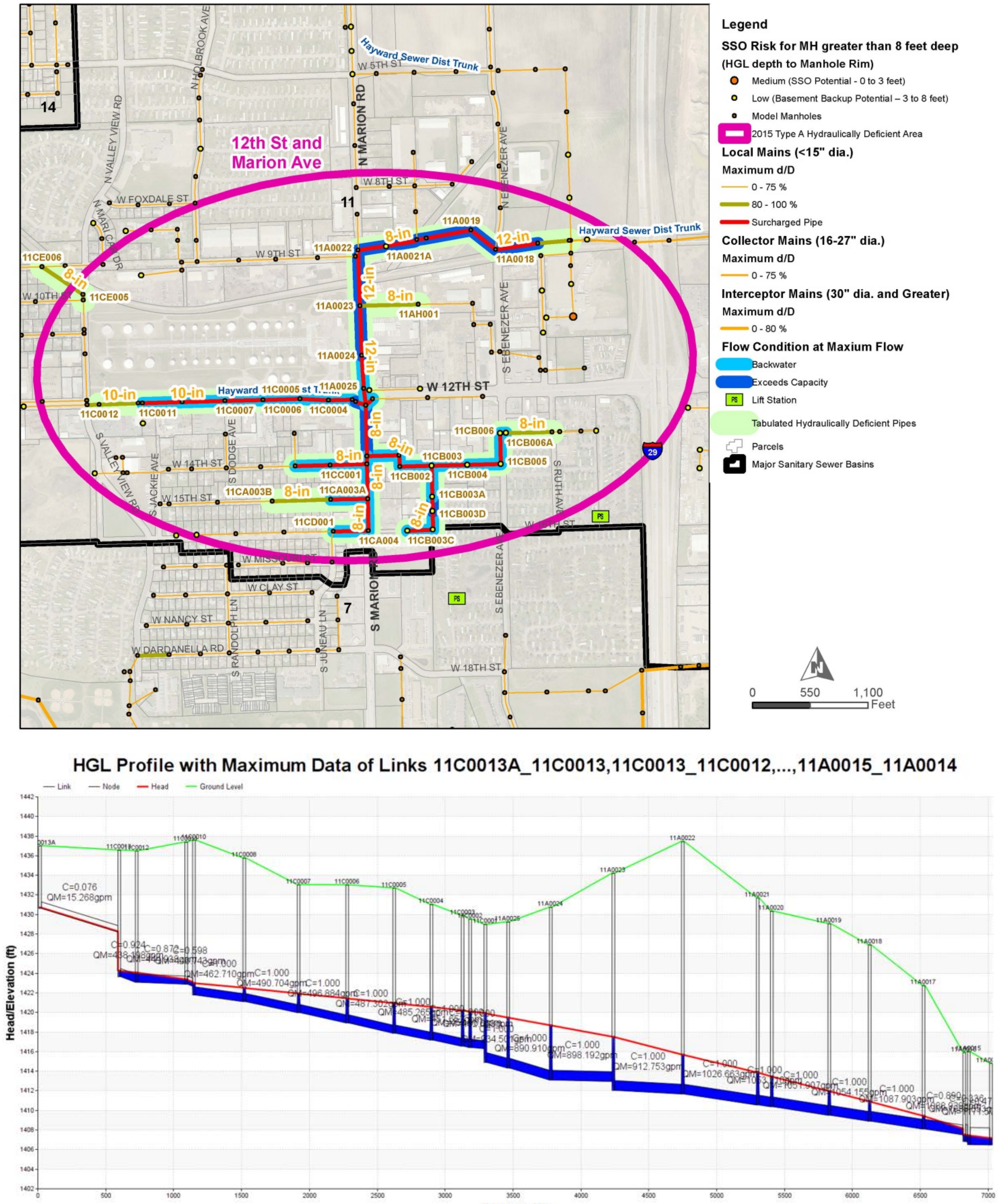
- There are segments in this line that are greater than 15 feet deep.
- This Type A Problem Area is part of the calibration for flow monitor 13F0001A on the Basin 13 Trunk.
- There are surcharging pipes in this area that in a headwater position in the system, meaning that there are no other areas or sewers contributing flow to some of these pipes.

Table 9.22 summarizes the capacity restricted pipes in this problem area. Figure 9.28 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.22 Existing Conditions Under Capacity Pipes for the 12th St and Marion Rd Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	3,010	RCP, VCP
	10	470	VCP
	12	3,020	RCP, VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	4,630	PVC, VCP
	10	2,050	VCP
	12	480	VCP

Figure 9.28 Existing Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the 12th St and Marion Rd Type A Problem Area



9.5.3.22 12th St and Marion Rd 2066 Conditions

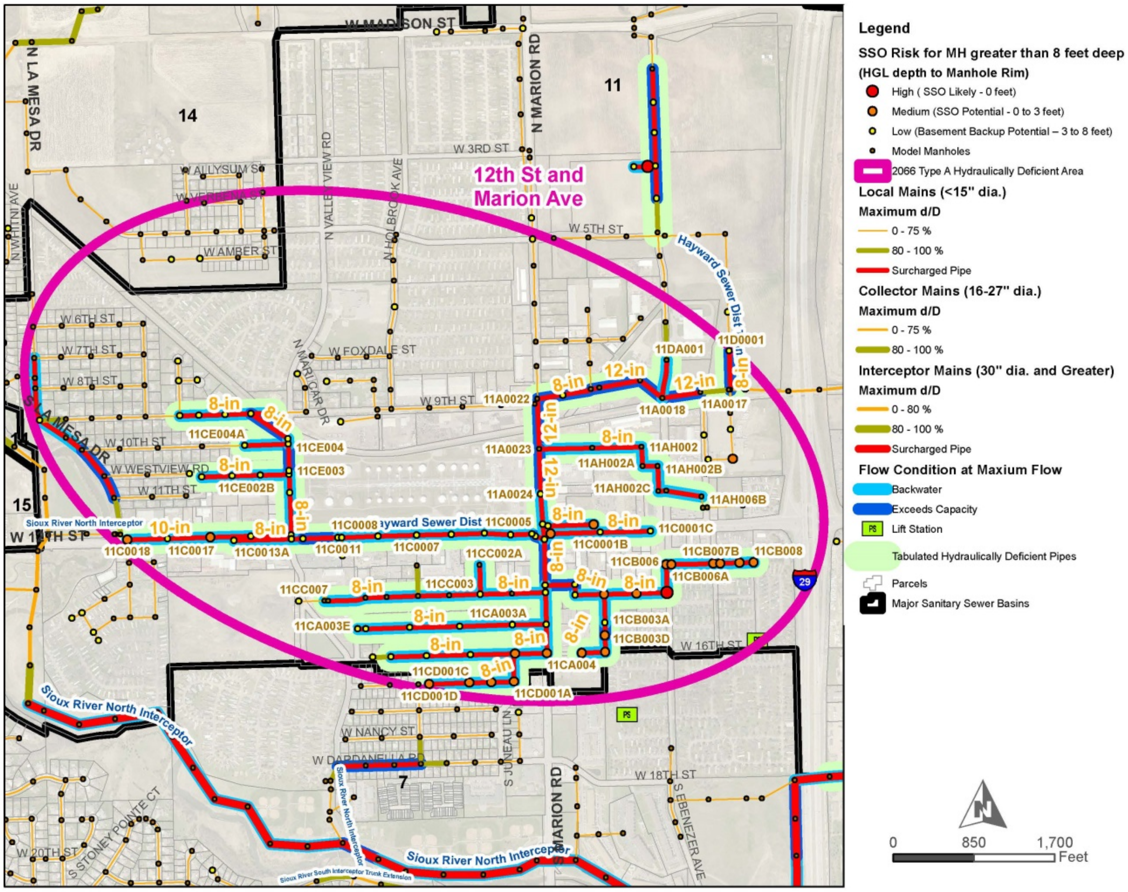
This problem location was identified as an existing system Type A problem area that is projected to expand under 2066 projected conditions. The same general notes for this problem area are the same as the existing system description. The range in pipe diameters is from 8- to 12-inch for approximately 29,440 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risk in a couple of locations.

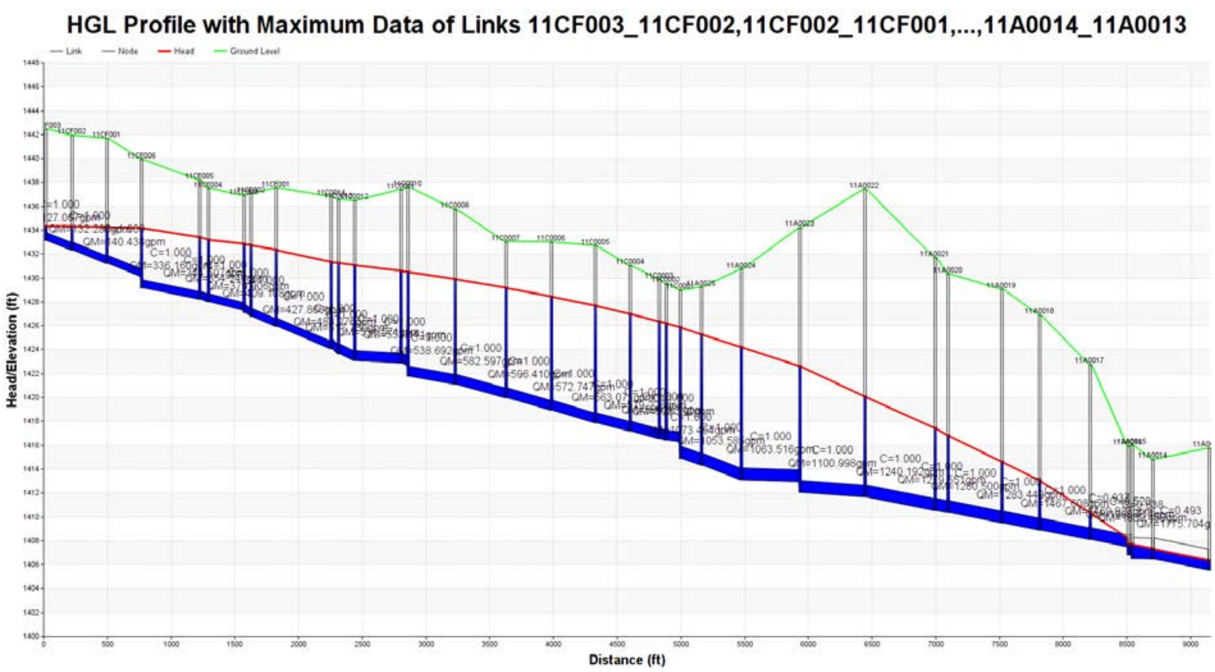
Table 9.23 summarizes the capacity restricted pipes in this problem area. Figure 9.29 provides a map for this Type A area and a representative modeled 2066 profile along this line.

Table 9.23 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the 12th St and Marion Rd Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	2,510	PVC, RCP, VCP
	10	470	VCP
	12	3,110	RCP, VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	18,900	PVC, Truss White (PVC), VCP
	10	3,970	VCP
	12	480	VCP

Figure 9.29 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the 12th St and Marion Rd Type A Problem Area





9.5.3.22.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.5.4 Summary of Existing Collection System Type A Problem Areas

Table 9.24 summarizes the existing collection system Type A areas discussed in this section. Not all of the problem areas will require CIP mitigation alternatives depending upon the quality and availability of monitoring data impacting the confidence in the model results as well as the size of pipes impacted.

Table 9.24 Summary of Existing Collection System Type A Problem Areas

Problem Area	Basin	Length of Deficiency (Capacity)	Length of Deficiency (Backwater)	Flow Monitoring Data Available*
Basin 17A Trunk (Lewis Road)	Basin 17	8-in / 4,660 ft 10-in / 4,800 ft 12-in / 1,120 ft 15-in / 470 ft 18-in / 390 ft	8-in / 8,800 ft 10-in / 660 ft 12-in / 810 ft 18-in / 1,880 ft	Low
Lower Riverside Trunk Sewer	Basin 3	10-in / 320ft 12-in / 930 ft 15-in / 50 ft	10-in / 330 ft 12-in / 830 ft	High
Hilltop Trunk	Basin 4	12-in / 960 ft 15-in / 110 ft		Medium
Richmond Estates Trunk	Basin 1	8-in / 2,030 ft	8-in / 1,740 ft	Medium
Southeastern Drive	Basin 5	24-in / 1,130 ft		High
Pam road (Southside Interceptor)	Basin 8	16-in / 250 ft 18-in / 460 ft	18-in / 355 ft	High
Western Interceptor Trunk	Basin 10	24-in / 450 ft 30-in / 10 ft 36-in / 90 ft		Low
Airport Subdivision	Basin 12	8-in / 2,900 ft 18-in / 320 ft 21-in / 210 ft	8-in / 2,080 ft	Low
12th St and Marion Rd	Basin 11	8-in / 3,010 ft 10-in / 470 ft 12-in / 3,020 ft	8-in / 4,630 ft 10-in / 2,050 ft 12-in / 480 ft	Medium

*High – Data sufficient to make CIP recommendations
Medium – Basin data available but localized monitoring data needed
Low – Data not available and insufficient to make CIP recommendations

9.5.5 Existing Collection System Type B Problem Areas

All capacity limited pipes in Table 9.24 that are not contained in a Type A area represent a Type B problem area. Type B areas are isolated potential capacity limited pipes that are not hydraulically connected to other problem locations. Type B problems often result from isolated flat pipe slopes limiting the capacity of single pipe segments. Type B areas are locations where CCTV, localized flow monitoring, and invert survey are recommended to validate the problem extent before any design is begun. Based on the results from the capacity validation activities and actual upstream growth, they could be considered for capacity increases if necessary. In areas of the system with little upstream growth and future additional flow, some of the Type B problems may be addressed through decreased RDII contribution as the local and local collector systems are rehabilitated. Neither pipe improvement alternatives nor costs were developed for Type B conditions.

9.6 Alternatives for Future Trunk Sewer Extensions to Serve Development Expansion

Development of future collection system trunk sewer extensions was discussed in Chapter 5. These extensions were developed based on ultimate Tier 5 build-out for the 2116 planning year using topography, growth tier areas, and discussions with the City. Sizing of future trunk sewer extensions are based on 2116 projected flow rates based on the 25-year level of service (Design Storm) and project criteria. These trunk sewers are conceptualized to be fully independent of the existing system in the 2066 planning year given the high peak flow rates and volumes generated by the expansion of the City's service area. Either lift stations or satellite WRFs are conceptualized to serve these 2116 trunk sewers.

There are a number of interim solutions, however, that are evaluated so that future trunk sewer extensions can be directed into the existing collection system as many of the downstream locations of trunk sewers are not planned until the later planning years. This section first describes improvement methods, the interim solutions that were examined for this WTCSMP using these improvement methods, and improvement sizing.

9.6.1 Improvement Methods

Improvement methods used to develop interim flow solutions through the 2066 planning year include the following:

- *Equalization*: Equalization basins control and reduce flow in a wastewater collection system. They also have the added benefit of enhancing the gravity separation of solids. The general approach to equalizing future flows is to equalize flow to just above maximum day ADWF and temporarily store RDII flows. However, consideration is given to a reasonable drain time of the equalization facility.
- *Force mains to the existing collection system*: It is desired to use the existing collection system to the maximum extent practical as interim solutions to future flows. In most instances, this requires construction of long force mains to transfer the flows to the existing collection system. Future force main alignments are conceptualized based on topography and to follow existing roadway alignments.

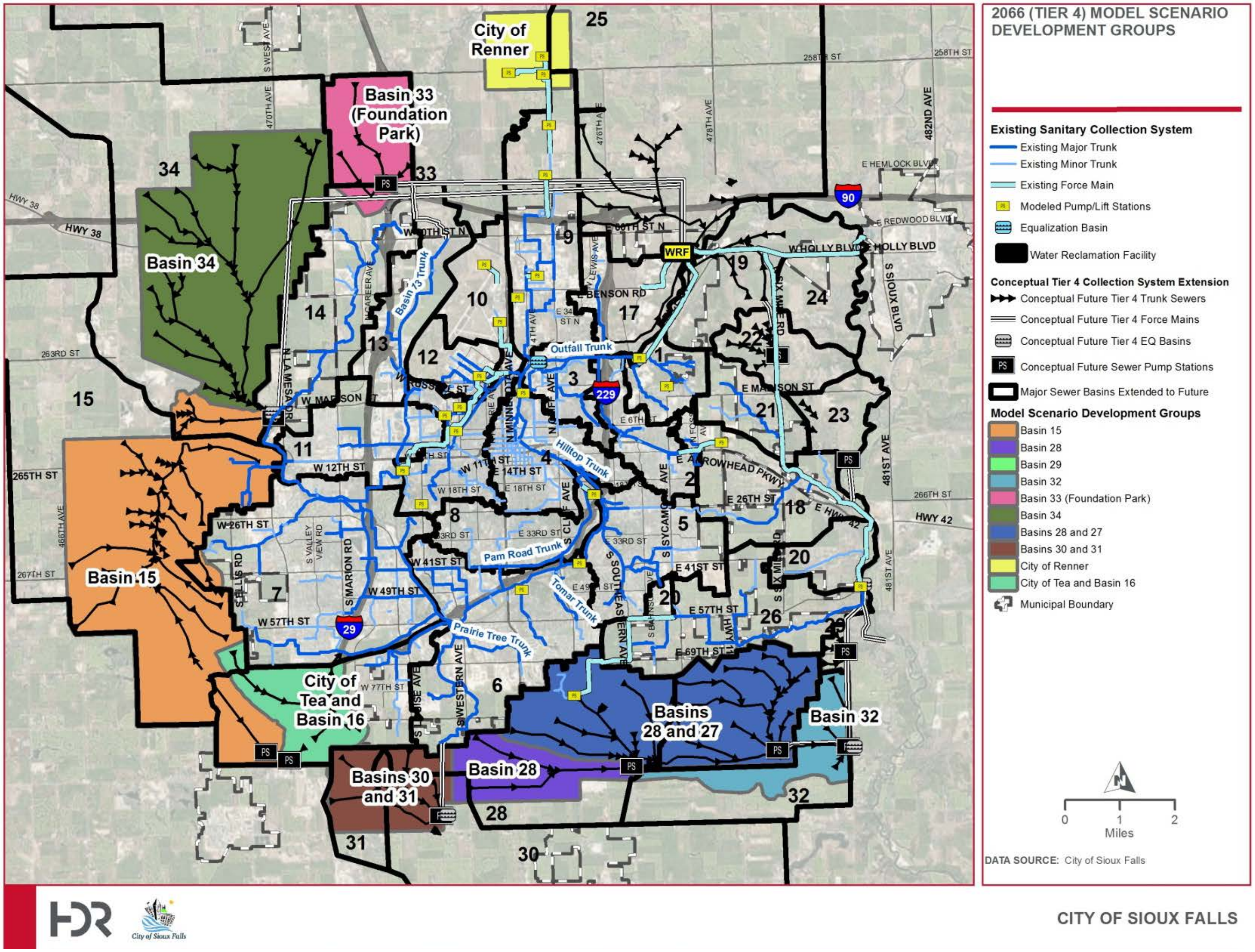
- *Upsizing the existing collection system*: In many instances the existing collection system cannot handle future flows from development expansion and will require increase conveyance capacity. When most (greater than 60 percent) of a trunk line requires conveyance capacity increases, increasing the size of the entire under capacity trunk sewer is considered.
- *Parallel sewers for the existing collection system*: When future flows from development expansion results in less than 60 percent of a trunk sewer not having the required conveyance capacity, parallel relief sewers to the existing trunk sewers are considered.

9.6.2 Interim Flow Solutions for Future Trunk Sewer Extensions

A WTCSMP objective for the handling of future flows and future trunk sewer extensions is to use the existing system to the extent practical for each planning year. One challenge to handling future flow extensions is that some areas have upstream development anticipated to occur before downstream areas and associated collection system infrastructure are built. The results are interim flow solutions that use the remaining hydraulic capacity of existing infrastructure. Base solutions are what are anticipated to occur in 2066.

Future flow extensions are divided into distinct development groups reflective of development expansion basins. These development groups are mapped in Figure 9.30 and are described, along with their examined solutions, in this section.

Figure 9.30 Model Scenario Development Groups Based on the 2066 Planning Year (Tier 4)



9.6.2.1 City of Tea and Basin 16

Basin 16 is located just north of the City of Tea on the southwest side of the City. Flows directly into the Basin 16 trunk extension are added with diurnal patterns based on anticipated growth within that basin. The City of Tea flows are added a constant, equalized, max day point inflow to Basin 7R. Given the location of the trunk extensions and based on the remaining capacity of the existing system, the location to add the Tea flows and the Basin 16 development extensions to Basin 7R, which will discharge into the I-229/Louise Trunk. Therefore, adding the basin 16 extension and the Tea flows into the I-229/Louise Trunk is considered the base scenario. Other options considered include either diverting the Tea flows into the Sioux River South Trunk south of I-229 or into the Basin 6 trunk. To summarize, the following solutions were considered for this WTCSMP:

Option 1: Adding Basin 16 trunk extension and Tea flows into the Basin 7R I-229/Louise Trunk, mitigating the existing system as necessary.

Option 2: Adding Basin 16 trunk extension flows into the I-229/Louise Trunk and adding the Tea flows into the Sioux River South Trunk south of I-229. Mitigating the existing system was not examined as it is not a preferred option over Option 1.

Option 3: Adding Basin 16 trunk extension flows into the I-229/Louise Trunk and adding the Tea flows into the Basin 6 Trunk. Mitigating the existing system was not examined as it is not a preferred option over Option 1.

9.6.2.2 Basin 15 and Basin 34

Basins 15 and 34 are on the west side of the City and cover large future development areas and represent large sources of future flows. Their general proximity to one another, their large flow contributions, and the large scope required to handle their developments result in Basins 15 and 34 being considered to have connected future flow solutions. Given the large volumes of future flow anticipated from these areas, all future solutions are costly either in the form of required large equalization volumes, large increases in existing pipe sizes, or long distances in future force mains. The following solutions were considered for this WTCSMP:

Option 1: Future flows are carried directly to the existing WRF using a force main that goes around the north side of the City. The pump station flows would be equalized to reduce sizing of this force main.

Option 2: Future flows are carried through the existing collection system via the Sioux River North Trunk. There is limited excess capacity in the existing trunk sewer and upsizing would be required along its entire line. Equalization at PS 215 could also be required depending upon the planning year.

Option 3: Future flows are carried to the south to the future Basin 27/28 trunk sewer. The pump station flows would be equalized to reduce sizing of this force main. Sizing the Basin 27/28 trunk and pump stations would need to account for these future flows.

Option 4: Future flows are carried through the existing collection system via the Sioux River North Trunk. There is limited excess capacity in the existing trunk sewer and upsizing would be required along its entire line depending upon the planning year. Equalization would be implemented to reduce the required Sioux River North upsizing.

Option 5: Future flows are treated with a future WRF located on the west side of the City.

9.6.2.3 Basin 33 (Foundation Park)

Basin 33, otherwise known as Foundation Park, is on the north side of the City just north of Basin 13. Development is anticipated to start occurring throughout the basin in the short term, with anticipated population increases for each planning year. The following solutions were considered for this WTCSMP:

Option 1: Future flows are carried directly to the existing WRF using a force main. This would either be a direct force main connection to the WRF or potentially tied into a Basin 15/34 force main solution, depending upon timing of development both within Basin 33 and Basins 15 and 34. The pump station flows would be equalized to reduce sizing of this force main.

Option 2: Future flows are carried to Basin 13 using a force main. The pump station flows would be equalized to reduce sizing of this force main and potential upsizing of the Basin 13 Trunk. Upsizing of the Basin 13 trunk and increases in the pump station 215 wet well to equalize the flow increases may be required.

9.6.2.4 City of Renner

The City of Renner is a current regional customer for the City and current flows are directed through Basin 9 via a series of lift stations. These flows include future flows from the City of Baltic. Future growth both in Basin 9 and for the City of Renner could cause surcharges in the current flow patterns, therefore an option of diverting flow to the future Basin 25 infrastructure is examined. To summarize, the following solutions were considered for this WTCSMP:

Option 1: Future flows are carried as they are now under current conditions through Basin 9 via a force main. It is not desired to extensively upsize existing Basin 9 infrastructure.

Option 2: Future flows are carried through the future trunk sewer anticipated for Basin 25 via a force main.

9.6.2.5 Basins 30 and 31

Basin 30 and 31 are on the south side of the City, just south of Basin 6. The proximately, anticipated timing of future development, and connected anticipated future trunk sewers result in Basins 30 and 31 having connected future flow solutions. These basins are anticipated to have rapid short term development that will require both short term and long term solutions. The anticipated future trunk sewer to serve this area would be to the south of Harrisburg and would not be constructed until after the 2066 planning year, meaning that interim flow solutions are necessary. The following solutions were considered for this WTCSMP:

Option 1: Future flows are carried to the upstream location of the 15-inch Basin 6 Trunk via a force main. Flows would be equalized to reduce sizing of this force main and potential upsizing of the Basin 6 Trunk.

Option 2: Future flows are carried directly to the Sioux River South via a force main. Flows would be equalized to reduce sizing of this force main and decrease potential impacts to the

Sioux River South. This option is only examined if the existing Basin 6 Trunk sewer does not have the capacity to handle the additional equalized flows from Basins 30 and 31.

Option 3: Future flows are carried directly to the future Basin 28 Trunk. Flows would be equalized to reduce sizing of this force main and minimize sizing of the future Basin 28 Trunk. This solution makes sense given that the planning year timing indicates that growth of Basins 30 and 31 may be concurrent with construction of the Basin 28 trunk. However, there is a high likelihood that the Basins 30 and 31 will precede development in Basins 28 and 27 and the cost of constructing the Basin 28 trunk is high and will require a force main to PS 240.

9.6.2.6 Basin 28

Basin 28 is located on the south side of the City, just south of Basins 6 and 26. Basin 28 is anticipated to have rapid short term development that will require both short term and long term solutions. The anticipated future trunk sewer would be through Basin 27 that would in turn be served by a force main that direct flows to existing PS 240. The following solutions were considered for this WTCSMP:

Option 1: Future flows are carried to the 15-inch Southeastern Trunk Sewer via a force main in anticipation of upstream developments occurring before construction of the Basin 27/28 future trunk sewer. Flows would be equalized to reduce sizing of this force main and decrease potential impacts to the limited capacity Southeastern Trunk. Gravity sewer upgrades from the upstream point of 15-inch Southeastern Trunk Sewer to Central Main Interceptor would be part of this solution.

Option 2: Future flows are carried to the existing 24-inch Basin 26 Trunk Sewer via a force main in anticipation of upstream developments occurring before construction of the Basin 27/28 future trunk sewer. Flows would be equalized to reduce sizing of this force main and decrease potential impacts to the limited capacity Basin 26 Trunk. Gravity sewer upgrades from the upstream point of 24-inch Basin 26 Trunk Sewer to PS240 would be part of this solution.

Option 3: Future flows are carried directly to the Basin 27/28 future trunk sewer and require a pump station in Basin 27 to carry flows to PS 240. This solution would require the complete build of the Basin 27/28 future trunk sewer prior to local development to that trunk.

9.6.2.7 Basins 28 and 27

Basins 28 and 27 are located on the south side of the City, just south of Basins 6 and 26. Basins 28 and 27 are anticipated to have rapid short term development on the upstream/upslope portions that will require both short term and long term solutions. The conceptualized future Basin 28/27 trunk is anticipated to not be able to pass through Basin 32 until after the 2066 planning year and thereby require a pump station to serve this area to bring flows to the ESSS/PS 240. The following solutions were considered for this WTCSMP:

Option 1: Future flows in the Basin 28/27 trunk are carried to the existing 24-inch Basin 26 Trunk Sewer via a force main. Flows would be equalized to reduce sizing of this force main and potential upsizing of the Basin 26 Trunk. Gravity sewer upgrades along the Basin 26

Trunk Sewer to PS 240 would be part of this solution. As this Basin 26 Trunk Sewer is only 10 years old, replacement is not recommended with favor towards either a parallel gravity main to the Basin 26 Trunk Sewer or extension of the force main to PS 240, effectively making this option the same as Option 2.

Option 2: Future flows in the Basin 28/27 trunk are directly to the ESSS/PS 240 via a force main. Flows would be equalized to reduce sizing of this force main and peak 25-year Design Storm level of service flows to PS 240.

Option 3: Future flows in the Basin 28/27 trunk are carried via gravity main to Basin 32 and the Basin 32 lift station to the ESSS/PS 240. Although this is the optimum solution given that Basin 32 will already require a force main, this solution is anticipated to not be constructible until after the 2036 planning year and therefore is not considered in more depth for this study.

9.6.2.8 Basins 29 and 32

Basins 29 and 32 are located to the southeast of the city, south of Basin 26 and east of future basins 27 and 28. These basins only have the option of directly pumping flow to the ESSS/PS 240 or to a future WRF whose location would be optimized to treat most of the future flow generated by anticipated development on the west side and south side future growth areas. The only solutions examined for these basins are non-equalized flow to PS 240 as well as an examination of flow rates for the solution of a future eastside WRF.

9.6.2.9 East Side Sanitary Sewer (ESSS) Pump Station 240

The ESSS is served by PS 240, which pumps all flow 9 miles north to the existing WRF. The city needs to start the process of developing plans for equalization and another force main that would serve PS 240 on a 9.1 mile alignment that is independent of the current force main. The future duel force main is considered a fixed solution whose only alternative is a future WRF that would be located on the southeast side of the City. The complete evaluation for the selected force main alternative is contained in the Appendix 7.B -E*astside Sanitary Sewer System Treatment, Pump Station and Force Main Evaluation* report. Solutions that were considered result from combinations of solutions evaluated for other development areas. Focuses for these solutions were placed on equalization and pump capacity at PS 240 as well as an examination of flow rates for the solution of a future eastside WRF. The following summarizes the flow scenarios that were considered for this WTCSMP:

Option 1: PS 240 equalization and pump station/force main capacity are based on future flows from the ESSS, Basin 29, Basin 32, Basin 27, and Basin 28: These flows were also evaluated for the solution of a future eastside WRF.

Option 2: PS 240 equalization and pump station/force main capacity are based on future flows from the ESSS, Basin 29, Basin 32, Basin 27, Basin 28, Basin 30, and Basin 31. These flows were also evaluated for the solution of a future eastside WRF.

Option 3: PS 240 equalization and pump station/force main capacity are based on future flows from the ESSS, Basin 29, Basin 32, Basin 27, Basin 28, Basin 30, Basin 31, Basin 15, and Basin 34. These flows were also evaluated for the solution of a future eastside WRF.

9.6.2.10 Improvement Sizing

Improvement sizing to the existing collection system to handle 25-year Design Storm level of service future development expansion flows are based on the full flow capacity as opposed to the 80 percent d/D hydraulic criteria. The general approach to improvement sizing for development expansion flows was to maximize EQ to reduce required lift station capacities and required capacities in the existing system.

9.6.3 Alternative Summary

Interim solutions for development expansion as described above can have an impact on other interim solutions when one is upstream from the other. For instance, the solution of taking flows from Basins 15 and 34 to the Basin 27/28 trunk can impact both the size of the Basin 27/28 trunk and the required pump station capacity and force main size to carry the flows to PS 240. In addition, several of the options listed above were removed from consideration given the remaining modeled capacity of the existing collection system being less than the equalized flow rates that are generated from development expansions.

Options that were removed from consideration include the following:

- Basin 28, Option 1 (Basin 28 to Southeastern Trunk): The Southeastern Trunk is almost at capacity under existing conditions with existing flows. Adding development expansion flows would overwhelm the Southern Trunk and add additional flow to the Central Main Trunk.
- Basins 28 and 27, Option 1 (Basins 27 and 28 outlet through the Basin 26): The Basin 26 trunk is under capacity for local development flows and would require upsizing for flows resulting from development expansion.

The numerous scenarios reviewed were refined to eight scenarios and named A thru H, representing the basis of analysis for this WTCSMP. These scenarios are listed in Table 9.25.

Table 9.25 Model Scenarios Developed for the City of Sioux Falls WTC SMP

Model Scenario[1]	Costing ID	City of Tea and Basin 16	Basin 15 and Basin 34	Basin 33 (Foundation Park)	City of Renner	Basins 30 and 31	Basin 28	Basins 27 and 28	ESSS and PS 240
Scenario 1: Base	A	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 2 (Flow through the City)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Assumes Option 3 through 2066 and then Gravity through Basin 30 in 2116	Assumes Option 3 (Gravity to Basin 27)	Assumes Option 2 (FM directly to PS240 through 2066)	Assumes Option 2 (PS240 sized for ESSS and Basins 27, 28, 30, and 31 flows) for both 2066 and 2116
Scenario 4	B	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 2 (Flow through the City)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 2 (Basin 30 and 31 direct connection to SRS)	Option 2 (Basin 28 to Basin 26 Trunk)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)
Scenario 6	C	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 1 (FM to the north)	Option 1 (Direct Flow to WRF)	Option 1 (Flow to Basin 9)	Option 3 (Basin 30 and 31 to future Basin 28 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 2 (PS240 sized for ESSS and Basins 27, 28, 30, and 31 flows)
Scenario 9	D	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 3 (FM to the south)	Option 1 (Direct Flow to WRF)	Option 2 (Flow to Basin 25)	Option 3 (Basin 30 and 31 to future Basin 28 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 3 (PS240 sized for ESSS and Basins 15, 27, 28, 30, 31, and 34 flows for 2026, 2036, and 2066)
Scenario 10	E	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 3 (FM to the south)	Option 1 (Direct Flow to WRF)	Option 2 (Flow to Basin 25)	Option 2 (Basin 30 and 31 direct connection to SRS)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 3 (PS240 sized for ESSS and Basins 15, 27, 28, 30, 31, and 34 flows for 2026, 2036, and 2066)

Table 9.25 Model Scenarios Developed for the City of Sioux Falls WTC SMP

Model Scenario[1]	Costing ID	City of Tea and Basin 16	Basin 15 and Basin 34	Basin 33 (Foundation Park)	City of Renner	Basins 30 and 31	Basin 28	Basins 27 and 28	ESSS and PS 240
Scenario 11	F	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 4 (Flow through the City with EQ prior to entering)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 2 (Basin 30 and 31 direct connection to SRS)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)
Scenario 12	G	Option 2 (Tie into and parallel I-229 Trunk – Tea to Basin 7R)	Option 4 (Flow through the City with EQ prior to entering)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 1 (Basin 30 and 31 to Basin 6 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)
Scenario 13	H	Option 1 (Tie into and upsize I-229 Trunk – Tea to Basin 7R)	Option 4 (Flow through the City with EQ prior to entering)	Option 2 (Transfer Flow through Basin 13)	Option 2 (Flow to Basin 25)	Option 1 (Basin 30 and 31 to Basin 6 Trunk)	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	Option 2 (Basin 27 and 28 directly to PS240)	Option 1 (PS240 sized only for ESSS and Basins 27 and 28 flows)

1. Scenarios 2, 3, 5, 7, and 8 were eliminated as extensive and unrealistic infrastructure improvements were evidenced after the initial model runs.

9.6.4 Satellite WRF versus Regional Lift Station Comparison

Flows projected to conceptualized satellite WRFs were considered equal to the flows conceptualized to regional lift stations.

9.6.5 Improvement Optimization

One of the objectives of the above scenarios, including their development and subsequent analysis, is to provide operational optimization for the collection system to handle the 25-year Design Storm level of service. Numerous trunk sewers within the City's collection system have excess capacity under existing conditions. While a lot of this excess capacity will be used for flow increases from local infill development within existing basins, the remaining capacity is examined to use the existing trunks for development expansion. Trunk sewer extensions are sized to suit long term (2116) needs with existing trunk sewers examined for 2066 needs. Equalization is used whenever possible to reduce impacts to the existing collection system.

9.7 Preferred Alternative Selection for Future Trunk Sewer Extensions to Serve Development Expansion

The scenarios described in Table 9.25 were executed within the model with the existing system sized, as necessary, to accommodate flows from development expansion. This section describes the selection of the preferred alternative based on these model results.

9.7.1 Approach

Using model results from the scenarios described in Table 9.25, the following information was extracted where applicable for each of the development expansion options:

- Size and length of force mains
- Required pumping capacity
- Size (Volume) of required equalization
- Size and length of required existing condition collection system modification

Capital cost estimates, as described in the following section, were then developed for each scenario. These costs, along with anticipated timing of development and reasonableness of constructability, were used to formulate the preferred alternative.

9.7.2 Capital Cost Estimates

Table 9.26 summarizes the capital costs for both construction and project costs (30 percent of the construction costs) for each Scenario. Table 9.27 summarizes these costs in terms of future equalization. Costs were developed from local contractor bids for recent City projects as well a database provided by the City. Cost estimates are in 2016 dollars.

Table 9.26 Total Capital Costs Associated with the Model Scenarios

Description	Scenario A (Model Base/ Scenario 1)	Scenario B (Model Scenario 4)	Scenario C (Model Scenario 6)	Scenario D (Model Scenario 9)	Scenario E (Model Scenario 10)	Scenario F (Model Scenario 11)	Scenario G (Model Scenario 12)
Construction Cost	$145,890,000	$167,290,000	$130,180,000	$147,500,000	$148,800,000	$166,550,000	$164,550,000
Project Cost	$184,168,000	$211,020,000	$164,826,000	$183,210,000	$184,810,000	$212,128,000	$205,388,000

Table 9.27 Estimate of Total Capital Costs Per Million Gallons in Equalization

EQ Costs per MG	
< 1 MG	$2,500,000
1-5 MG	$2,000,000
5-10 MG	$1,750,000
< 10 MG	$1,250,000

9.7.3 Alternative Comparison

Table 9.28 provides a comparative cost breakdown for the future extension alternatives, with these comparisons graphed in Figure 9.31. Costs, however, are not the only consideration when choosing a preferred alternative and recommended plan. There are other considerations such as development timing, constructability and maintenance, impact to existing infrastructure, and longevity. Equalization of wet weather peak flow rates, for instance, while generally requiring large upfront costs, can ease burdens on sizing of other infrastructure components as well as mitigating impacts to existing infrastructure. Table 9.29 summarizes the EQ requirements for each planning scenario for each development Tier.

Table 9.28 Tabular Summary of Capital Costs (In Millions of Dollars) for Each Model Scenario Broken Down by Infrastructure Type

Model Scenario	A	B	C	D	E	F	G
Gravity Mains	$46.50	$55.80	$27.70	$31.30	$31.30	$44.20	$44.20
Pump Stations/Force Mains (PS / FM)	$58.10	$67.40	$101.80	$116.20	$118.80	$79.20	$74
Equalization (EQ)	$79.60	$87.80	$35.30	$35.70	$34.70	$88.70	$86.20
Total Project Specific Costs (Not Including Common Elements)	**$184.20**	**$211.00**	**$164.80**	**$183.20**	**$184.80**	**$212.10**	**$203.90**
Common Elements (Sewer Mains, Common EQ, Common FMs, etc.)	$153.60	$153.60	$153.60	$153.60	$153.60	$153.60	$153.60
Total Project Costs (Including Common Elements)	**$337.80**	**$364.60**	**$318.40**	**$336.80**	**$338.40**	**$365.70**	**$357.50**

Figure 9.31 Graphical Summary of Capital Costs (In Millions of Dollars) for Each Model Alternative Broken Down by Infrastructure Type

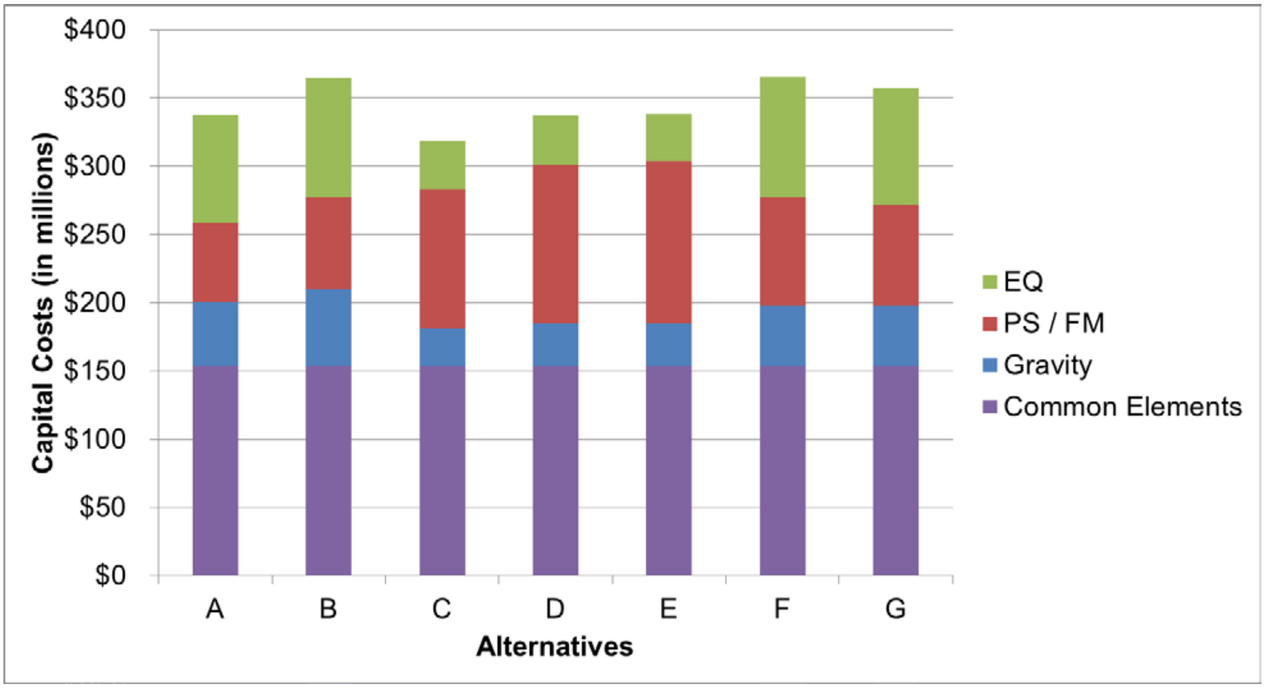


Table 9.30 summarizes advantages and disadvantages associated with analyzed future development expansion model scenarios for each development group to handle interim sanitary flows. The following section further discusses these advantages and disadvantages based on each development group.

Table 9.29 Equalization Summaries (in Million Gallons) for the Analyzed Model Scenarios for Future Development Expansions

Description	Scenario A (Model Base/Scenario 1)			Scenario B (Model Scenario 4)			Scenario C (Model Scenario 6)			Scenario D (Model Scenario 9)			Scenario E (Model Scenario 10)			Scenario F (Model Scenario 11)			Scenario G (Model Scenario 12)		
Facilities / Interceptors	2026	2036	2066	2026	2036	2066	2026	2036	2066	2026	2036	2066	2026	2036	2066	2026	2036	2066	2026	2036	2066
Central Equalization Expansion In addition to Existing 32 MGD	0	Total Needed 14.3 MG (no additional)	2.6	-	-	8.6	-	-	-8.6	-	-	-9.6	-	-	-7.8	-	-	3		Total Needed 14.3 MG (no additional)	-0.2
LS 215 (Sioux River North) Equalization	0	0	38.7	-	-	38.1	-	-		-	-	-	-	-	-	-	-	29	Not modeled	3.31	34
LS 218 (Tuthill) Equalization	0	0	2.1	Not modeled	Not modeled	2.3	-	-	2.1	-	-	2.1	-	-	2.3	-	-	2.3	Not modeled	Not modeled	2.3
LS 240 Equalization	-	-	2.1	0.26	0.76	1.6	-	-	2.1	-	-	2.5	-	-	2.5	-	-	2.1	0.26	0.73	2.1
Foundation Park Equalization	-	-	0.7	0.61	0.61	0.7	-	-	0.69	-	-	0.69	-	-	0.69	-	-	0.7	0.6	0.6	0.7
Basins 30/31 LS Equalization	-	-	0.88	0.75	0.84	0.88	-	-	0.88	-	-	0.88	-	-	0.88	-	-	0.88	0.75	0.84	0.91
Basin 28 LS - Interim Equalization	-	-	-	N/A	N/A	0.7	-	-	-	-	-	-	-	-	-	-	-	-	N/A	N/A	-
Basins 27/28 LS Equalization	-	-	2.6	1.5	1.95	2.1	-	-	2.6	-	-	2.2	-	-	1.6	-	-	2.1	1.1	1.6	2.1
Basins 34 LS Equalization	-	-	No LS; Gravity through system	No EQ; Gravity through system	No EQ; Gravity through system	No EQ; Gravity through system	-	-	8.5	-	-	8.5	-	-	8.6	-	-	3.7	0.1	3.3	3.7
Basins 15 LS Equalization	-	-	No EQ; Gravity through system	No EQ; Gravity through system	No EQ; Gravity through system	No EQ; Gravity through system	-	-	EQ tied to Basin 34	-	-	EQ tied to Basin 34	-	-	EQ tied to Basin 34	-	-	4.4	0.7	1.6	4.4
Total			49.68	3.12	4.16	54.98			16.87			16.87			16.57			48.18	3.51	11.98	50.21

Table 9.30 Advantages and Disadvantages of the Analyzed Model Scenarios for Future Development Expansions

Major Development Group	Options	Solution Components	Advantages	Disadvantages
City of Tea and Basin 16	**Option 1** (Tie into and upsize I-229 Trunk)	• Basin 16 and Cities of Tea and Lennox to I-229 trunk (Basin 7R)	• One tie-in point for both Basin 16 and Tea, making future development expansion and regional customer flows easier to manage • Only one existing trunk sewer that requires improvement	• Upsizing the I-229 Trunk is required (2 miles)
	Option 2 (Tie into and parallel I-229 Trunk)	• Basin 16 and Cities of Tea and Lennox to I-229 trunk (Basin 7R)	• One tie-in point for both Basin 16 and Tea, making future development expansion and regional customer flows easier to manage • Parallel sewer could make it easier to manage flow s and be easier to construct	• A long parallel main is required (2 miles)
	Option 3 (Basin 16 to I-229/Louise Trunk; Tea flows to Basin 6 Trunk)	• Basin 16 to I-229 trunk • Cities of Tea and Lennox to Basin 6 trunk	• Fewer portions of the Basin 6 trunk would require upsizing	• Another force main is required to direct Tea flows • Would not allow the Basin 30/31 to Basin 6 solution
Basin 15 and Basin 34	**Option 1** (FM to the north to WRF)	• Basin 15/34 EQ • FM to the north	• Upsizing long segments of the Sioux River North Interceptor is not required • EQ (8.5 MG) requirement is less overall then the through town options • EQ is not required at PS 215 • Force main could be tied into the solution for Basin 33	• A high capacity, long force main (13.3 miles) is required
	Option 2 (Flow through the City)	• Basin 15/34 EQ at PS 215 • Max Flow through City	• A long force main is not required • EQ requirement is in one location (at PS 240) and it is recommended to build the entire volume but could be built in phases	• Upsizing is required for the entire Sioux River North Trunk from the Basin 34 connection (4.5 miles) • High Volume of EQ (40 MG) at one location with a long drain time
	Option 3 (FM to the south to Basin 27/28)	• Basin 15/34 PS and EQ • Force main from PS and EQ to upstream point Basin 27/28 Trunk Sewer • Basin 27 FM	• Upsizing long segments of the Sioux River North Interceptor is not required • EQ (8.5 MG) requirement is less overall then the through town options • EQ is not required at PS 215 • The Basin 27/28 trunk is not yet constructed and could be built to handle these flows.	• A high capacity, long force main (16.7 miles) is required • The pump station or WRF requirements at PS 240 would increase substantially
	Option 4 (Flow through the City with EQ prior to entering)	• Basin 15/34 EQ at connection	• A long force main is not required • Size required for Sioux River North upsize isn't as great compared to the non-prior Basin 15/34 EQ option • EQ volume requirement is spread out to three locations and can allow for greater operational flexibility	• Upsizing is required for the entire Sioux River North Trunk from Basin 34 connection (4.5 miles) • High Volumes of EQ (41.3 MG) between basin 15, basin 34, and PS 215 with long drain times
	Option 5 (Future Westside WRF)	•All Basin 15/34 flows are handled with a new Westside WRF	• A long force main is not required • Upsizing long segments of the Sioux River North Interceptor is not required • Solution offers further growth and regional customer opportunities on the City's west side	• Cost and maintenance • Interim options are still required until the WRF gets built
Basin 33 (Foundation Park)	**Option 1** (FM directly to WRF)	• EQ • Direct Flow to WWTF	• No impacts to existing infrastructure • Depending on timing, force main could be tied into a Basin 15/34 project	• 6.6 mile force main is required
	Option 2 (Flow through the City)	• EQ • Flow through Basin 13	• Upsize of Basin 13 Trunk is not required • Shorter force main than the direct to WRF option	• 2.0 mile force main is required • Limited future growth opportunity • Increased flows to PS 215 with increased EQ requirements
City of Renner	**Option 1** (Flow through Basin 9)	• Flow through Basin 9	• New pipe alignments are not required	•Existing infrastructure many not handle future flow requirements
	Option 2 (Flow through Basin 25)	• Flow through Basin 25	• Future flows are directed to new basin whose trunk lines can be sized accordingly	• Requires construction of a Basin 25 trunk sewer that may precede local development and flow requirements
Basins 30 and 31	**Option 1** (Basin 30 and 31 to Basin 6 Trunk):	• Basin 30/31 PS and EQ • Force main from PS and EQ to upstream point of 15-inch Basin 6 Trunk Sewer • Gravity sewer upgrades from upstream point of 15-inch Basin 6 Trunk Sewer to Sioux River South Interceptor	• Interim force main length is the shortest of all Basins 30/31 options • The existing Basin 6 trunk can handle the additional flows	• 1.6 mile force main is required • More flow to the Sioux River South and Tuthill Lift Station

Table 9.30 Advantages and Disadvantages of the Analyzed Model Scenarios for Future Development Expansions

Basins 30 and 31	**Option 2** (Basin 30 and 31 direct connection to SRS):	• Basin 30/31 PS and EQ • Force main from PS and EQ all the way to Sioux River South Interceptor	• The only impact to existing infrastructure is on the Sioux River South and Tuthill LS	• 4.0 mile force main is required • More flow to the Sioux River South and Tuthill Lift Station
	Option 3 (Basin 30 and 31 to future Basin 28 Trunk)	• Basin 30/31 PS and EQ • Force main from PS and EQ to upstream point of future Basin 28 Trunk Sewer • Gravity sewer upgrades from upstream point of future Basin 28 Trunk Sewer to Future PS 32	• No impacts to existing infrastructure (other than PS 240) • The Basin 27/28 trunk is not yet constructed and could be built to handle these flows. • The Basin 27/28 trunk construction is in the same planning year (2026) as basins 28 and 27	• 2.8 mile force main is required • Earlier construction of the Basin 28 trunk
Basin 28	**Option 1** (Basin 28 to Southeastern Trunk)	• Basin 27/28 PS and EQ • Force main from PS and EQ to upstream point of 15-inch Southeastern Trunk Sewer • Gravity sewer upgrades from upstream point of 15-inch Southeastern Trunk Sewer to Central Main Interceptor	• Construction of future trunk sewers in Basins 28 and 27 is not required	• A long force main (3.5 miles) is required • Upsizing of the entire Southeastern Trunk (1.2 miles) is required. • Flow rates directly impact flows in the Central Main Trunk
	Option 2 (Basin 28 to Basin 26 Trunk)	• Basin 27/28 PS and EQ • Force main from PS and EQ to upstream point of 24-inch Basin 26 Trunk Sewer • Gravity sewer upgrades from upstream point of 24-inch Basin 26 Trunk Sewer to PS240	• Construction of future trunk sewers in Basins 28 and 27 is not required	• A long force main (3.7 miles) is required • Upsizing Basin 26 Trunk (3.5 miles) is required
	Option 3 (Tie to the Basin 27 and 28 PS and EQ)	• Gravity main to Basin 27/28 PS and EQ	• Upsizing of Basin 26 not specifically required for future trunk extensions (may be required for future local development) • No impacts to existing infrastructure (other than PS 240) • The Basin 27/28 trunk is not yet constructed and could be built to handle these flows. • The Basin 27/28 trunk construction is in the same planning year (2026) basin 28 and 27	• Earlier upstream development within Basin 28 will require earlier construction of the downstream portions of the Basin 28/27 trunk
Basins 28 and 27	**Option 1** (Basin 27 and 28 outlet through basin 26)	• Force main from PS and EQ to mid-point of 24-inch Basin 26 Trunk Sewer • Gravity sewer upgrades to midpoint of 24-inch Basin 26 Trunk Sewer to PS240	• Shorter force main (2.4 miles) compared to the direct to PS 240 option	• Upsize of Basin 26 Trunk is required (1.1 miles)
	Option 2 (Basin 27 and 28 directly to PS240)	• Basin 27/28 PS and EQ • Force main from PS and EQ directly to PS240	• Upsizing of Basin 26 not specifically required for future trunk extensions (may be required for future local development)	• A long force main (4.1 miles) is required • Earlier upstream development within Basin 28 will require earlier construction of the downstream portions of the Basin 28/27 trunk
	Option 3 (Gravity connection to Basin 32)		• This option is considered a 2116 condition, however, earlier construction would allow one force main to serve Basins 27, 28, and 32 • Upsizing of Basin 26 not specifically required for future trunk extensions (may be required for future local development)	• Earlier upstream development within Basin 28 will require earlier construction of the downstream portions of the Basin 28/27/32 trunk
East Side Sanitary Sewer (ESSS) Pump Station 240	**Option 1** (PS240 sized only for ESSS and Basins 29, 32, 27 and 28 flows)	• PS240 sized only for ESSS and Basins 29, 32, 27 and 28 flows	• Flows in excess of PS 240 could be mitigated with EQ • Adds flexibility of a future east side WRF	• Large PS 240 pump station and long duel force mains on separate alignments
	Option 2 (PS240 sized for ESSS and Basins 29, 32, 27, 28, 30, and 31 flows)	• PS240 sized for ESSS and Basins 29, 32, 27, 28, 30, and 31 flows	• Flows in excess of PS 240 could be mitigated with EQ • Adds flexibility of a future east side WRF	• Large PS 240 pump station and long duel force mains on separate alignments
	Option 3 (PS240 sized for ESSS and Basins 29, 32, 27, 28, 30, 31, 15 and 34 flows)	• PS240 sized for ESSS and Basins 29, 32, 27, 28, 30, 31, 15, and 34 flows	• Flows in excess of PS 240 could be mitigated with EQ • Adds flexibility of a future east side WRF	• Large PS 240 pump station and long duel force mains on separate alignments
	Option 4 (Eastside WRF)		• Solution offers further growth and regional customer opportunities on the City's east and south sides	• Cost and maintenance • Interim options are still required until the WRF gets built

9.7.3.1 City of Tea and Basin 16

Model results indicate that when flows from the future Basin 16 expansion, the City of Tea, and the City of Lennox are added to the I-229/Louise Trunk, capacity in the I-229/Louise Trunk needs to be increased beginning in the 2026 planning year. If only the Basin 16 expansion flows are added to the I-229/Louise Trunk, then capacity in the I-229/Louise Trunk does not need to be increased until after the 2026 planning year.

While the Sioux River South Trunk south of I-229 and the Basin 6 trunk have the capacity to convey flows from the Cities of Tea and Lennox until 2026 planning year, they do not have capacity to convey these flows for the 2036 planning year without some measure of increasing the existing capacity.

9.7.3.2 Basin 15 and Basin 34

While the Sioux River North Trunk runs at capacity, it can handle additional Basin 15 and Basin 34 flows in 2026 planning year without equalization. However, by the end of the 2036 planning year, the Sioux River North Trunk surcharges substantially without prior equalization. If 4.9 million gallons of equalization is applied to Basin 15 and Basin 34 flows prior to discharge into the Sioux River North Trunk, the Sioux River North Trunk still surcharges but with surcharges that may be acceptable given the depth of sewer. In addition, pump station 215 would not require additional equalization.

For the 2066 planning year, if 8 million gallons of equalization is applied to Basin 15 and Basin 34 flows prior to discharge into the Sioux River North Trunk, 33.3 million gallons of additional equalization would still be required at pump station 215 as well as increasing the capacity of the entire Sioux River North Trunk from the Basin 34 discharge point.

When a lift station is analyzed to carry the Basin 15 and Basin 34 flows directly to the WRF, the equalization requirement reduces to 8.5 million gallons to minimize pump station capacity requirements to 7,600 gpm with a 24 inch force main (or equivalent capacity).

9.7.3.3 Basin 33 (Foundation Park)

Without equalization applied to the Basin 33 flows, the existing Basin 13 trunk has the capacity to convey these flows through the 2036 planning year. In the 2066 planning year, applying 0.61 million gallons of equalization to the Basin 33 flows will allow conveyance through the Basin 13 trunk system.

9.7.3.4 City of Renner

Without flows from the Cities of Renner and Baltic, the Basin 9 trunk does not have capacity to convey 2066 flows and there are a couple of sections of sewer pipe that require capacity increases in 2035. Therefore, either CIP projects performed on the Basin 9 trunk need to account for the low flows generated from the Cities of Renner and Baltic or these flows need to be diverted to a future Basin 25 trunk

9.7.3.5 Basins 30 and 31

Based on the analysis described in Chapter 4, Basin 30 and Basin 31 do not have BSF contributions until the 2066 planning year. However, they are within the City's Tier 2 boundary and the City anticipated this area to receive early growth. Therefore, all of the inflows in the 2026 and 2036 planning years are from projected DWI and RDII only.

Tying Basin 30 and 31 into Basin 6 will allow for short-term growth within these basins without the necessity of upsizing the existing collection system or requiring early construction of the Basin 28 trunk.

Equalization is required for the 2026 and 2036 planning years to keep the Basin 30 and Basin 31 trunk sewers from backing up and surcharging. Equalization volumes could potentially be reduced for these planning years, but upsizing of the force main capacity would also be required and thus require increasing capacity of portions of the Basin 6 trunk sewer. Should the Basin 28 trunk be constructed concurrently with developments within Basin 30 and Basin 31, then increasing the capacity of the Basin 28 trunk can be considered to reduce equalization volumes/increase pump station capacity.

9.7.3.6 Basin 28

Modeling indicates that the Southeastern Trunk Sewer has capacity limitations from future flow increases due to local development within the basin. Adding future west side Basin 28 flows exacerbates these conditions and creates additional flow and volume to the Central Main Trunk that get passed on to the Outfall trunk and equalization basin. In addition, the required force main would be over 3.5 miles long and would only be temporary due to development tier timing requiring construction of the Basin 28/29 trunk sewer. This scenario was therefore not examined in detail.

Modeling also indicates that the Basin 26 Trunk sewer also has capacity limitations from future flow increases due to local development within the basin starting in the 2026 planning year. Adding future west side Basin 28 flows exacerbates these conditions and upsizing significant portions of the Basin 26 trunk. However, given that this line has already been identified with potential future capacity problems, CIP projects could account for these additional Basin 28 flows. However, the required force main would be over 3.7 miles long and would only be temporary due to development tier timing requiring construction of the Basin 28/29 trunk sewer. This option is therefore also considered impractical.

Carrying the west side Basin 28 flows through the rest of Basin 28 and then on to Basin 27 makes the most sense given the development tier timing and that this trunk sewer is already required in the short term. This would also make for only one pump station/force main to convey these flows from Basin 28 and Basin 27 to pump station 240.

9.7.3.7 Basins 28 and 27

Modeling indicates that the Basin 26 Trunk Sewer has capacity limitations from future flow increases due to local development within the basin starting in the 2026 planning year. Adding future west side Basin 28 and Basin 27 flows exacerbates these conditions and requires upsizing significant portions of the Basin 26 trunk. However, given that this line already has future capacity problems, CIP projects could account for these additional flows from Basin 28 and Basin 27.

Carrying future Basin 28 and Basin 27 flows via gravity sewer to Basin 32 provides for the optimum solution given that Basin 32 will already require a force main to pump station 240 and/or be a location for a future remote WRF. However, this solution is not anticipated to be constructible until after the 2036 planning year and therefore is not considered as an interim solution for this WTCSMP.

Carrying the Basin 28 and Basin 27 flows directly to pump station 240 via a Basin 27 lift station and force main provides for the recommended solution given the development tier timing, the no impact to the Basin 26 trunk sewer, and that directing flow through basin 32 is not an option. Flows at the Basin 27 pump station would be equalized to reduce sizing of this pump station/force main and reduce peak flow rates to pump station 240 for 25-year level of service flows.

9.7.3.8 Basins 29 and 32

The only options for Basin 29 and Basin 32 were either direct non-equalized flow to pump station 240 via lift stations/force mains or a remote WRF. Basin 29 is anticipated to have development in the 2026 planning year and Basin 32 is anticipated to have development beginning in the 2066 planning year. Therefore interim solutions only involve direct lift station/force main flows to pumps station 240.

9.7.3.9 East Side Sanitary Sewer (ESSS) Pump Station 240

There are essentially two options for the ESSS/pump station 240 and they are either a second force main to the main WRF or pumping to a remote WRF that would be constructed in the future. Plans need to be underway to construct the second force main from pump station 240 to the main WRF. There are also immediate growth needs in the ESSS, Basin 28, Basin 27, and Basin 29 that would come before a remote east side WRF would be considered. The second force main is therefore considered the base solution.

9.7.4 Preferred Alternatives for Future Collection System Trunk Sewer Extensions

A preferred alternative is developed based on the above discussion of advantages and disadvantages as well and conversations with the City. The preferred alternative is to implement Alternative G (Scenario 12) through 2036 and Alternative C (Scenario 6).

The benefits through 2036 for Alternative G are as follows:

- Does not require long force main for Basin 15 and Basin 34 through 2036.
- Accommodates Basin 33 (Foundation Park) through existing system via a 6.6 mile force main.
- Allows early opening of Basins 30 and 31 to be sent through the existing system via Basin 6 with a 1.4 mile force main (least cost option).
- Upsizing of Basin 26 not specifically required for future trunk extensions (may be required for future local basin development). Diamond Valley Lift Station will be directed to Basin 28 in the Future.
- Minimizes short-term EQ needs (high cost item).

The benefits for beyond 2036 for Alternative C are as follows:

- Basin 33 (Foundation Park) force main could eventually be tied into Basin 15/34 force main.
- Avoids need to upsize Sioux River North.

- Avoids need to construct large EQ at PS 215.
- Minimizes long-term EQ needs (high cost item).
- Leaves flexibility for long-term eastside (2036-2116) and west side (2066-2116) WRFs.

The impact to Pump Station 240 and the East Side WRF are as follows:

- 2020 - Equalization Storage Needed
  - 3-5 MG
- 2026 - Pump Station Upgrade and 2nd 30-inch Force main
  - 2036 – 2116 - Satellite Eastside WRF Alternative (North or South Options)
- 2036 – 2116 - 2nd Pump Station Upgrade and 3rd Force main

This preferred alternative is the basis for the recommended plan associated with each development group for these trunk sewer extensions. Table 9.31 summarizes these preferred alternatives.

Table 9.31 Preferred Alternative For Future Trunk Sewer Extension for the Recommended Plan

Major Development Group	Long-Term Alternative C Preferred (2066) Option	Interim Alternative G (2026,2036) Option
City of Tea and Basin 16	Tie into and upsize or parallel I-229 Trunk (needed by 2036 with Tea) *(Option 1 or 2)*	Same as preferred 2066 option
Westside Basin 15 and Basin 34	Pump station and force main to the north (with EQ) *(Option 1)*	Flow through the City with EQ *(Option 4)*
Basin 33 (Foundation Park)	EQ (by 2066), pump station and force main to transfer flow through Basin 13 *(Option 2)*	Same as preferred 2066 option
City of Renner	Pump station and force main to future Basin 25 Trunk *(Option 2)*	Pump station and force main to future Upgraded Basin 9 Trunk *(Option 1)*
Basins 30 and 31	Pump station and force main to transfer flow through Basin 6 *(Option 1)*	Same as preferred 2066 option
Basin 28	Gravity to future Basin 27 Trunk *(Option 3) including the Diamond Valley service area*	Same as preferred 2066 option
Basins 27 and 28	Direct connection to PS 240 with pump station and force main *(Option 2)*	Same as preferred 2066 option
ESSS and PS 240	Flows from ESSS and Basins 27/28/29/32 with pump station and force main to WRF *(Option 1)*	Flows from ESSS and Basins 27/28/29/30/31/32 with pump station and force main to WRF *(Option 2)*

9.8 Hydraulic Problem Area Identification and Characterization to the Existing Collection System Based on 2066 Future Flows and the Recommended Plan for Future Trunk Sewer Extensions

After formulating the recommended plan for the future trunk sewer extensions to serve development expansion, the 2066 model was executed to determine hydraulic capacity limitations within the existing sanitary collection system. Since downstream impacts specific to each development expansion group was considered in that associated alternative, this section focuses on impacts to the existing collection system due to infill development.

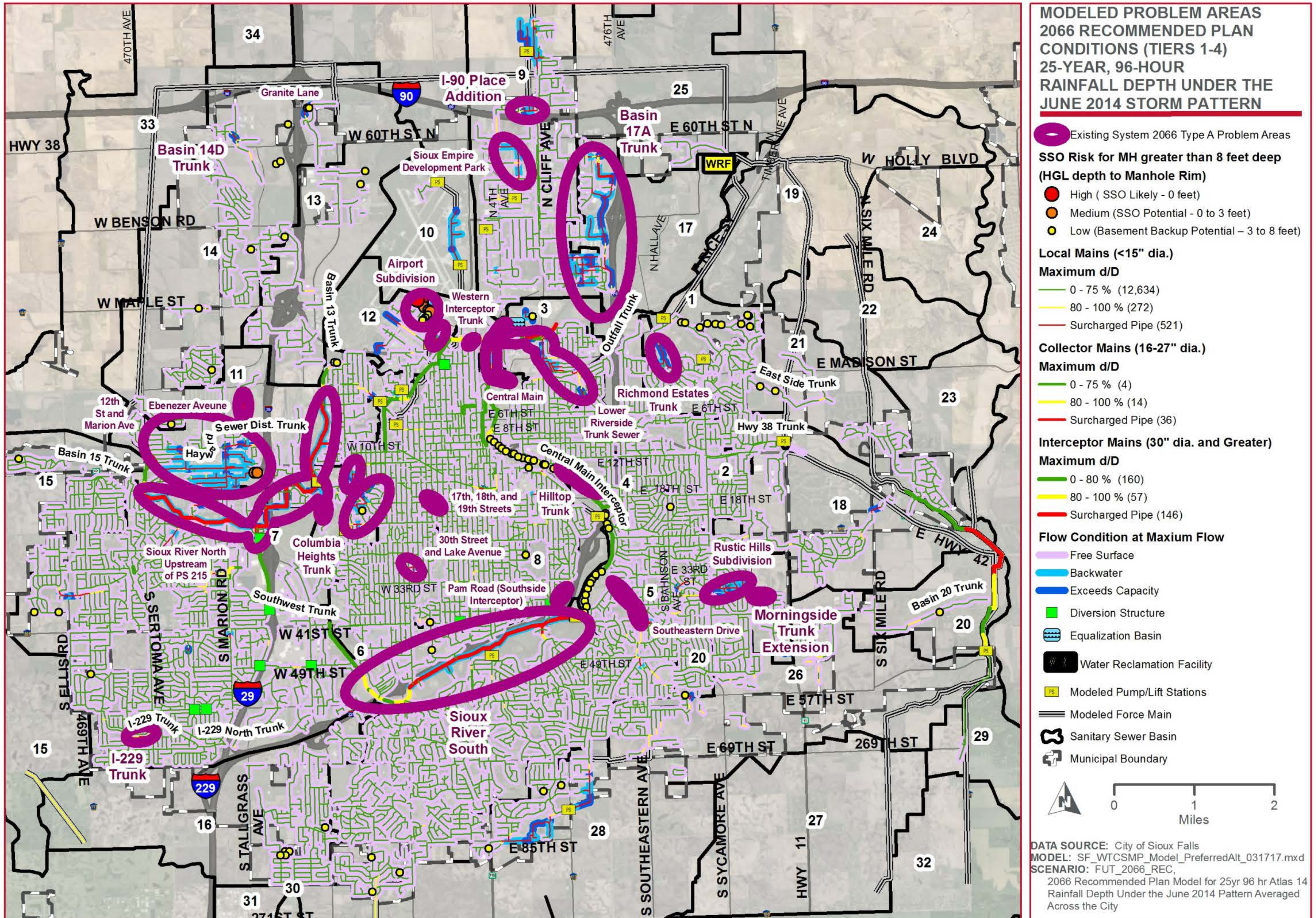
The hydraulic problems for 2066 were separated into two categories for characterization and prioritization: Type A and Type B areas. These two categories are defined below.

- Type A problem areas represent a series of under capacity pipes that are hydraulically connected to one another. For Type A hydraulic problems, the system wide criteria is a modeled peak wet weather flow that surcharges the existing system.
- Type B problem areas represent isolated under capacity pipes that are not hydraulically connected to other problem locations. For Type B hydraulic problems, the system wide criterion is a modeled peak wet weather flow that surcharges the existing system.

9.8.1 2066 Collection System Type A Problem Areas in the Existing Collection System

Model results for the 2066 recommended plan indicate a number of additional areas that may have Type A existing sanitary collection system capacity limitations. These areas are identified and named in Figure 9.32. This section describes each of these problem areas newly identified for the 2066 condition modeling. The areas described previously as existing Type A capacity limited areas included the 2066 model results in their specific subsections in Section 9.5.

Figure 9.32 Tiers 1-4, 50-Year Build-out (2066) Collection System Type A Problem Areas



9.8.1.1 I-90 Place Addition

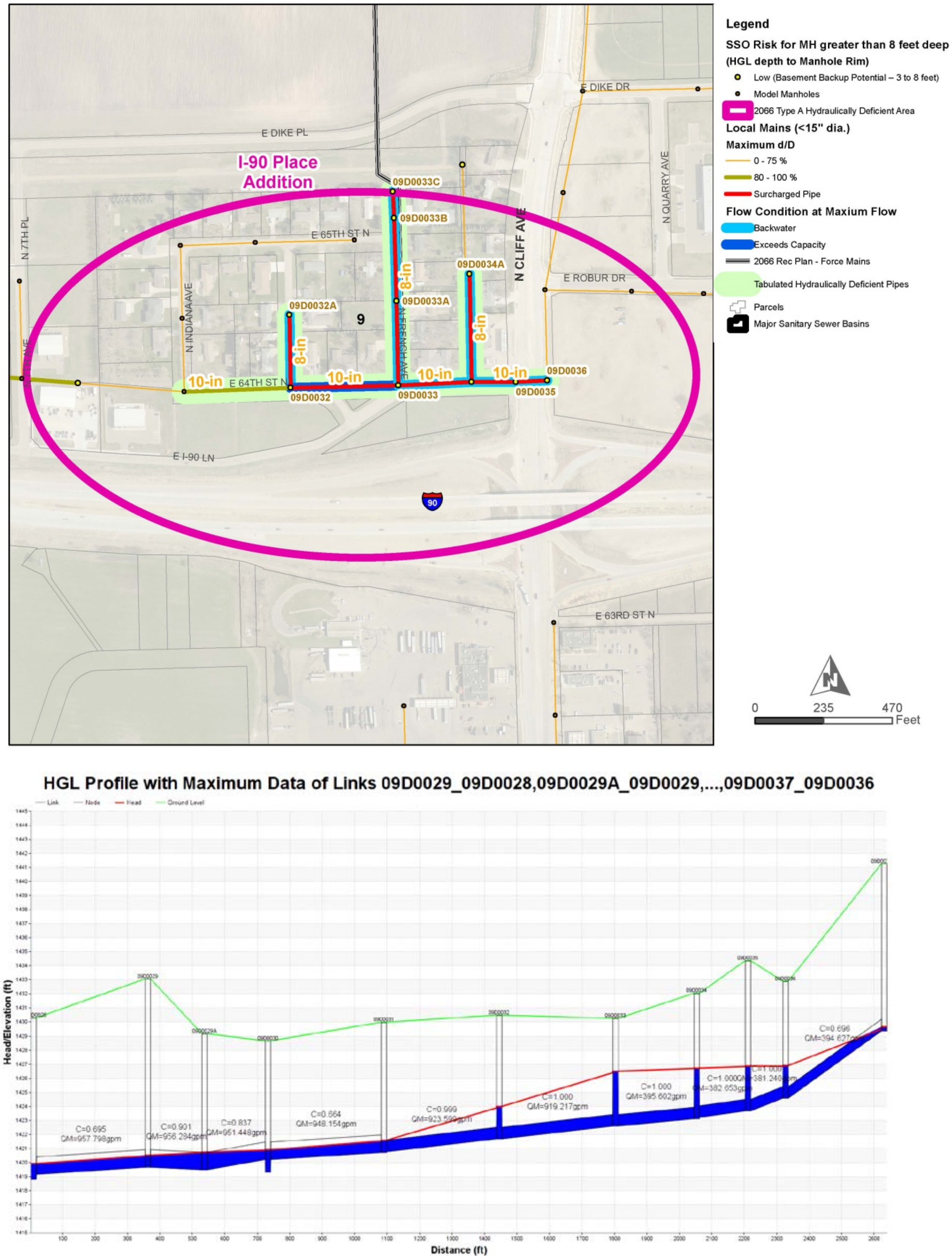
The I-90 Place Addition in Basin 9 is a subdivision just north of I-90 at North Cliff Avenue and is immediately downstream of the PS 233 force main. Modeling indicates that surcharges occur upstream of the 10-inch to 15-inch pipe transition due to projected 2066 flow increases and that several segments of pipe require increased capacity to handle these flows. The range in pipe diameters is from 8- to 10-inch for approximately 2,520 feet with the GIS not indicating that pipe lining has taken place.

Table 9.32 summarizes the capacity restricted pipes in this problem area. Figure 9.33 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.32 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the I-90 Place Addition Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	1,280	VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	10	510	CIP, VCP
	10	730	VCP

Figure 9.33 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the I-90 Place Addition Type A Problem Area



9.8.1.1.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.8.1.2 Sioux Empire Development Park

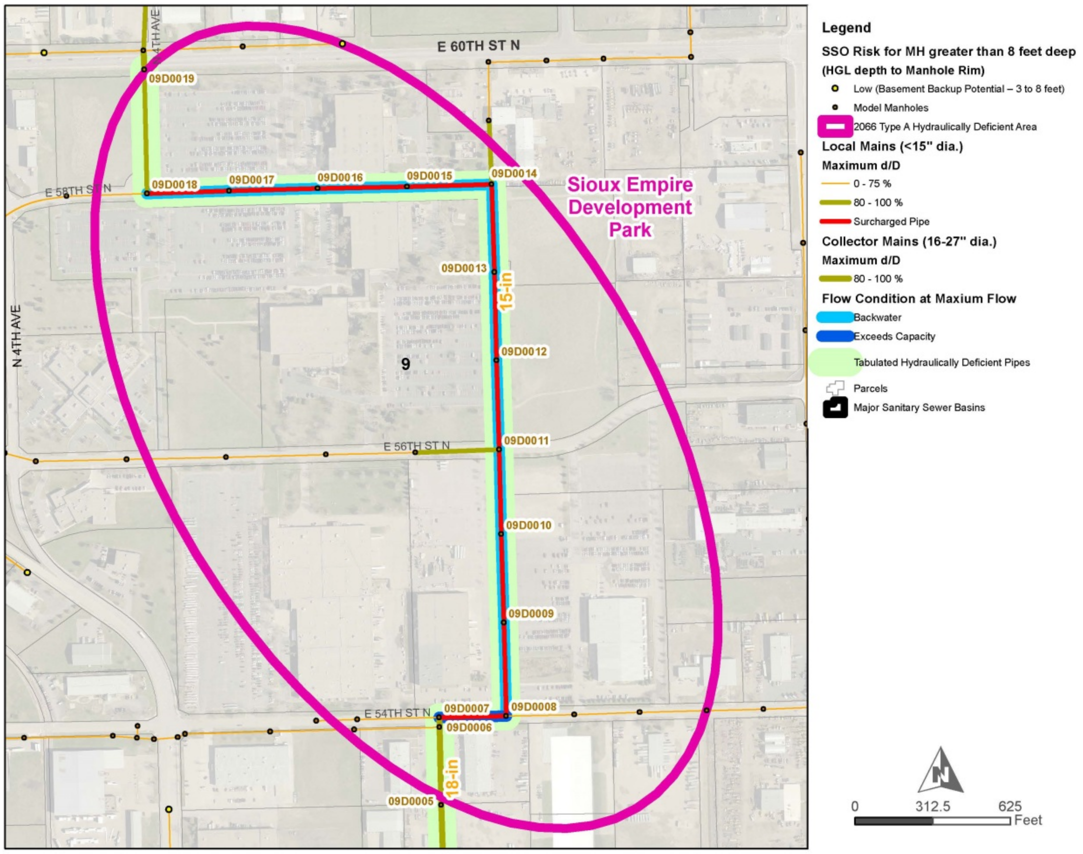
The trunk sewer in the Sioux Empire Development Park subdivision experiences slight surcharges due to projected 2066 flow increases. This trunk line is between East 54th Street North and East 60th Street North in Basin 9. The range in pipe diameters is from 15- to 18-inch for approximately 5,000 feet with the GIS not indicating that pipe lining has taken place.

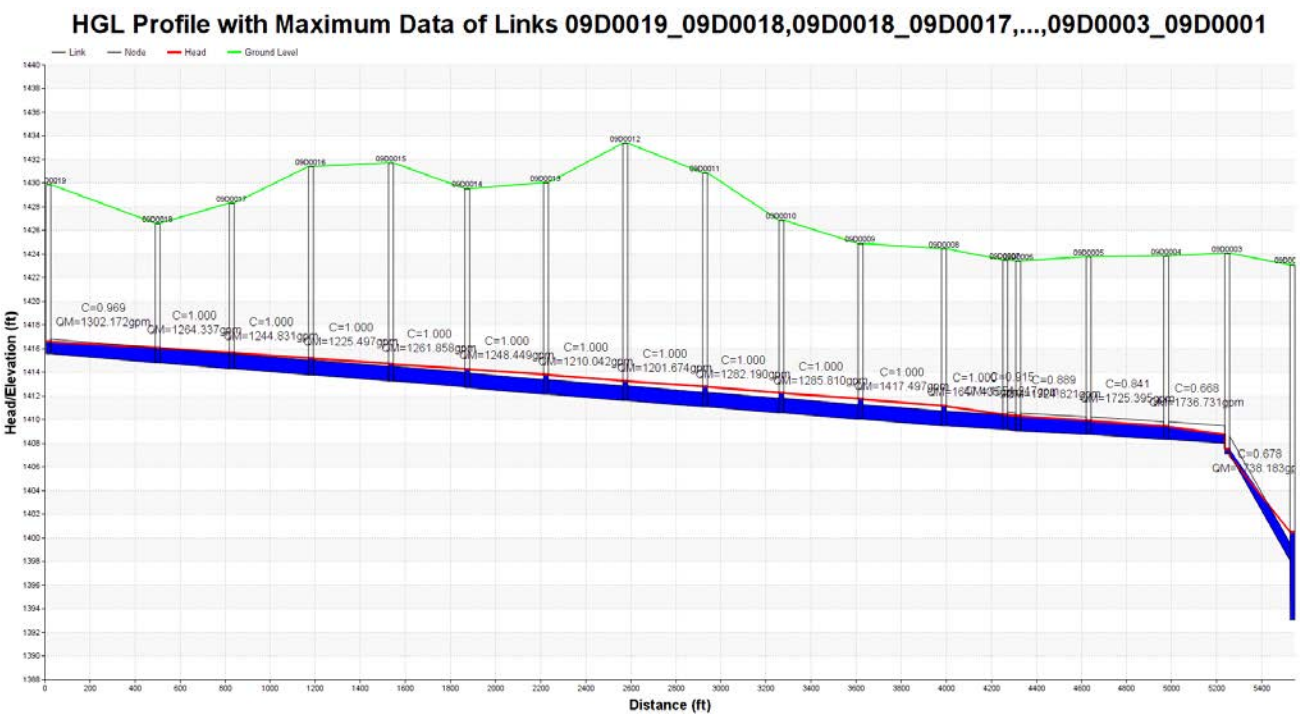
Table 9.33 summarizes the capacity restricted pipes in this problem area. Figure 9.34 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.33 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Sioux Empire Development Park Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	15	770	VCP
	18	700	VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	18	3,530	VCP

Figure 9.34 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Sioux Empire Development Park Type A Problem Area





9.8.1.2.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.8.1.3 Central Main

The Central Main upstream of the Outfall trunk in Basins 3 and 4 experiences surcharging under projected 2066 flow increases. This surcharge backs up flow throughout the 60-inch portion of the trunk to East Falls Park Drive. This surcharge also backs up flow in the East Side Trunk Sewer to North Weber Avenue due to the elevations required for the East Side Trunk to go under the Big Sioux River (Figure 9.35). Surcharging in the Central Main is due both to hydraulic capacity of the trunk sewer as well as backups from the Outfall Trunk EQ diversion. This is part of the design for the equalization diversion structure hydraulics.

The range in pipe diameters is from 8- to 60-inch for approximately 5,640 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risk.

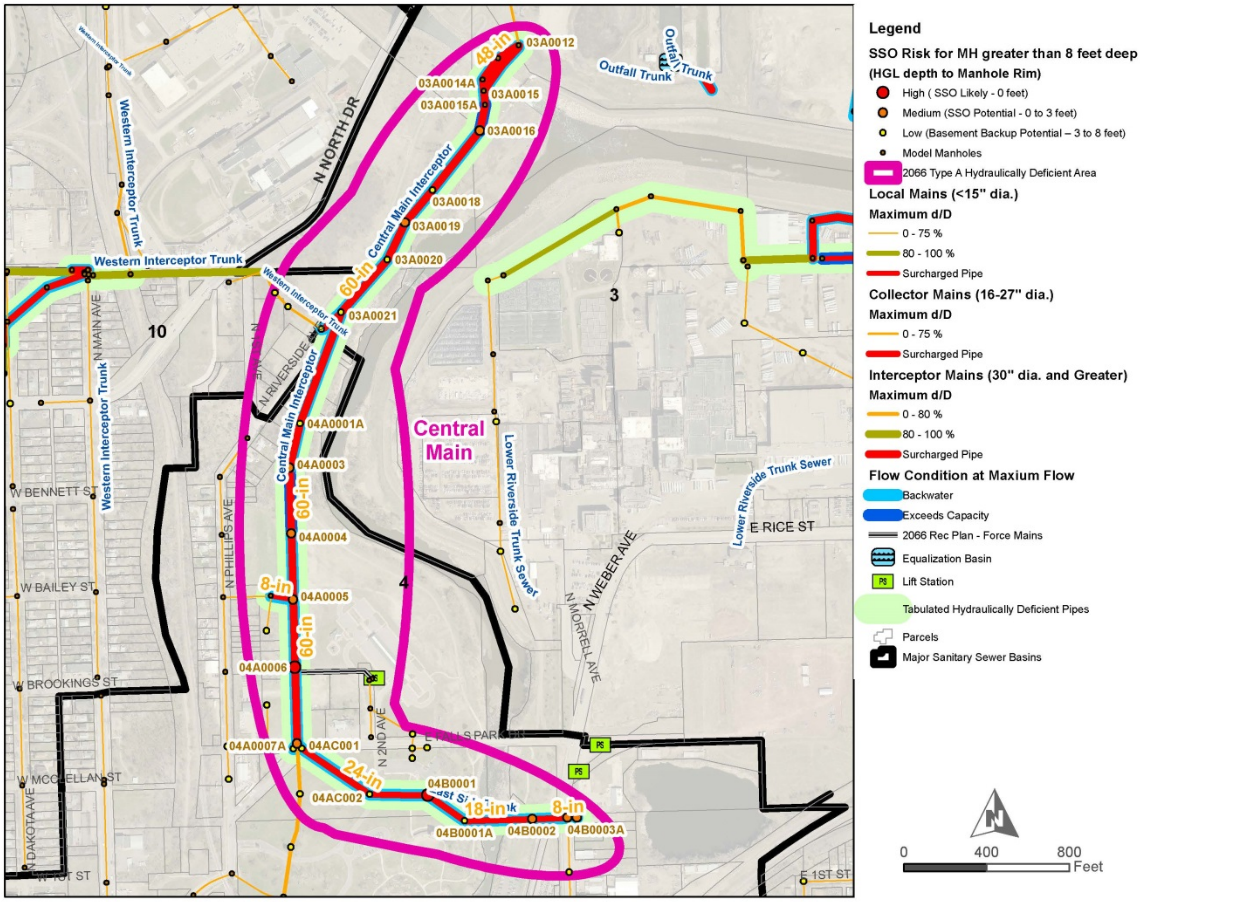
It should be noted that Survey data was collected in 2016 on a number pipes from manhole 04A0005 to 03A0021. There were also flow monitors used for dry and wet weather calibration located in the middle of this hydraulically limited problem area.

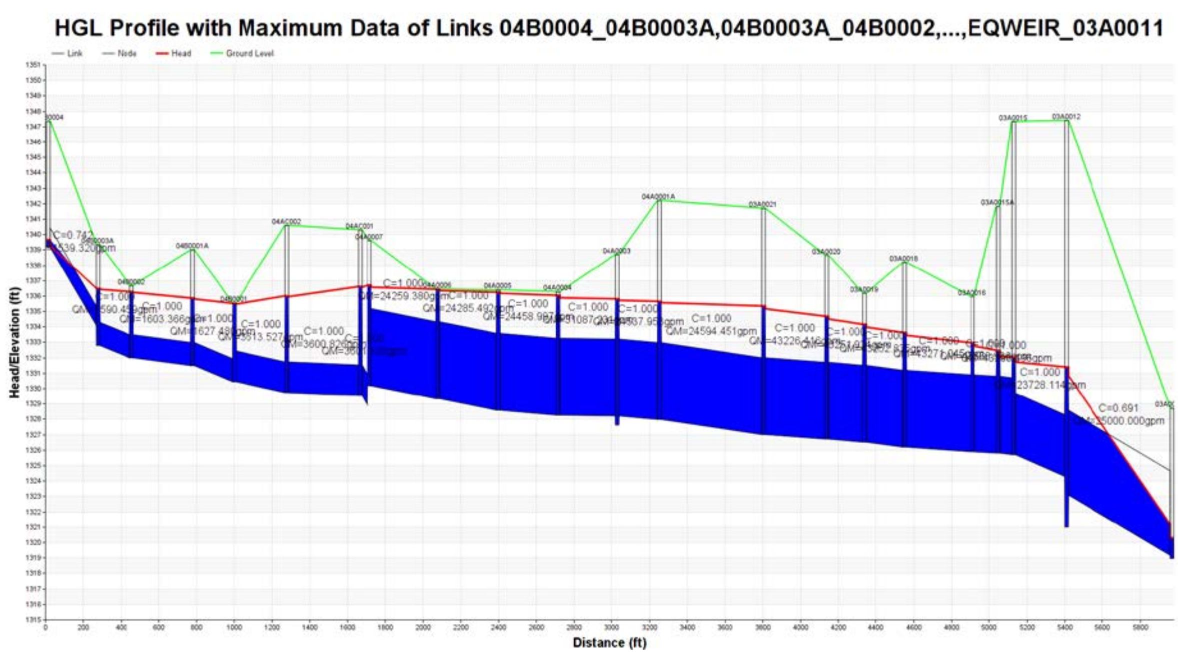
Table 9.34 summarizes the potential capacity restricted pipes in this problem area. Figure 9.35 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.34 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Central Main Type A Problem Area

<table>
<tr><th>Description</th><th>Pipe Diameter (inch)</th><th>Sum of Length (ft)</th><th>Pipe Material</th><th>Year of Installation</th></tr>
<tr><td>Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)</td><td>60</td><td>450</td><td>HOBAS</td><td>2009</td></tr>
<tr><td rowspan="5">Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)</td><td>8</td><td>190</td><td>DIP, PVC, Truss White (PVC)</td><td>1980</td></tr>
<tr><td>18</td><td>720</td><td>DIP, VCP</td><td></td></tr>
<tr><td>24</td><td>710</td><td>RCP</td><td></td></tr>
<tr><td>48</td><td>530</td><td>PVC, RCP</td><td>2003</td></tr>
<tr><td>60</td><td>3,040</td><td>DIP, HOBAS</td><td>2003, 2009</td></tr>
</table>

Figure 9.35 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Central Main Type A Problem Area





9.8.1.4 Central Main Recommendations

The Central Main Trunk Sewer project area is hydraulically limited only under projected flow increases. The problem area starts in 2026 and extents are similar for the 2026, 2036, and 2066 flow conditions. Surcharging in the Central Main is due both to hydraulic capacity of the trunk sewer as well as backups from the Outfall Trunk EQ diversion.

Surcharges in the East Side trunk were not addressed because in order for this trunk sewer to go under the Big Sioux River and discharge in the Central Main Trunk Sewer, the inverts need to be at a lower elevation as the inverts in the Central Main. Surcharging along this portion of the East Side Trunk will not impact sewer laterals or service connections.

Table 9.35 summarizes the hydraulic improvement pipe sizes for 2066 associated with this project area. All of the pipes presented in are directly connected to each other. The pipes in are recommended assuming that bypass to the Outfall Trunk EQ basin is such as to have flow in the Outfall trunk at around 70 MGD with a flow depth of 80 to 90 percent of the full pipe (0.8 to 0.9 d/D).

Table 9.35 Central Main Trunk Sewer Tiers 1-4, 50-Year Build-out (2066) Improvements

Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size (ft)
60-inch	369
66-inch	2,458
72-inch	536
TOTAL	**3,958**

No capital improvement project is recommended. Continue to monitor and evaluate as there is no impact to adjacent services and problem Area has minimal impact on connecting laterals other than the East Side Trunk Sewer.

9.8.1.5 Ebenezer Avenue

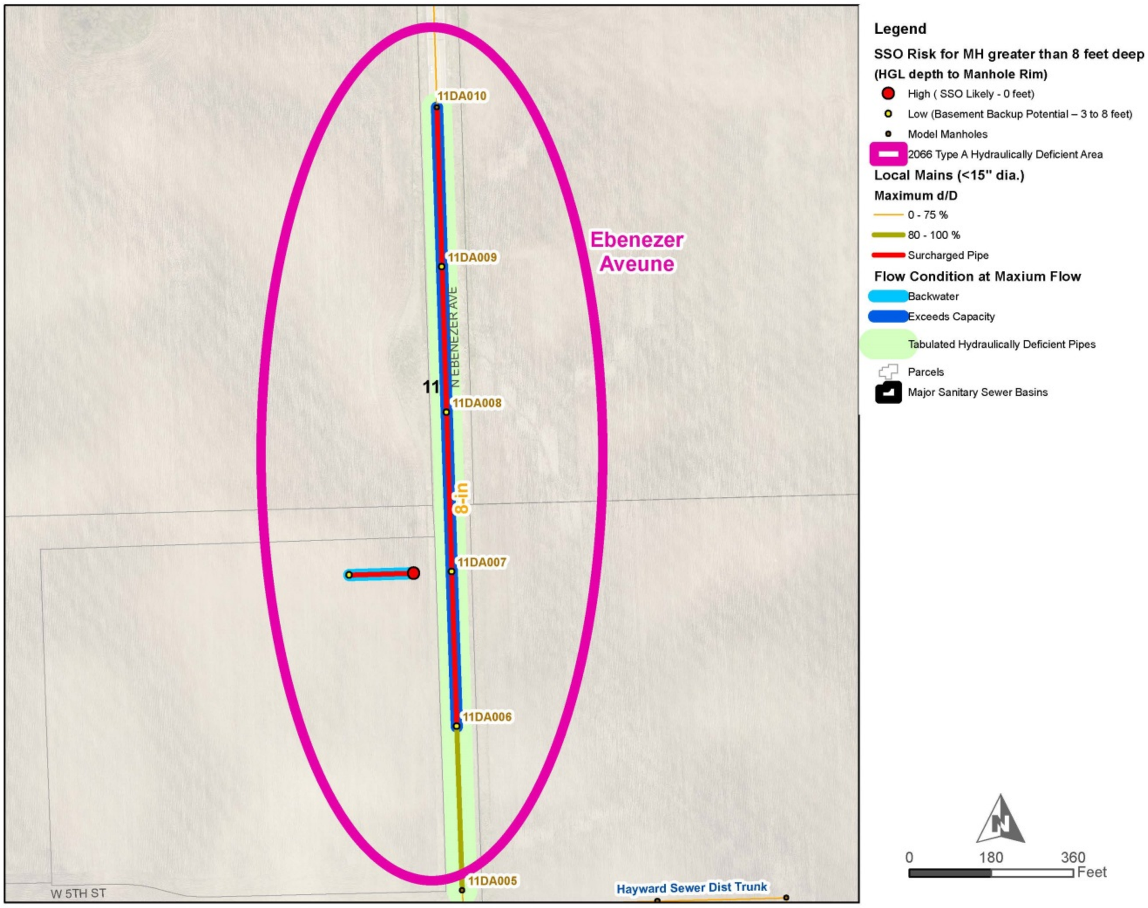
Portions of the 8-inch sewer pipe along Ebenezer Avenue south of West Madison Street in Basin 11 surcharges under projected 2066 flow increases. The pipe diameters are 8-inch for approximately 1,720 feet with the GIS not indicating that pipe lining has taken place.

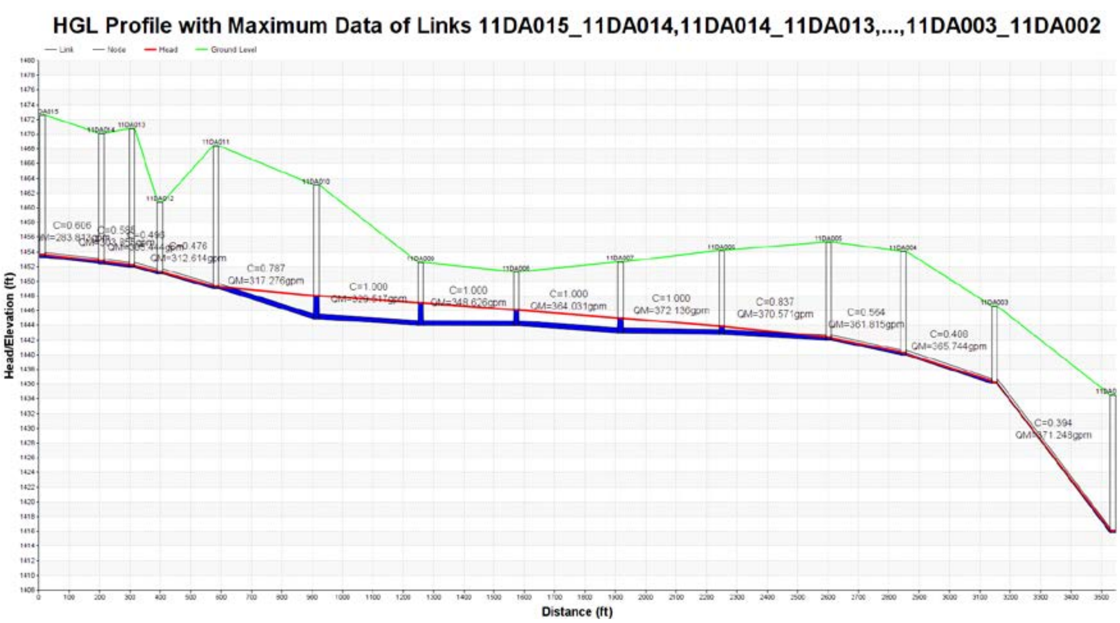
Table 9.36 summarizes the capacity restricted pipes in this problem area. Figure 9.36 provides a map for this Type A area and the modeled profile along this line.

Table 9.36 Tiers 1-4, 50-Year Build-out (2066)) Conditions Capacity Findings for the Ebenezer Avenue Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	1,720	PVC	2005

Figure 9.36 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Ebenezer Avenue Type A Problem Area





9.8.1.5.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.8.1.6 Sioux River North Upstream of PS 215

The Sioux River North Interceptor upstream of PS 215 in Basins 10 and 11 experiences surcharging with the projected 2066 flow increases. From PS 215, the Sioux River North Interceptor goes in three directions (west [Figure 9.37], south [Figure 9.38] and east [Figure 9.39]) with all three experiencing some level of surcharge. The range in pipe diameters is from 8- to 42-inch for approximately 28,880 feet with the GIS not indicating that pipe lining has taken place. The majority of surcharging in this area is due to backups at PS 215. It should also be noted that the Sioux River North west of PS 215 is deep and that a small amount of surcharging has minimal impact on adjacent laterals. It should also be noted that he surcharge also to the north also exists without the Basin 33 flows.

Table 9.37 summarizes the capacity restricted pipes in this problem area. Figure 9.37 provides a map for this Type A area and Figure 9.37 through Figure 9.39 provides representative modeled profiles along this line.

Table 9.37 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Sioux River North Upstream of PS 215 Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	10	460	PVC
	12	1,670	RCP, VCP
	30	1,450	DIP, PVC
	36	430	PVC
	42	3,990	DIP, PVC
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	520	PVC, VCP
	10	1,270	PVC
	12	830	PVC, VCP, RCP
	18	950	PVC
	30	230	PVC
	36	11,200	DIP, PVC, HOBAS
	42	5,880	DIP, PVC, HOBAS

Figure 9.37 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Sioux River North Upstream of PS 215 Type A Problem Area

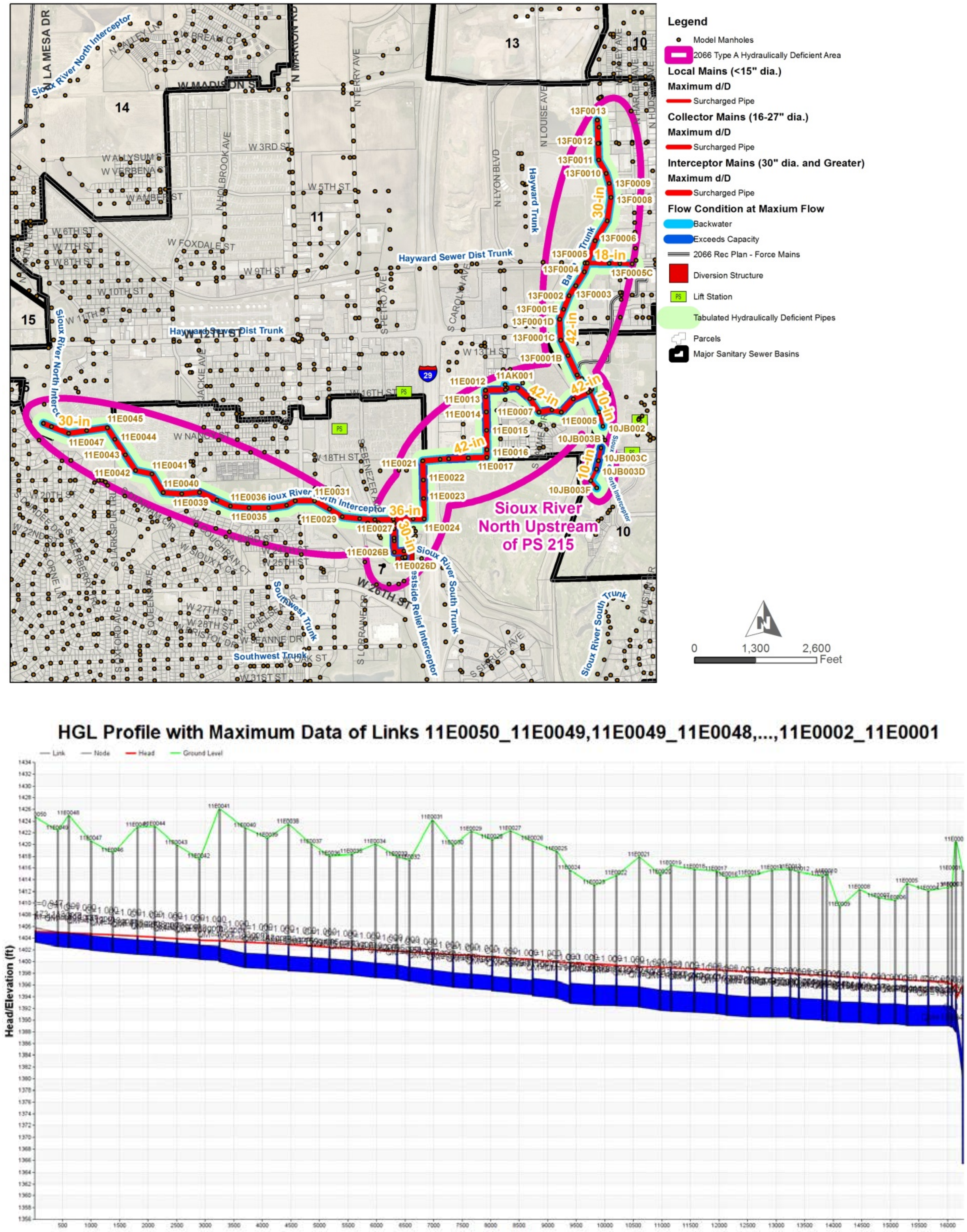


Figure 9.38 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Pipe Profile for the Sioux River North Upstream of PS 215 Type A Problem Area

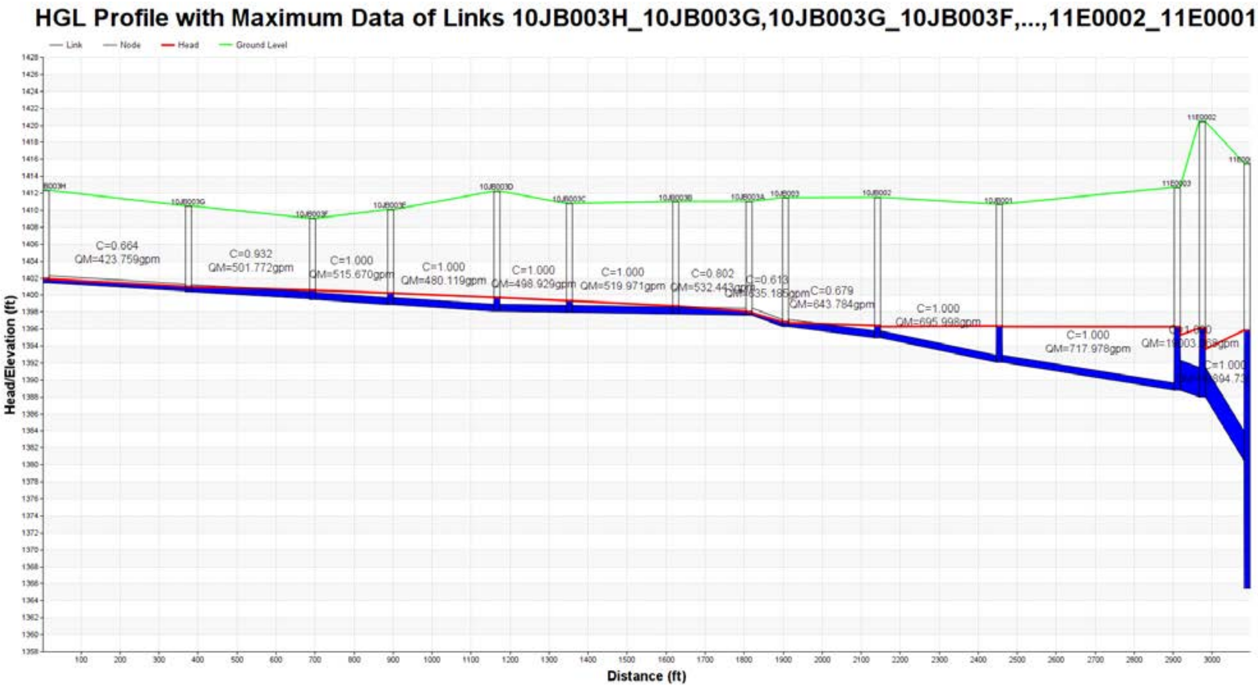
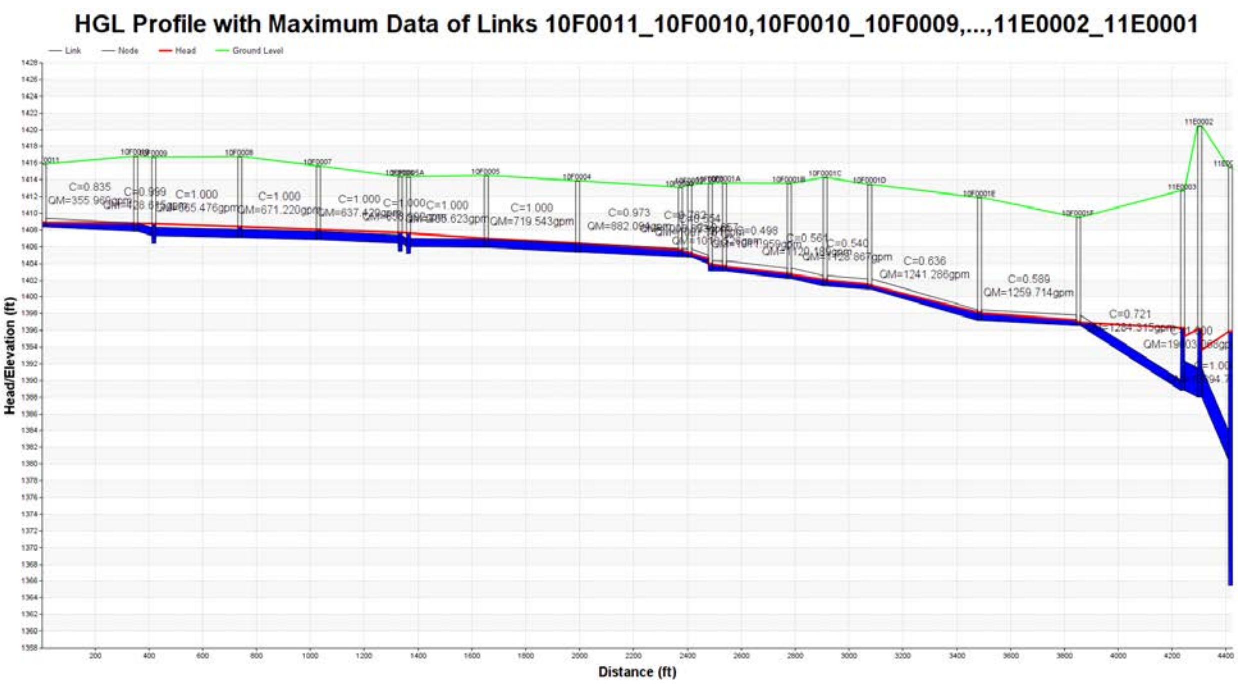


Figure 9.39 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Pipe Profile for the Sioux River North Upstream of PS 215 Type A Problem Area



9.8.1.7 Sioux River North Recommendations Upstream of PS 215

The Sioux River North Trunk Sewer Upstream of PS 215 project area is hydraulically limited only under projected flow increases, with the problem increasing for each of the 2026, 2036, and 2066 planning years. While 2026 and 2036 flows from Basins 14 and 34 are recommended to pass through this area, 2066 flows are recommended to be diverted via a force main around the City. The problem extent is greatest in 2066 despite the system not carrying flows from Basins 15 and 34 during this time period. Basin 33 flows, however, are recommended to go through the Basin 13 trunk to PS 215. Backups at PS 215 cause the majority of surcharging in this project area. However, there are some pipe capacity limitations along the Sioux River North west of PS 215. This line is deep and therefore a small amount of surcharging has minimal impact on adjacent laterals. The Sioux River North south of PS 215 also has a couple of pipe segments with potential capacity limitations that are part of this project area.

Given that PS 215 discharges into the Western Interceptor, which in turn discharges into the Outfall Trunk (both future problem areas), increasing pumping capacity of PS 215 would exacerbate this condition and was therefore not examined. The primary recommended solution is therefore equalization/increase in wet well capacity at PS 215. To minimize surcharging in the Basin 13 Trunk and Sioux River northwest of PS 215, 1.6 million gallons of storage is required at PS 215. Table 9.38 summarizes the pipe improvements required to mitigate the hydraulic capacity limitations of the Sioux River North south of PS 215.

Table 9.38 Sioux River North Upstream of PS 215 Tiers 1-4, 50-Year Build-out (2066) Improvements

Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size (ft)
15-inch	460
TOTAL	**460**

9.8.1.8 Columbia Heights Trunk

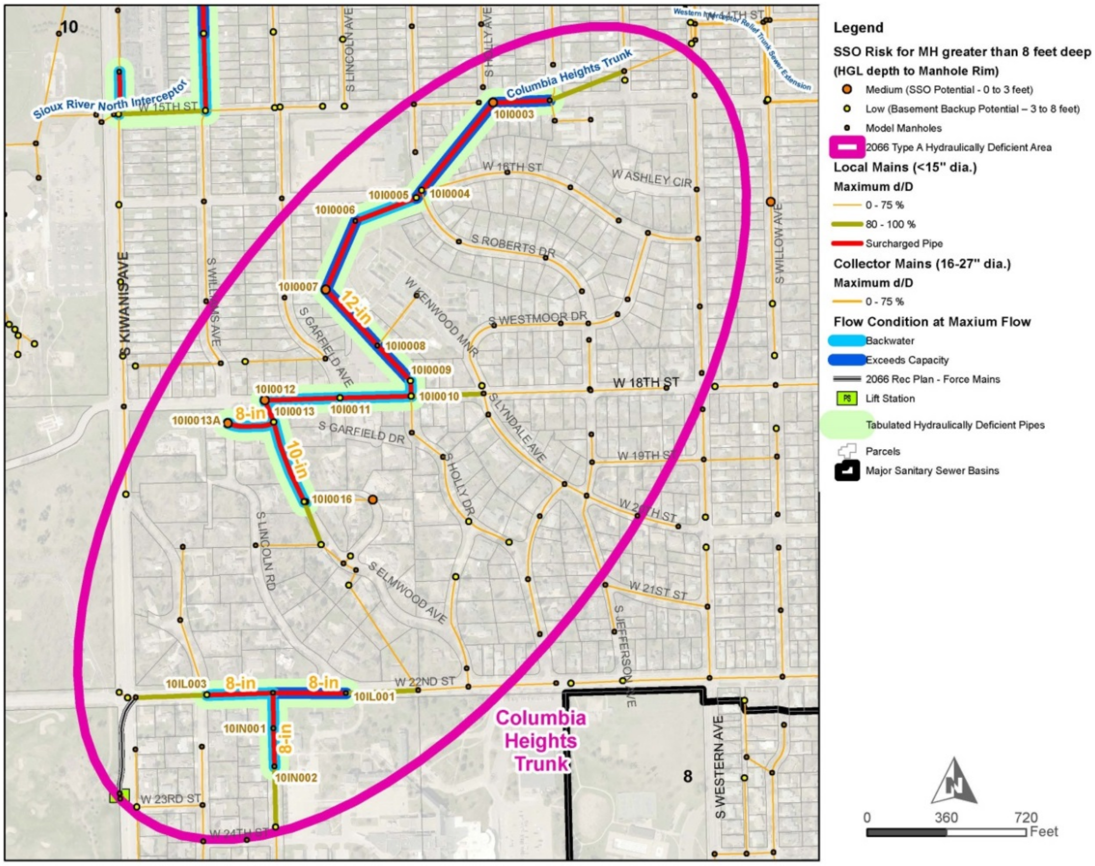
The Columbia Heights Trunk in Basin 10 from East Elmwood Ave to West 15th Street experiences surcharges resulting from projected 2066 flow increases. The range in pipe diameters is from 8- to 12-inch for approximately 4,410 feet with the GIS indicating that some CIP pipe lining has taken place.

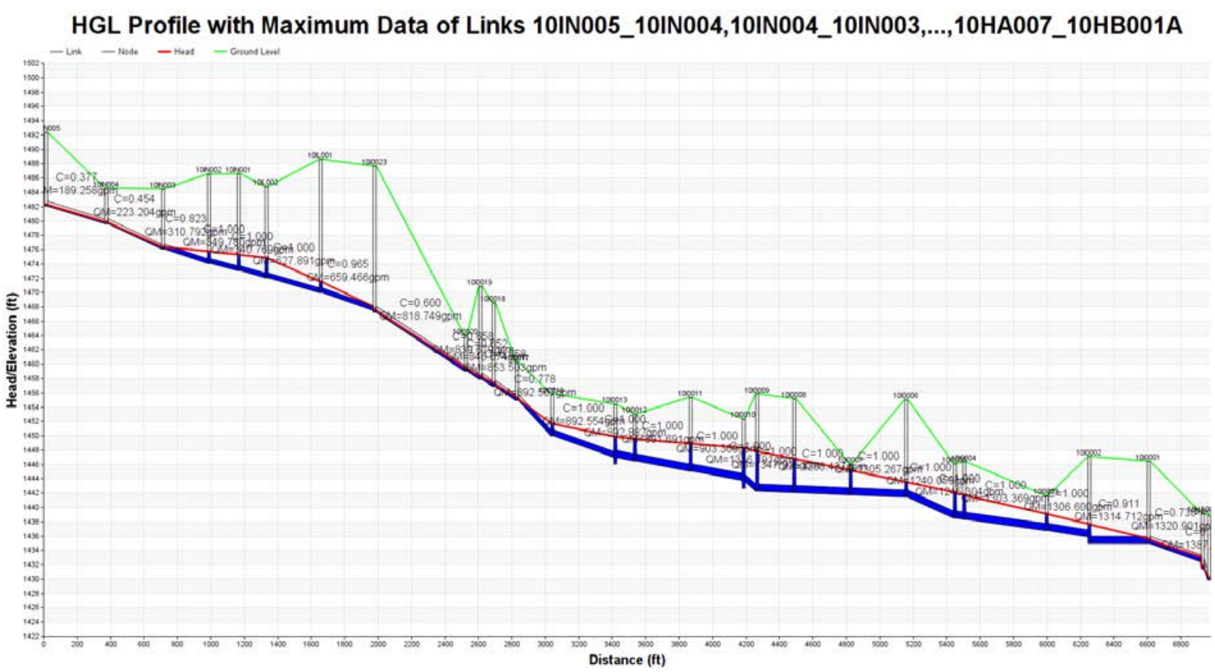
Table 9.39 summarizes the capacity restricted pipes in this problem area. Figure 9.40 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.39 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Columbia Heights Trunk Type A Problem Area

Descriptions	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	330	PVC
	12	1,710	VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	850	PVC, Truss White (PVC), VCP
	10	390	VCP
	12	1,130	PVC, VCP

Figure 9.40 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Columbia Heights Trunk Type A Problem Area





9.8.1.8.1 Recommendations

The model confidence for this area is low which means the basin data is not available. No CIP projects are identified. Flow monitoring including the capture of a significant wet weather event is recommended.

9.8.1.9 17th, 18th, and 19th Streets

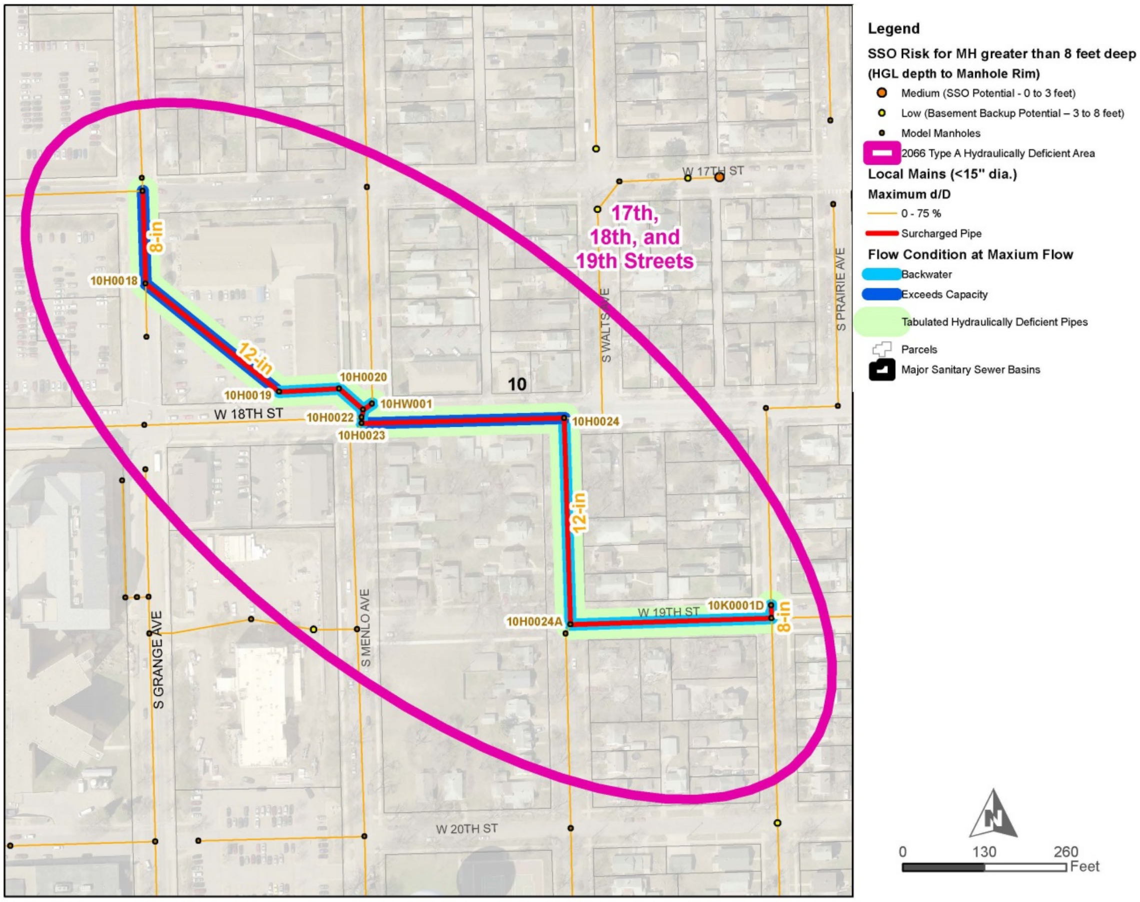
The 17th, 18th, and 19th Street hydraulically limited area is in Basin 10 and is projected to surcharge as flows in 2066 increases. Projected hydraulic capacity limitations start at South Prairie Avenue and follow the line west along West 19th Street, then north along South Walts Avenue, then west along West 18th Street then northwest to South Grange Avenue, then north along South Grange Avenue, and ending at West 17th Street. It should be noted that there is a 12-inch to 8-inch diameter pipe restriction along this line at South Grange Avenue. The range in pipe diameters is from 8- to 12-inch for approximately 1,610 feet with the GIS not indicating that pipe lining has taken place.

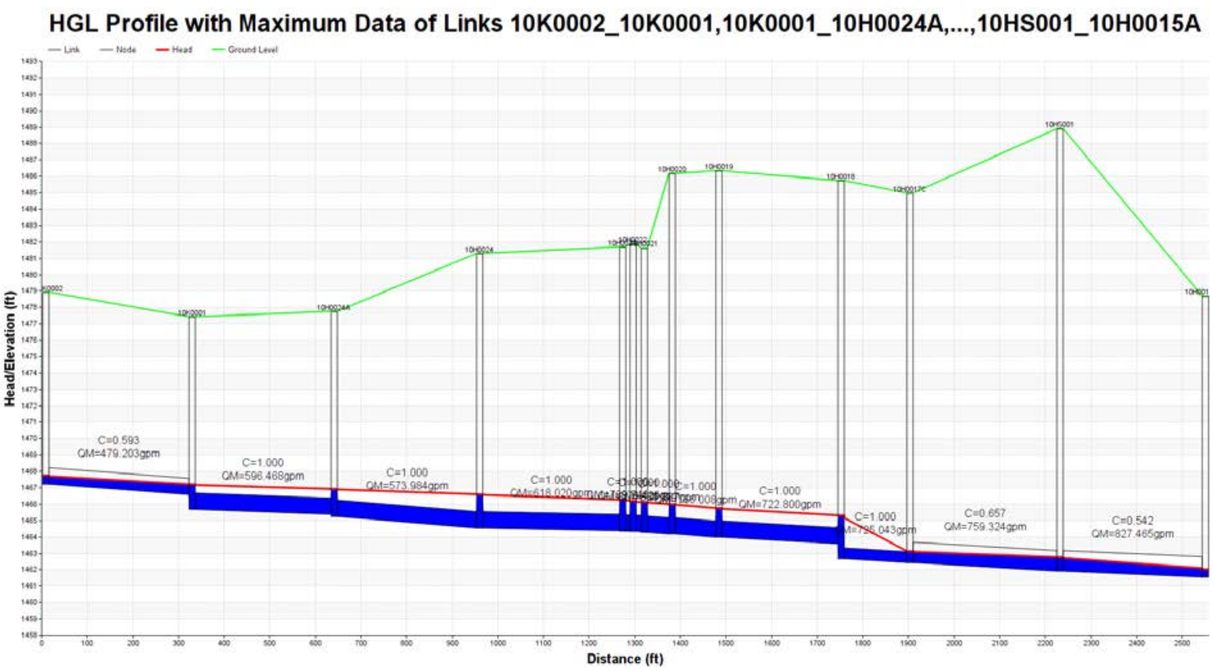
Table 9.40 summarizes the capacity restricted pipes in this problem area. Figure 9.41 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.40 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the 17th, 18th, and 19th Streets Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	150	PVC
	12	600	PVC, VCP
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	40	PVC
	12	820	PVC, VCP

Figure 9.41 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the 17th, 18th, and 19th Streets Type A Problem Area





9.8.1.9.1 Recommendations

The model confidence for this area is low which means the basin data is not available. No CIP projects are identified. Flow monitoring including the capture of a significant wet weather event is recommended.

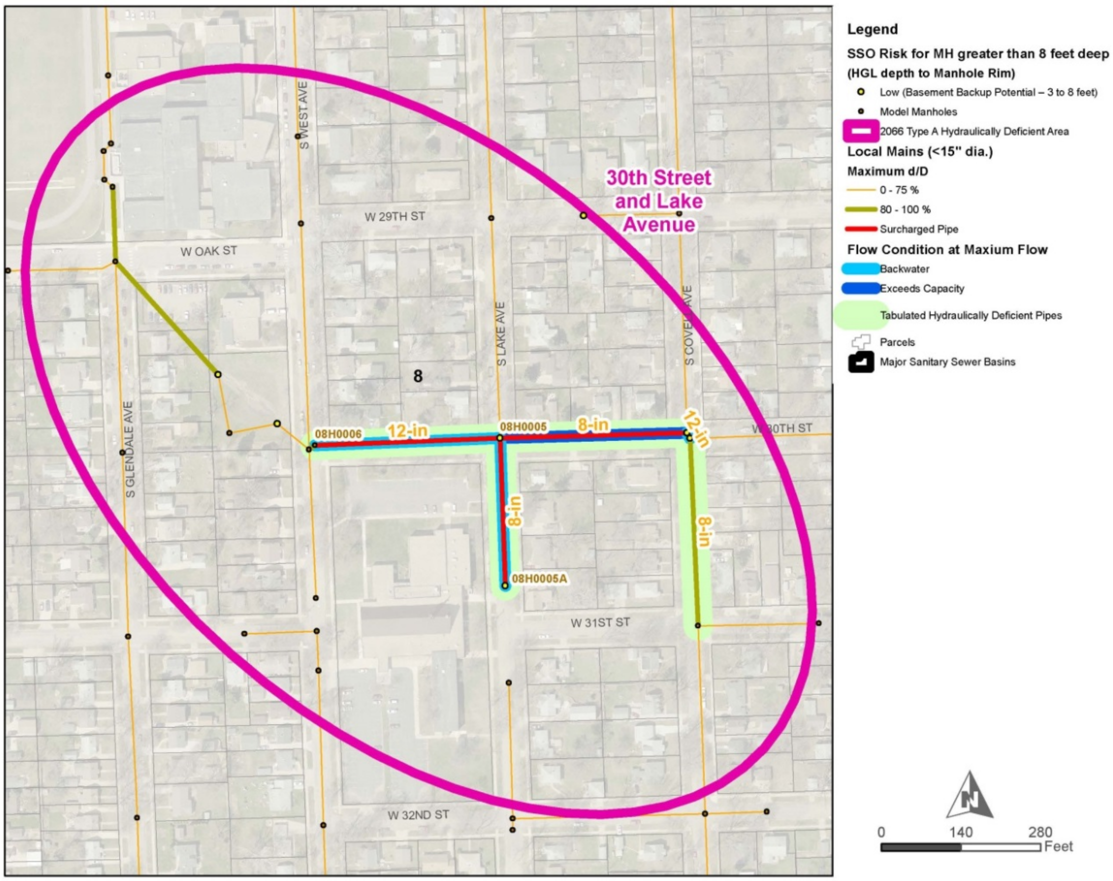
9.8.1.10 30th Street and Lake Avenue

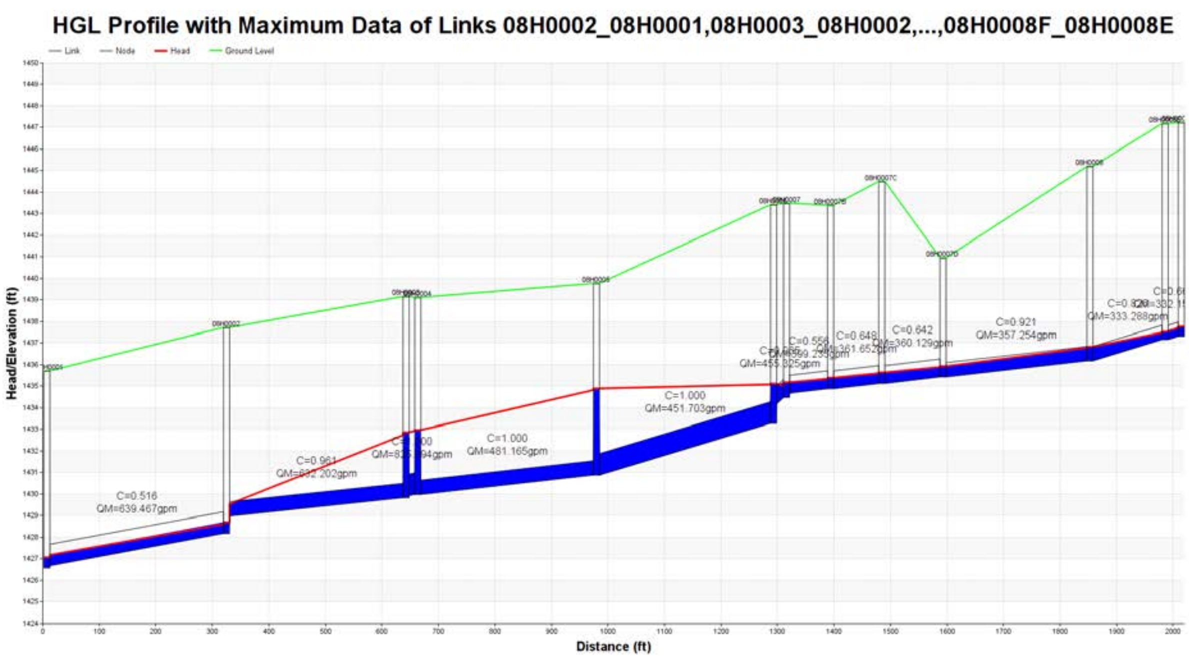
The 30th Street and Lake Avenue potential capacity limitations are in Basin 8 and is projected to surcharge due to 2066 flow increases. Projected hydraulic problem areas begin at South West Avenue and follow the line east along West 30th Street, then south along South Covell Avenue to West 31st Street, with backups occurring on South Lake Avenue. The range in pipe diameters is from 8- to 12-inch for approximately 1,260 feet with the GIS not indicating that pipe lining has taken place. Table 9.41 summarizes the capacity restricted pipes in this problem area. Figure 9.42 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.41 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Finding for the 30th Street and Lake Avenue Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	660	Truss White (PVC)
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	260	PVC
	12	340	Truss White (PVC)

Figure 9.42 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the 30th Street and Lake Avenue Type A Problem Area





9.8.1.10.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

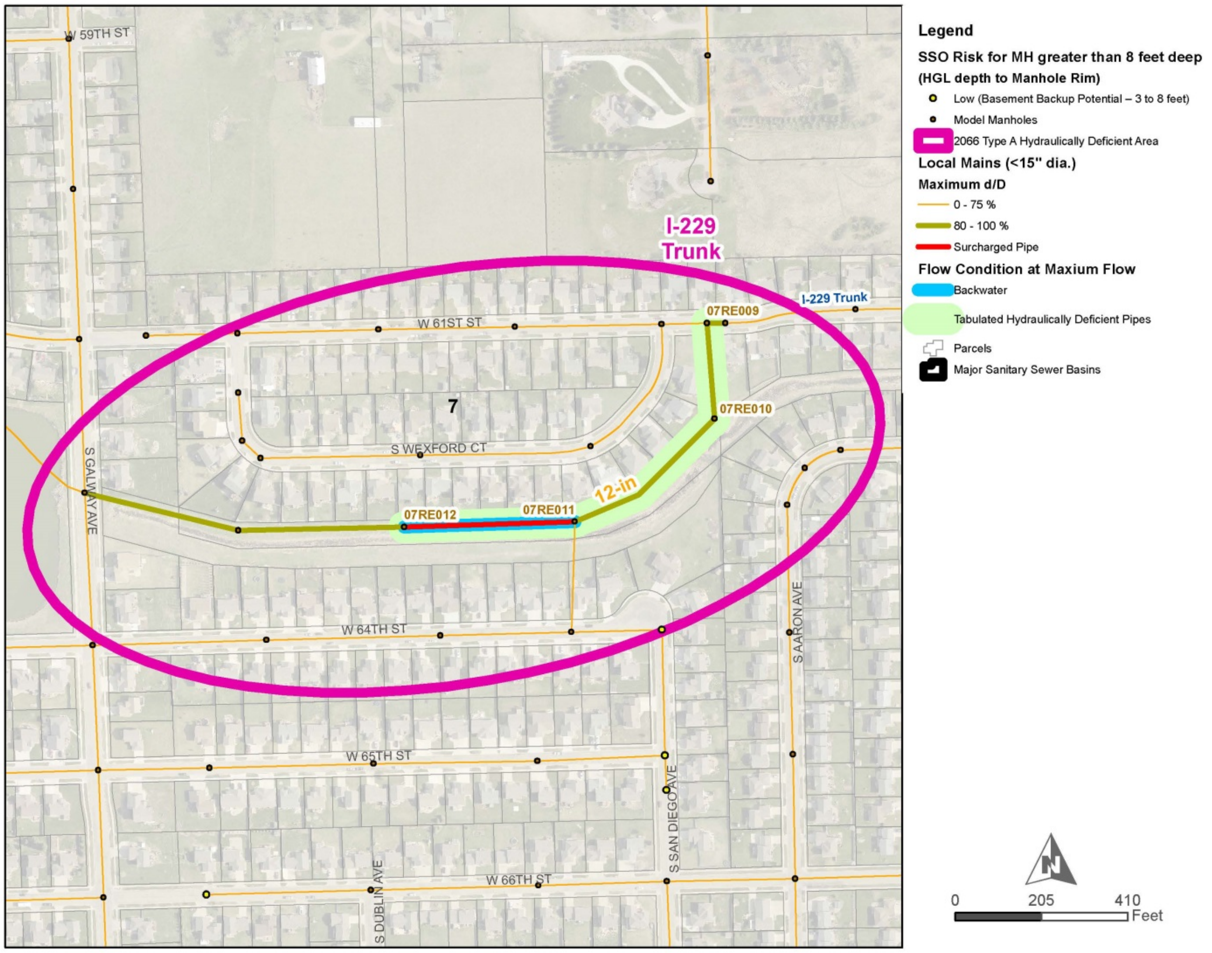
9.8.1.11 I-229 Trunk

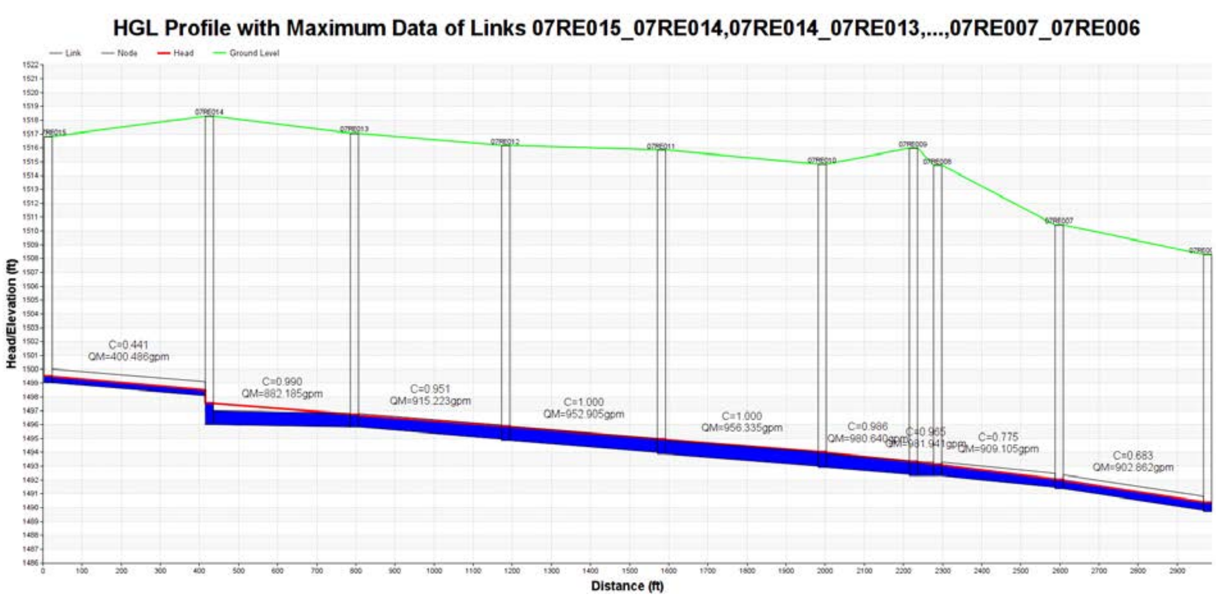
The I-229 Trunk capacity limited area is in Basin 7 and is projected to slightly surcharge and not meet hydraulic criteria due to 2066 flow increases. Projected hydraulic capacity limitations occur east of South Galway Avenue to West 61st Street. The pipe diameters are 12-inch for approximately 1,060 feet with the GIS not indicating that pipe lining has taken place. Table 9.42 summarizes the capacity restricted pipes in this problem area. Figure 9.43 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.42 Tiers 1-4, 50-Year Build-out (2066)) Conditions Capacity Findings for the I-229 Trunk Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	12	650	PVC	2002
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	12	410	PVC	2002

Figure 9.43 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the I-229 Trunk Type A Problem Area





9.8.1.11.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.8.1.12 Sioux River South

The Sioux River South capacity limited area is along the South River South Interceptor Trunk in Basins 6 and 7 and is projected to surcharge due to 2066 flow increases. The primary cause of surcharge is due to backups at the Tuthill Lift Station (PS 218) and could be mitigated with equalization. However, surcharge does not impact laterals or service lines and it is recommended to maintain without equalization. The Sioux River South Interceptor Trunk also follows the Big Sioux River and represents a low area on the landscape. This results in the Sioux River South Interceptor Trunk being lower in elevation than then the laterals that feed into it, meaning that surcharges in trunk sewer have minimal impact on these laterals.

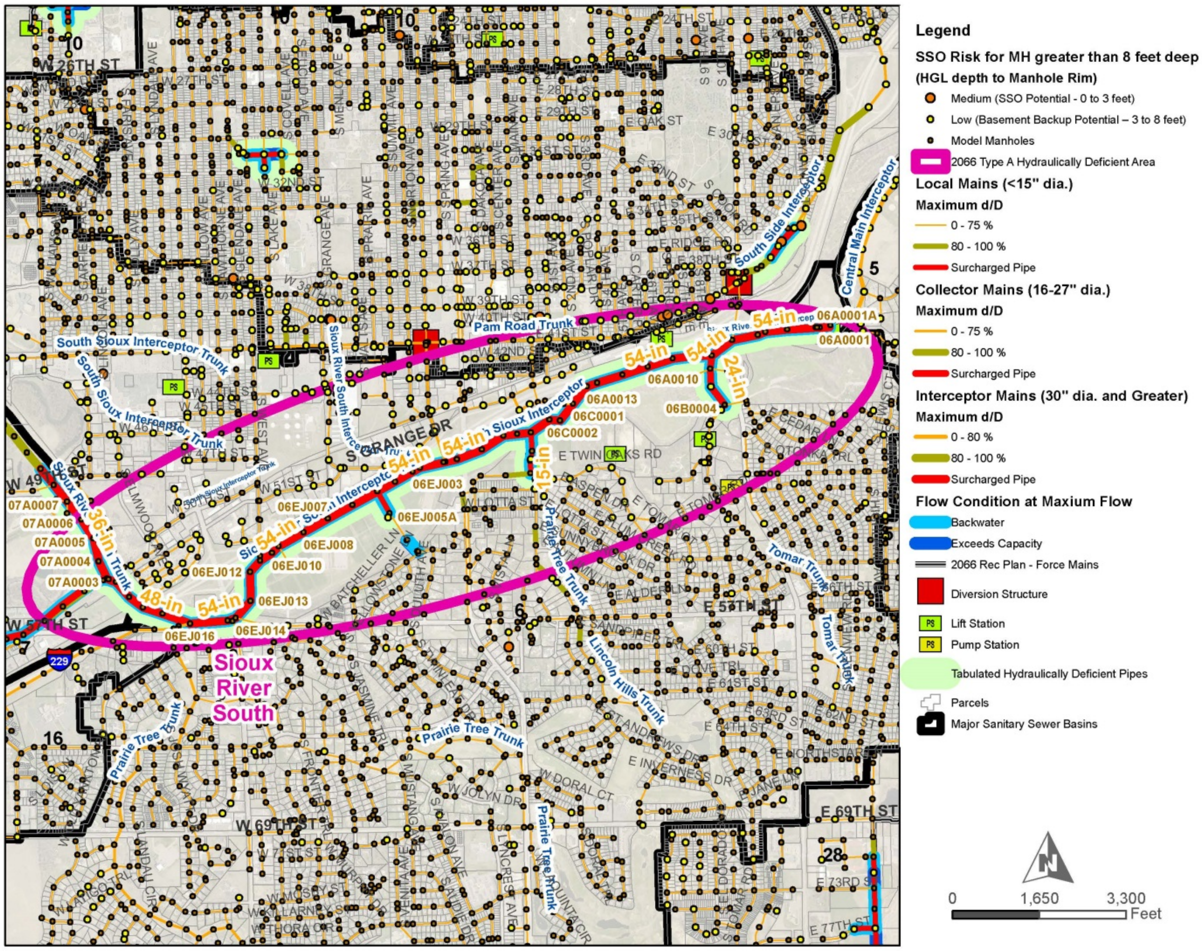
The range in pipe diameters is from 10- to 54-inch for approximately 19,780 feet with the GIS not indicating that pipe lining has taken place, however the 36-inch diameter has been lined.

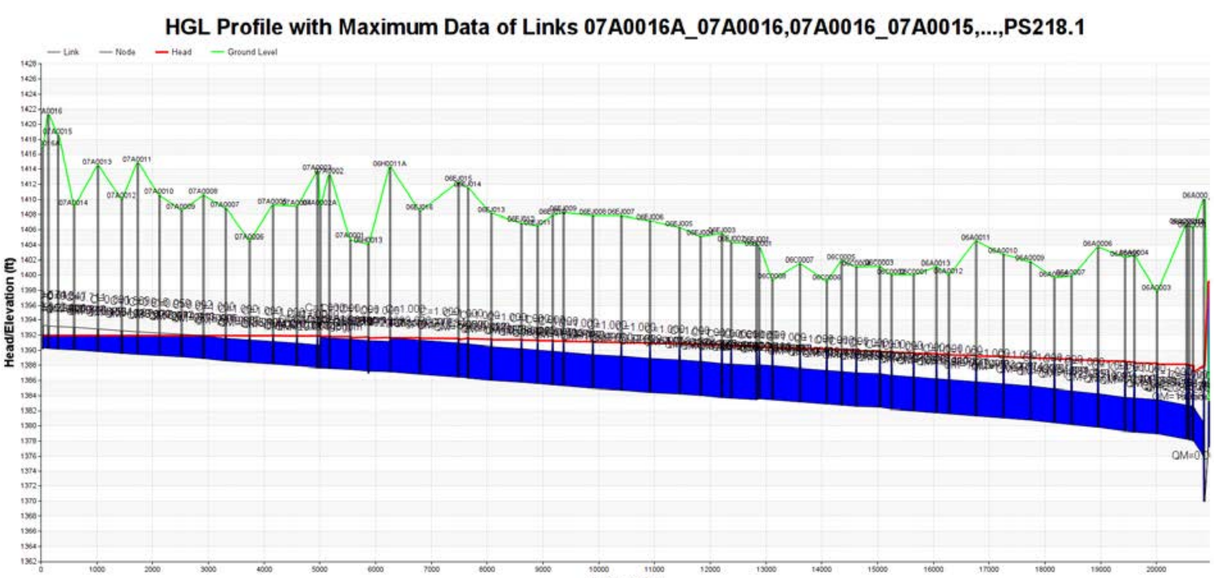
Table 9.43 summarizes the capacity restricted pipes in this problem area. Figure 9.44 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.43 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Sioux River South Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	48	400	HOBAS	
	54	180	HOBAS	2012, 2013
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	10	480	PVC	2013
	15	750	PVC	2012
	24	1,030	HDPE	2012
	36	2,080	Lined RCP	Lined 2013
	48	530	RCP	
	54	14,330	HOBAS	2012, 2013

Figure 9.44 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Sioux River South Type A Problem Area





9.8.1.13 Sioux River South Recommendations

The Sioux River South Trunk Sewer Upstream of PS 218 (the Tuthill Lift Station) project area is only significantly hydraulically limited under projected 2066 flow increases. For 2026 the d/D hydraulic criteria gets violated and for 2036 there is some surcharging immediately upstream of PS 218. Future flows from Basin 16, the City of Lennox, and the City of Tea are projected to discharge into the Sioux River South. Backups at PS 218 cause the majority of surcharging in this project area. The Sioux River South Interceptor Trunk follows the Big Sioux River and represents a low area on the landscape. This results in the Sioux River South Interceptor Trunk being lower in elevation than then the laterals that feed into it, meaning that surcharges in the trunk sewer have minimal impact on these laterals. Therefore a mitigation alternative is not necessarily required. However, a mitigation alternative was evaluated to determine if surcharging can be prevented.

To prevent potentially exacerbating pipe capacity limitations in the Central Main and to avoid creating new capacity constraints in other areas of the Central Main and Outfall Trunk, increasing capacity of PS 215 was not evaluated. Therefore, only equalization options were examined. Although only 2.3 million gallons of equalization/storage at the Tuthill lift station would prevent backups in the Sioux River North, there is little likelihood that land would be available for an aboveground basin. Therefore, upstream equalization was evaluated northwest of I-229.

To prevent surcharging from backups along the Sioux River South Trunk, 2.4 million gallons of equalization is required at I-229 with a release capacity of 5,000 gpm. This volume is greater than what would be required at Tuthill in order to prevent backups in the Sioux River South Trunk to the northwest of this conceptualized equalization basin.

Surcharges in the trunk sewer have do not impact the laterals during the design event. Therefore, a mitigation alternative of equalization is not being recommended.

9.8.1.14 Diamond Valley

The Diamond Valley potential capacity limited area is in Basin 28 and would be projected to surcharge due to 2066 flow increases. The City has indicated that it is their intent to eliminate the Diamond Valley Lift Station when the proposed Basins 27 & 28 sewer is installed, anticipated to be around the year 2036. Without this proposed modification, this hydraulically capacity limitation would appear to be widespread and could impact a large number of pipes. It should be noted, however, that flow monitors were not available for wet weather calibration and therefore RDII characteristics were estimated to be reflective of Basin 5D to the north. Although containing higher than average RDII RTK values, Basin 5D shares the most boundaries with the ESSS and most of the install dates for these sewers in Basin 5D, where available, are in 2002 – 2014 (where the data is provided). Immediate flow monitoring in this area is recommended to determine the extent of the potential hydraulic capacity problems.

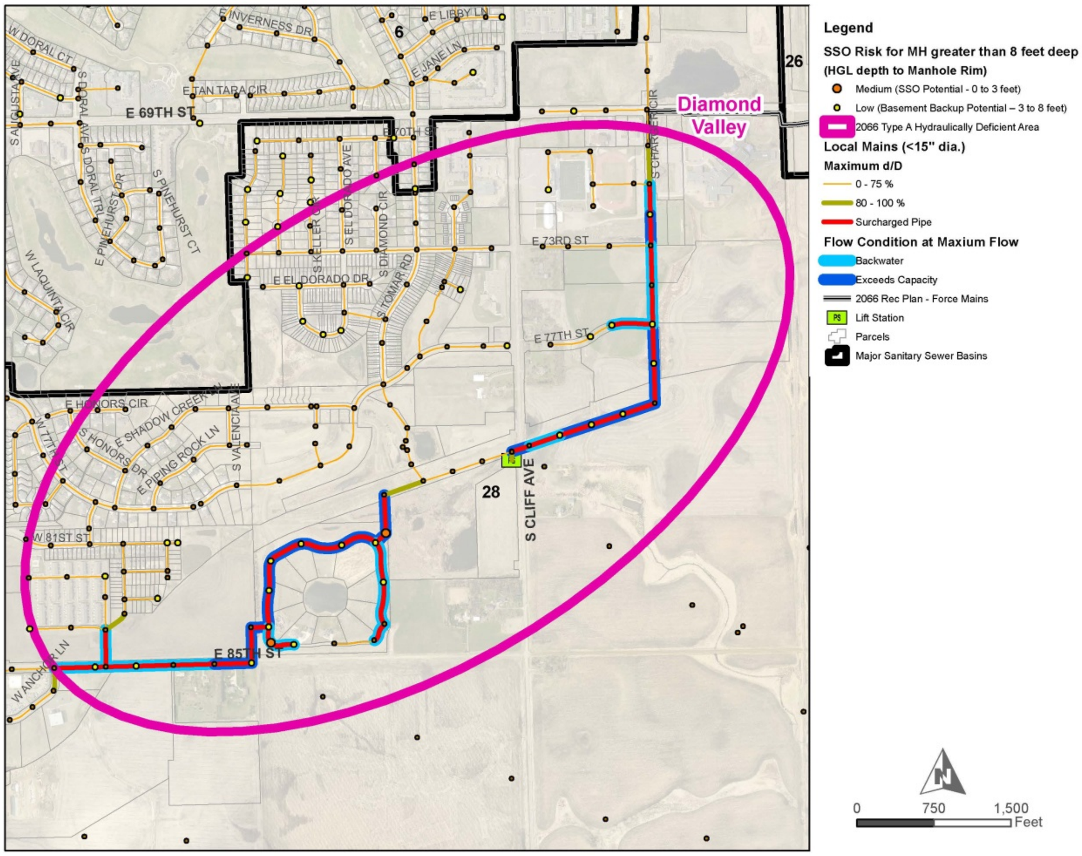
The range in pipe diameters is from 8- to 10-inch for approximately 10,910 feet with the GIS not indicating that pipe lining has taken place.

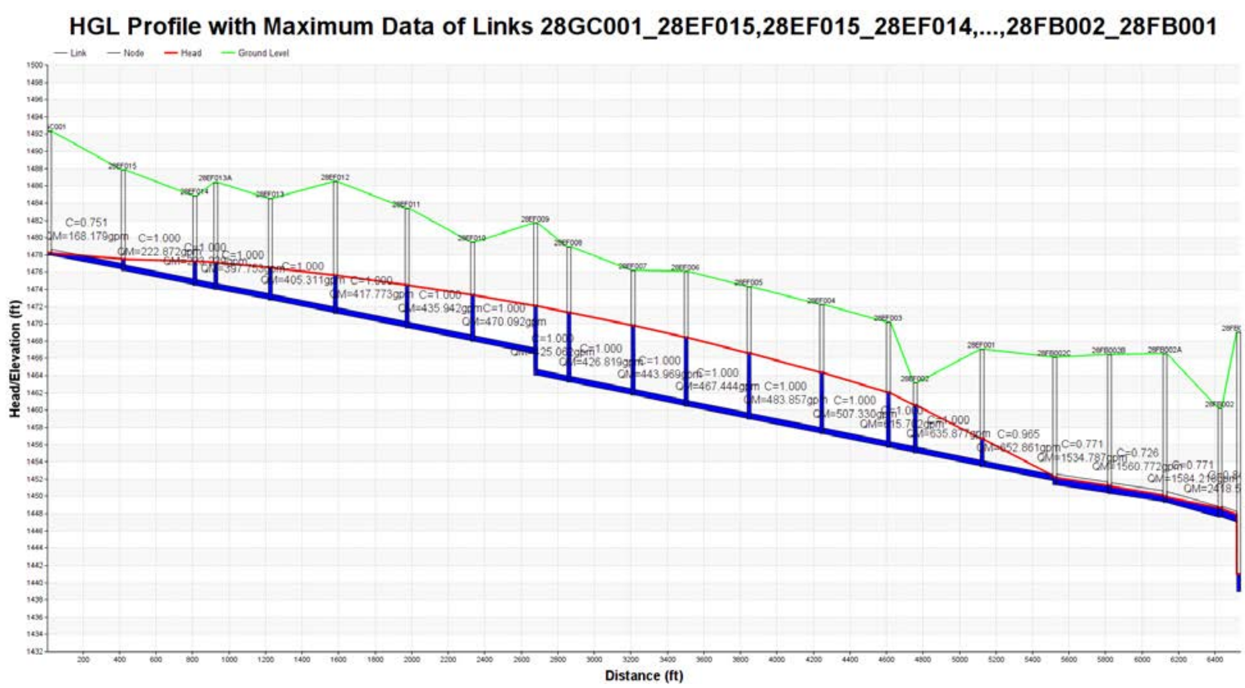
Table 9.44 summarizes the capacity restricted pipes in this problem area. Figure 9.45 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.44 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Diamond Valley Type A Problem Area (If Diamond Valley Lift Station is not Eliminated)

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	3,870	PVC	2008, 2009
	10	1,940	PVC	
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	4,020	PVC	2008, 2009, 2012, 2015
	10	1,080	PVC	

Figure 9.45 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Diamond Valley Type A Problem Area (If Diamond Valley Lift Station is not Eliminated)





The build out design peak capacity for the Diamond Valley Lift Station was 1250 gpm. The initial pump station project included pumps with a capacity of 200 gpm. These pumps are currently still in place, demonstrating the progress of development for this basin. However, there has been discussion regarding the types of new development and the updated proposed land use impact on the sanitary sewer system.

Basins 28E and 28F, currently served by the Diamond Valley lift station, have been modeled to determine if there is any available capacity to serve the following areas as there has been significant development activity in this area:

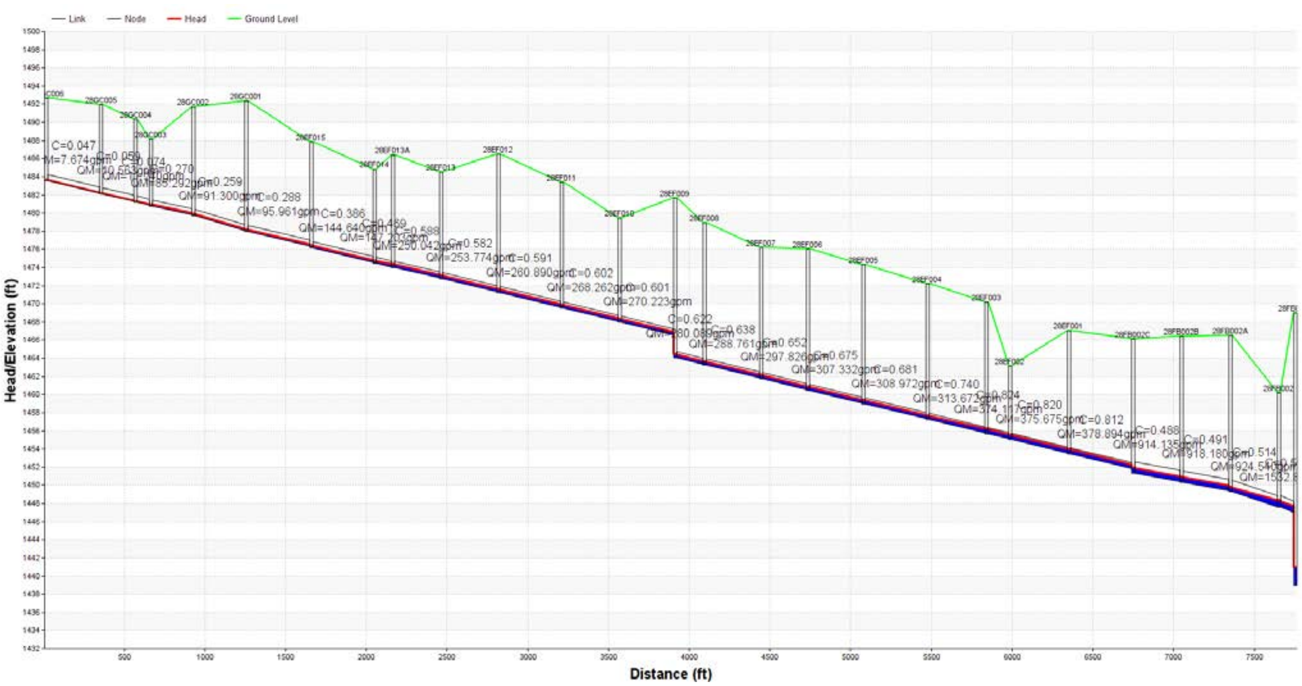
- Basin 28G (Walmart area): The model showed available capacity to direct flow from Basin G through Basin 28F and the sewer was extended to the Walmart location.
- Basin 28B (southeast corner of 85th Street and Minnesota Avenue): In 2013, there was a request to direct flow from 55 acres in Basin 28B through Basin 28F. The modeling performed at that time indicated that a maximum of 30 acres from this area could be directed into Basin 28F without causing a surcharge condition during the peak wet weather event.

The current scenario includes the area is shown on Figure 9.46. The results of the current model scenario are presented on Figure 9.47. The Hydraulic Grade line profile does not show any sanitary sewer surcharges for the planned wet weather event. The modeled Diamond Valley Lift station flow for the peak event is 1532 gpm.

This particular basin is still in the early development stage. As basin development matures, it would be appropriate to monitor the flows during the peak wet weather events. This would allow for future calibration for the model Rainfall Derived inflow and infiltration factors that could impact the allowable contributing area for the Diamond Valley lift station basins.

Figure 9.46 Diamond Valley Profiled Pipe Segments for Current Plan

Figure 9.47 Diamond Valley Profile



9.8.1.15 Basin 26

It is proposed that flows from Diamond Valley and Harrisburg will eventually not be contributing to Basin 26. As mentioned in the previous section, the City anticipates elimination of the Diamond Valley Lift Station around 2036, with flows going to the new Basin 27/28 sewer. The wastewater flow from Harrisburg is planned to be taken directly to Pump Station 240. If these proposed actions are implemented, there will be no projected flow limitations in Basin 26. If, however, they are not implemented, Basin 26 hydraulic limitations would be projected to surcharge due to 2066 flow increases. This problem area would appear to be widespread and impact a large number of pipes. It should be noted, however, that flow monitors were not available for wet weather calibration and therefore RDII characteristics were estimated to be reflective of Basin 5D to the north. Although containing higher than average RDII RTK values, Basin 5D shares the most boundaries with the ESSS and most of the install dates for these sewers in Basin 5D, where available, are in 2002 – 2014 (where the data is provided). Immediate flow monitoring in this area is recommended to determine the extent of the potential capacity problems. This is critical with respect to tying in projected Harrisburg flows.

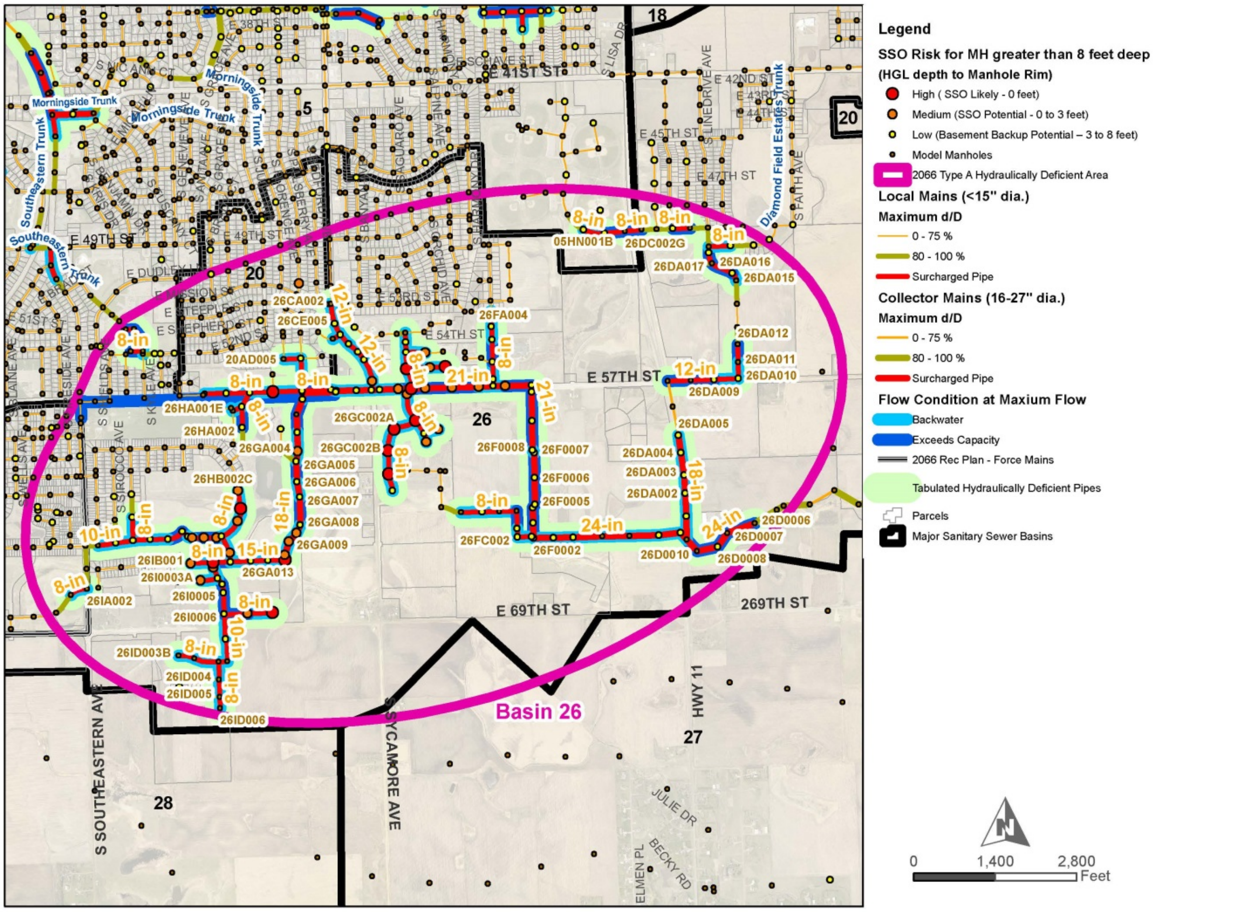
The range in pipe diameters is from 8- to 24-inch for approximately 43,445 feet with the GIS not indicating that pipe lining has taken place. Model results also indicate the potential for SSO risks.

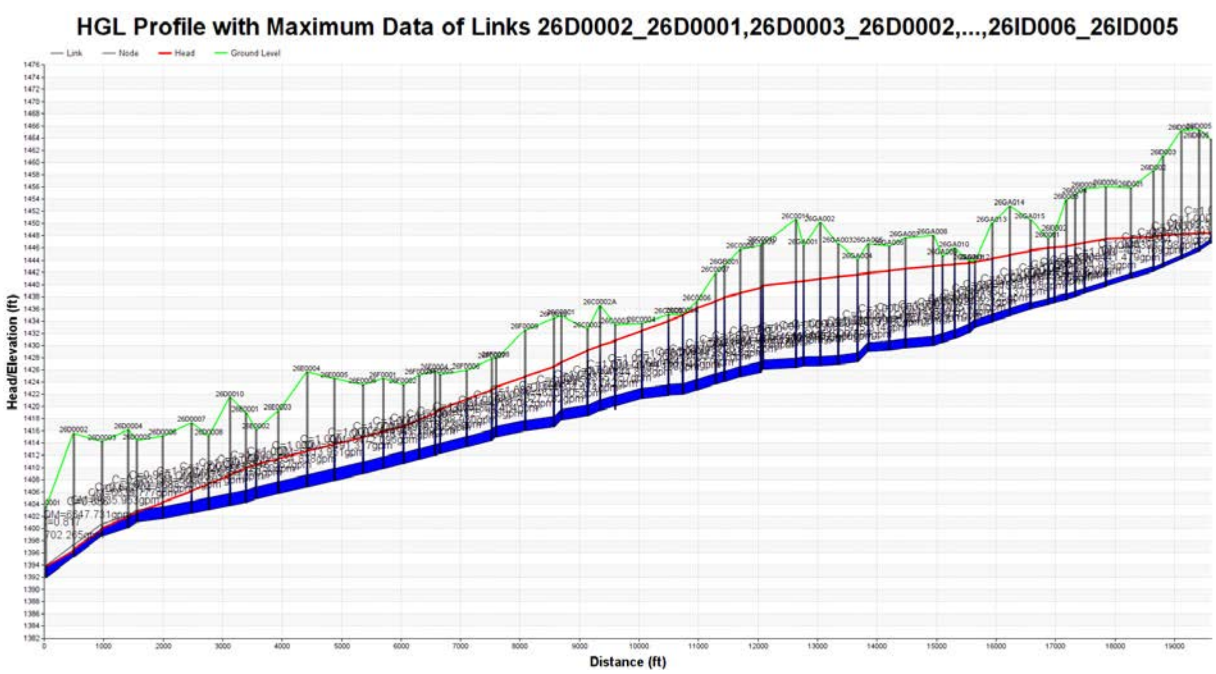
Table 9.45 summarizes the capacity restricted pipes in this problem area. Figure 9.48 provides a map for this Type A area and a representative modeled profile along this line if the Diamond Valley Lift Station remains in Basin 26.

Table 9.45 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Basin 26 Type A Problem Area (If Diamond Valley Lift Station and Harrisburg are not Eliminated from the Basin)

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	3,360	PVC	2008, 2009, 2010, 2012, 2014, 2015
	10	940	PVC	2008
	12	2,510	PVC	2008
	18	1,990	PVC	2008
	21	4,260	PVC	2007
	24	1,415	PVC	2007
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	14,420	PVC	2002, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015
	10	2,310	PVC	2008. 2014, 2015
	12	3,000	PVC, RCP	2008, 2014
	15	1,410	PVC	2008, 2014
	18	3,370	PVC, RCP	2006, 2008
	21	1,760	PVC	2007, 2010
	24	2,700	PVC	

Figure 9.48 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Basin 26 Type A Problem Area (If Diamond Valley Lift Station and Harrisburg are not Eliminated from the Basin)





The Basin 26 Collection System Master Plan included an alternative for the Diamond Valley Pump Station discharging into the Basin 26 Sanitary Sewer through 2066. The Collection System Master Plan also shows Basin 28 gravity sewers extended immediately adjacent to the Diamond Valley Pump Station. Diamond Valley Pump Station serves a Basin 28 subbasin and therefore could be connected to the future Basin 28 sanitary sewer system.

Figure 9.49 and Figure 9.50 present the HGL of the Basin 26 sanitary sewer for the 2066 condition without any Harrisburg impact and without any Diamond Valley contribution.

The figure results from the model indicate there are no areas of surcharge under these conditions.

The draft Master plan indicates that Basin 27/28 sanitary sewer system will be required by 2036 based on the projected growth of Sioux Falls. These Basins are included in growth Tiers 1 and 2.

In summary, the Diamond Valley Pump Station discharge into Basin 26 has a significant impact on the HGL of the Basin 26 sanitary sewer system. Revising the 2066 discharge location from Diamond Valley Pump Station to the Basin 28 gravity sanitary sewer system eliminates surcharge in the Basin 26 sanitary sewer. For planning purposes, the Basin 27/28 sanitary sewer system will be required by 2036. The Diamond Valley Pump Station will be discharged to Basin 26 until Basin 27/28 is fully operational.

Figure 9.49 Harrisburg directly to PS240, Diamond Valley to Basin 28

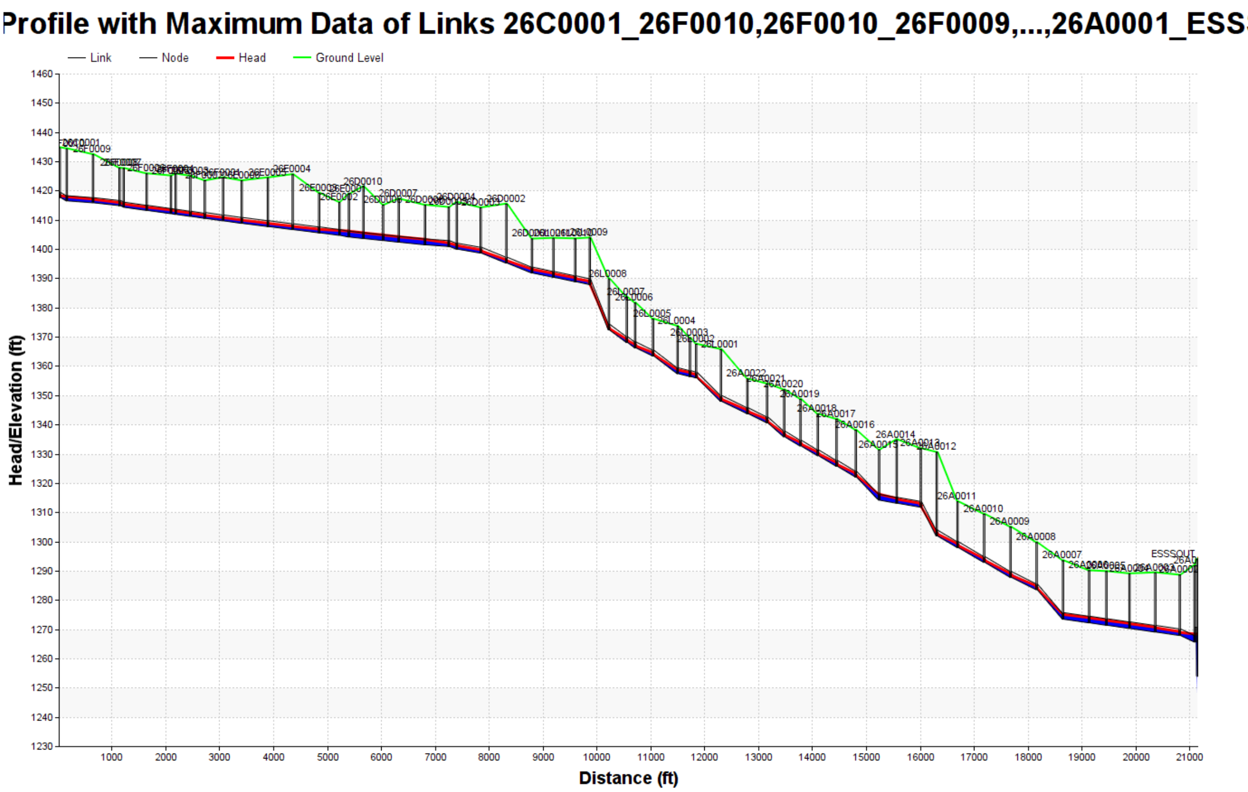
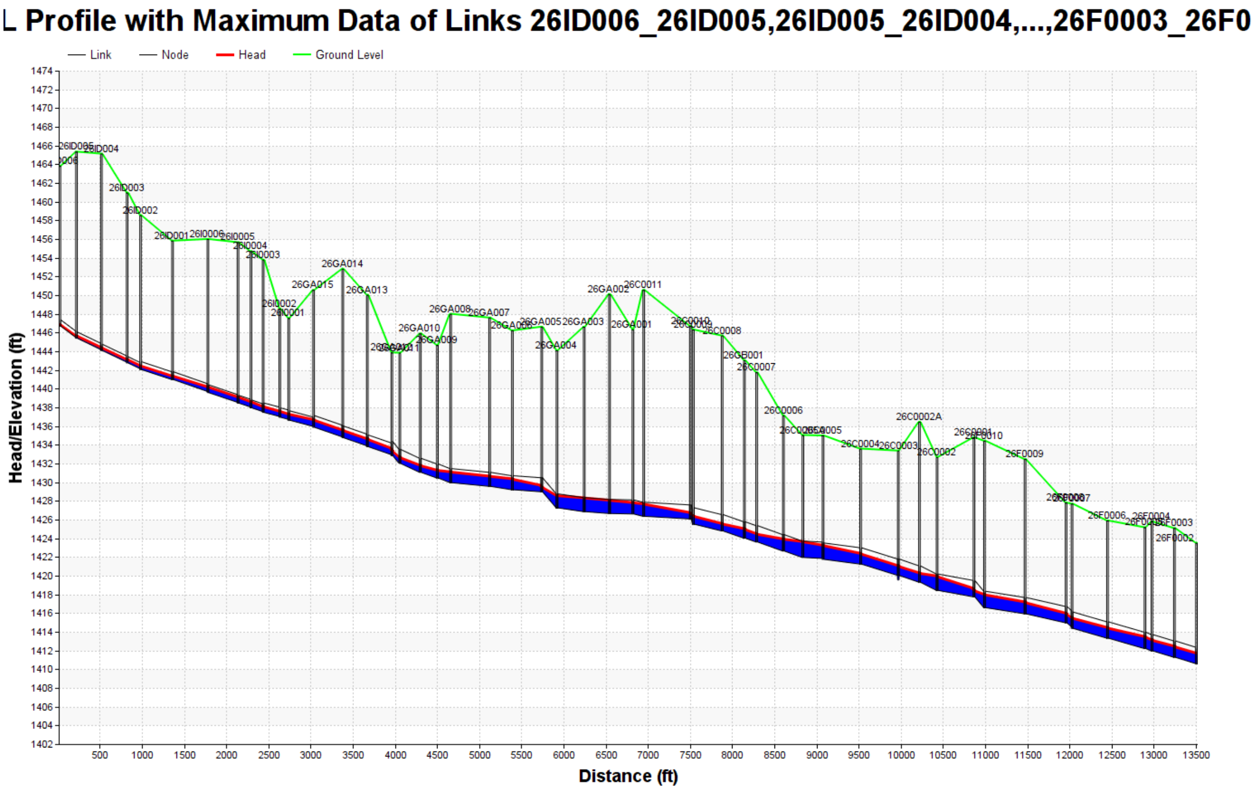


Figure 9.50 2066 Basin 26 Harrisburg directly to PS240, Diamond Valley to Basin 28



9.8.1.16 Rustic Hills Subdivision

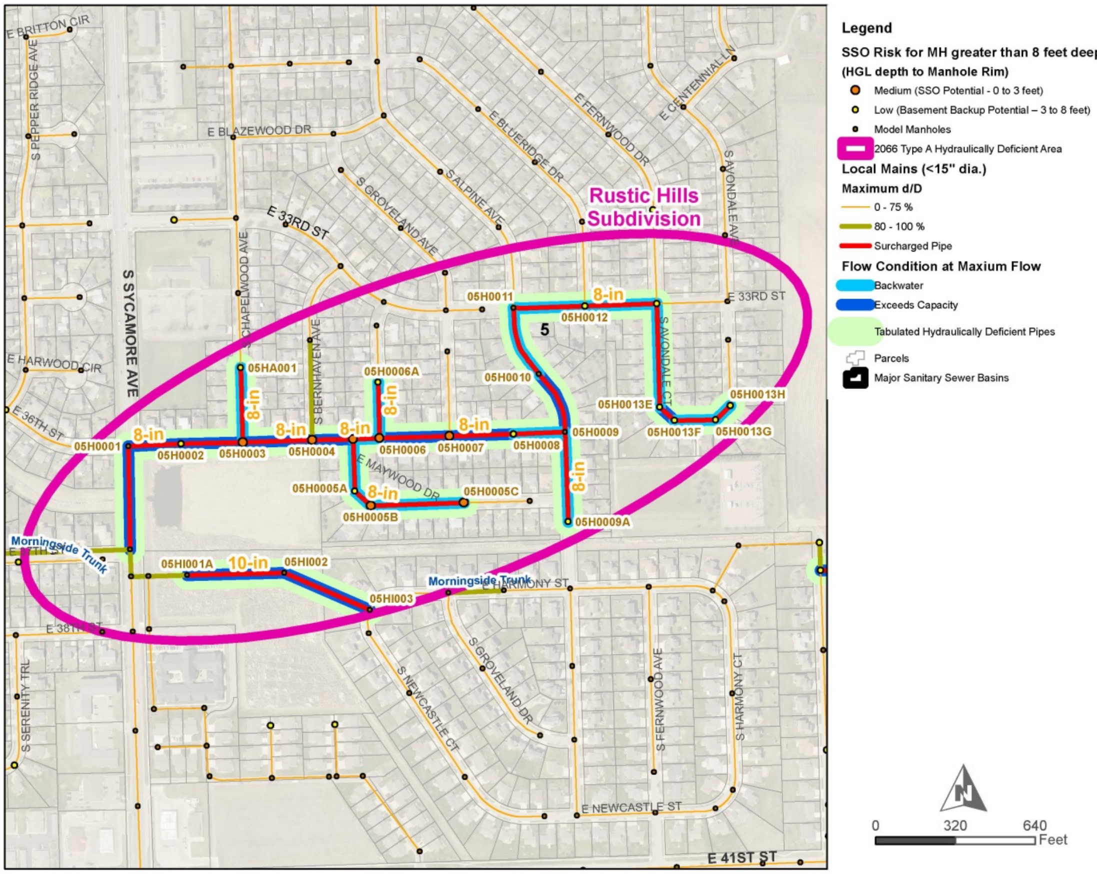
The Rustic Hills Subdivision in Basin 5 has areas of surcharge with projected 2066 flow increases. These surcharges occur along South Sycamore Avenue and East 36th Street and have a fairly widespread impact on surrounding laterals. The range in pipe diameters is from 8- to 10-inch for approximately 6,370 feet with the GIS not indicating that pipe lining has taken place.

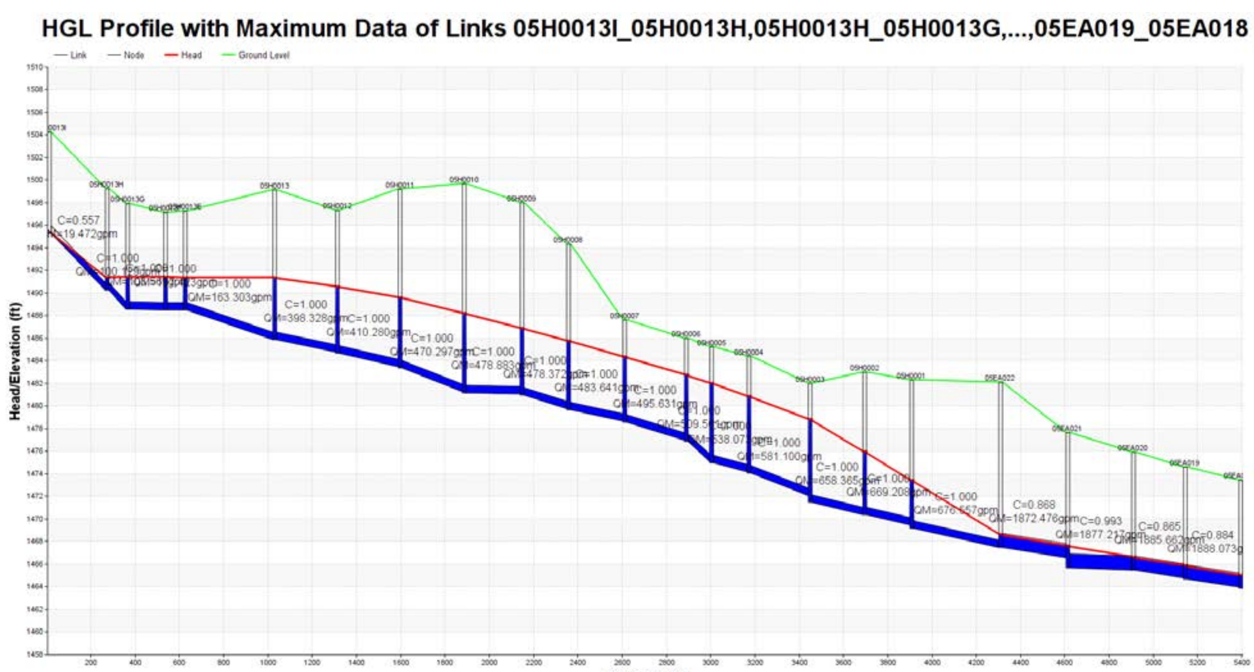
Table 9.46 summarizes the capacity restricted pipes in this problem area. Figure 9.51 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.46 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Rustic Hills Subdivision Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	2,200	PVC, Truss White (PVC), VCP
	10	770	PVC
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	3,400	PVC

Figure 9.51 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Rustic Hills Subdivision Type A Problem Area





9.8.1.16.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

9.8.1.17 Morningside Trunk Extension

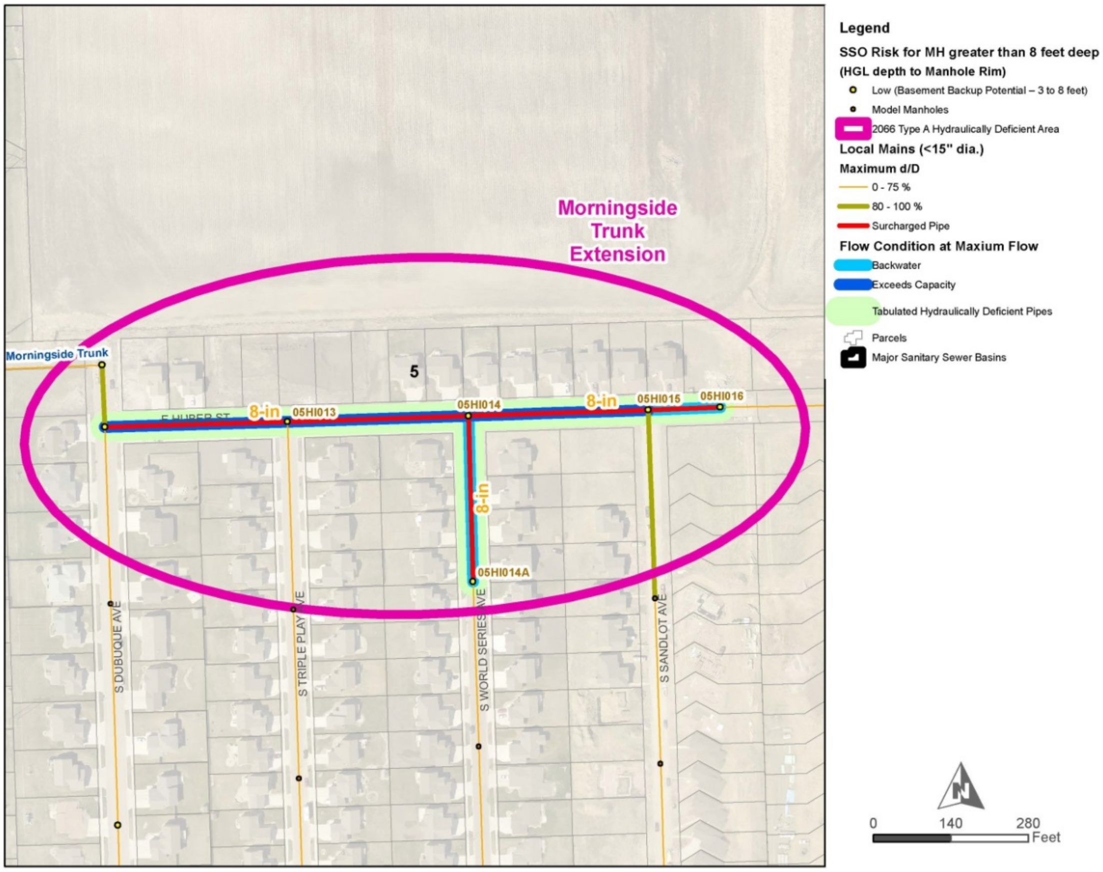
The Morningside Trunk Extension in Basin 5 surcharges with projected 2066 flow increases. These surcharges occur along East Huber Street from South Sandlot Avenue to South Dubuque Avenue. The pipe diameters are 8-inch for approximately 1,420 feet with the GIS not indicating that pipe lining has taken place.

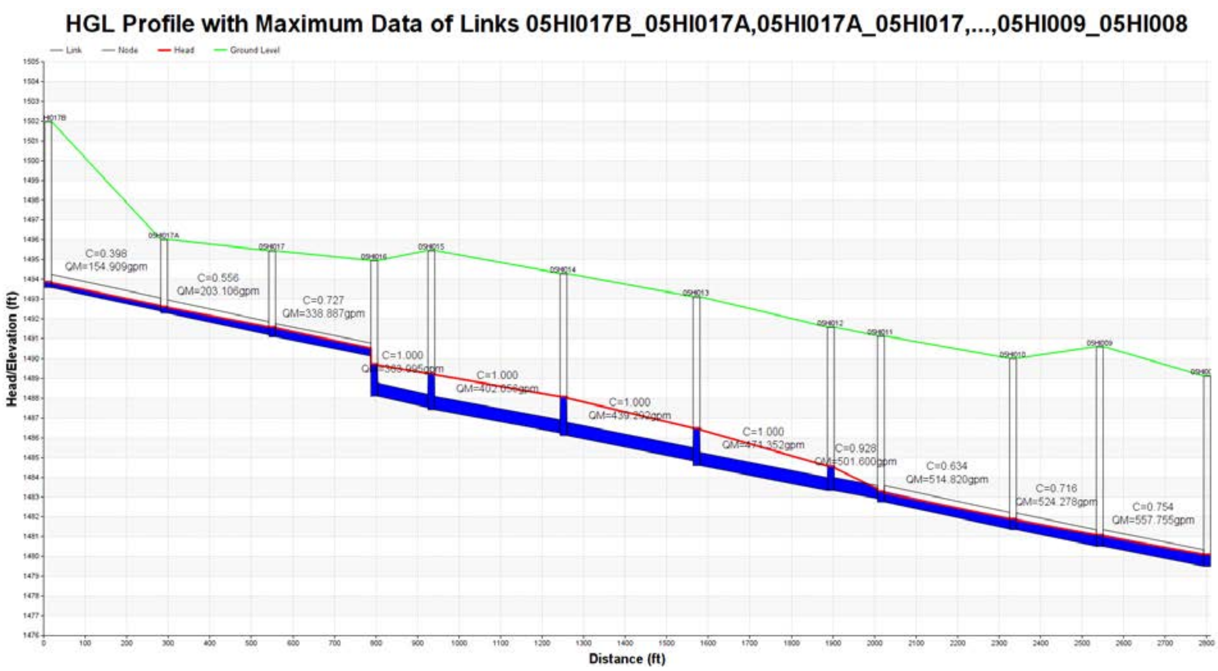
Table 9.47 summarizes the capacity restricted pipes in this problem area. Figure 9.52 provides a map for this Type A area and a representative modeled profile along this line.

Table 9.47 Tiers 1-4, 50-Year Build-out (2066) Conditions Capacity Findings for the Morningside Trunk Extension Type A Problem Area

Description	Pipe Diameter (inch)	Sum of Length (ft)	Pipe Material	Year of Installation
Pipes where Capacity is Exceeded (either surcharging or violating d/D criteria)	8	990	PVC	2010, 2012
Pipes where there is a Backwater Condition (either surcharging or violating d/D criteria)	8	430	PVC	2012

Figure 9.52 Tiers 1-4, 50-Year Build-out (2066) Conditions 25-year, 96-hour Wet Weather Area Map and Pipe Profile for the Morningside Trunk Extension Type A Problem Area





9.8.1.17.1 Recommendations

The model confidence for this area is medium which means the basin data is available but additional localized monitoring is recommended. No CIP projects are developed. I/I reduction is a potential solution.

Also note that this is a low priority as there is limited growth planned in this area. The growth area contributing to the model should be verified with any planned improvements as there appears to be more flow than expected.

9.8.2 Summary of 2066 Collection System Type A Problem Areas

Table 9.48 summarizes the existing collection system Type A problem areas discussed in this section. Not all of the problem areas will require CIP mitigation alternatives depending upon the quality and availability of monitoring data impacting the confidence in the model results as well as the size of pipes impacted.

Table 9.48 Summary of 50-Year Build-out (Future) Collection System Type A Problem Areas

Problem Area	Basin	Length of Capacity Limitation)	Length of Backwater Impact	Flow Monitoring Data Available*	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded
I-90 Place Addition	Basin 9	8-in / 1,280 ft	10-in / 2,250 ft	Medium	No	Yes
Sioux Empire Development Park	Basin 9	15-in / 770 ft 18-in / 700 ft	18-in / 3,530 ft	Medium	No	Yes
Basin 17A Trunk (Lewis Road)	Basin 17	8-in / 6,630 ft 10-in / 3,680 ft 12-in / 420 ft 15-in / 470 ft 18-in / 390 ft	8-in / 10,500 ft 10-in / 1,050 ft 12-in / 810 ft 18-in / 1,880 ft	Low	Yes	Yes
Lower Riverside Trunk Sewer	Basin 3	10-in / 320ft 12-in / 930 ft 15-in / 50 ft	10-in / 330 ft 12-in / 830 ft	High	Yes – similar to existing.	Yes – similar to existing.
Hilltop Trunk	Basin 4	12-in / 2,110 ft	10-in / 330 ft 12-in / 640 ft 15-in / 110 ft	Medium	Yes	Yes
Richmond Estates Trunk	Basin 1	8-in / 2,030 ft	8-in / 1,740 ft	Medium	Yes	Yes
Southeastern Drive	Basin 5	24-in / 2,200 ft	15-in / 380 ft 18-in / 710 ft 24-in / 350 ft	High	Yes	Yes
Pam road (Southside Interceptor)	Basin 8	16-in / 250 ft 18-in / 420 ft	18-in / 620 ft	High	Yes	Yes
Western Interceptor Trunk	Basin 10	24-in / 450 ft 32-in / 180 ft 36-in / 50 ft	24-in / 140 ft 30-in / 10 ft 36-in / 80 ft	Low	Yes	Yes

Table 9.48 Summary of 50-Year Build-out (Future) Collection System Type A Problem Areas

Problem Area	Basin	Length of Capacity Limitation)	Length of Backwater Impact	Flow Monitoring Data Available*	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded
Central Main	Basins 3 and 4	60-in / 450 ft	8-in / 190 ft 18-in / 720 ft 24-in / 710 ft 48-in / 530 ft 60-in / 3,040 ft	High	Yes	Yes
Airport Subdivision	Basin 12	8-in / 2,900 ft 18-in / 800 ft	8-in / 2,080 ft 18-in / 960 ft 21-in / 210 ft	Low	Yes	Yes
12th St and Marion Rd	Basin 11	8-in / 2,510 ft 10-in / 470 ft 12-in / 3,110 ft	8-in / 18,900 ft 10-in / 3,970 ft 12-in / 480 ft	Medium	Yes	Yes
Ebenezer Avenue	Basin 11	8-in / 1,720 ft		Medium	No	Yes
Sioux River North Upstream of PS 215	Basins 10 and 11	10-in / 460 ft 12-in / 1,670 ft 30-in / 1,450 ft 36-in / 430 ft 42-in / 3,990 ft	8-in / 520 ft 10-in / 1,270 ft 12-in / 830 ft 18-in / 950 ft 30-in / 230 ft 36-in / 11,200 ft 42-in / 5,880 ft	High	No	No
Columbia Heights Trunk	Basin 10	8-in / 330 ft 12-in / 1,710 ft	8-in / 850 ft 10-in / 390 ft 12-in / 1,130 ft	Low	Yes	Yes
17th, 18th, and 19th Streets	Basin 10	8-in / 150 ft 10-in / 600 ft	8-in / 40 ft 10-in / 820 ft	Low	Yes	Yes
30th Street and Lake Avenue	Basin 8	8-in / 660 ft	8-in / 260ft 12-in / 340 ft	Medium	Yes	Yes
I-229 Trunk	Basin 7	12-in / 650 ft	12-in / 410 ft	Medium	No	No
Sioux River South	Basins 6 and 7	48-in / 400 ft 54-in / 180 ft	10-in / 480 ft 15-in / 750 ft 24-in / 1,030 ft 36-in / 2,080 ft 48-in / 530 ft 54-in / 14,330 ft	Medium	No	Yes
Rustic Hills Subdivision	Basin 5	8-in / 2,200 ft 10-in / 770 ft	8-in / 3,400 ft	Medium	Yes	Yes
Morningside Trunk Extension	Basin 5	8-in / 990 ft	8-in / 430 ft	Medium	Yes – Verify contributing area in the model.	Yes - Verify contributing area in the model.

*High – Data sufficient to make CIP recommendations
Medium – Basin data available but localized monitoring data needed
Low – Data not available and insufficient to make CIP recommendations

Table 9.49 Collection System – Type A Deficient Areas Grouped by Priority Tier

Problem Area	Basin	Flow Monitoring Data Available*	CIP	2015 Problem Area? d/D Exceeded	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded	Problem Extent**	SSO Risk***	Lateral Backup Risk****	Priority Tier
Type A, Tier 1 Hydraulically Deficient Areas Areas where Model Confidence is Medium or High and Pipe Diameters are 18 Inches and Greater										
Lower Riverside Trunk Sewer	Basin 3	High	Further Monitoring	Yes	Yes	Yes	Medium	High	High	Tier 1
Central Main	Basins 3 & 4	High	Further Monitoring	No	Yes	Yes	Medium	Medium	Low	Tier 1
Southeastern Drive	Basin 5	High	Yes	Yes	Yes	Yes	Medium	Low	Low	Tier 1
Sioux River North Upstream of PS 215	Basins 10 & 11	High	Yes	No	No	No	High	Low	Low	Tier 1
Pam Road (Southside Interceptor)	Basin 8	High	No – Investigate profile via survey.	Yes	Yes	Yes	Low	Low	Low	Tier 1
Sioux River South	Basins 6 & 7	Medium	No	No	No	Yes	Medium	Low	Low	Tier 1
Richmond Estates Trunk	Basin 1	Medium	Yes	Yes	Yes	Yes	High	High	High	Tier 1
Type A, Tier 2 Hydraulically Deficient Areas Areas where Model Confidence is Medium and Pipe Diameters are Less than 15 Inches NO CIP Projects Alternatives are Developed Areas Should be Monitored and be a Target for I/I Reduction										
I-90 Place Addition	Basin 9	Medium	No	No	No	Yes	Medium	Low	High	Tier 2
Sioux Empire Development Park	Basin 9	Medium	No	No	No	Yes	High	Low	Low	Tier 2
Hilltop Trunk	Basin 4	Medium	No– monitor and target for I/I reduction	Yes	Yes	Yes	Low	Medium	High	Tier 2
12th St and Marion Rd	Basin 11	Medium	No – monitor and target for I/I reduction	Yes	Yes	Yes	High	Medium	Medium	Tier 2

Table 9.49 Collection System – Type A Deficient Areas Grouped by Priority Tier

Problem Area	Basin	Flow Monitoring Data Available*	CIP	2015 Problem Area? d/D Exceeded	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded	Problem Extent**	SSO Risk***	Lateral Backup Risk****	Priority Tier
Ebenezer Avenue	Basin 11	Medium	No	No	No	Yes	Low	Low	Medium	Tier 2
30th Street and Lake Avenue	Basin 8	Medium	No	No	Yes	Yes	Low	Low	High	Tier 2
I-229 Trunk	Basin 7	Medium	No	No	No	No	Low	Medium	Low	Tier 2
Rustic Hills Subdivision	Basin 5	Medium	No	No	Yes	Yes	High	Low	Medium	Tier 2
Morningside Trunk Extension	Basin 5	Medium	No	No	Yes	Yes	Medium	Low	Low	Tier 2
Type A, Tier 3 Hydraulically Deficient Areas Areas where Model Confidence Low NO CIP Projects Alternatives are Developed Flow Monitoring Data Should be Obtained with the Capture of a Significant Wet Weather Event										
Basin 17A Trunk (Lewis Road)	Basin 17	Low	No	Yes	Yes	Yes	High	High	High	Tier 3
Western Interceptor Trunk	Basin 10	Low	No	Yes	Yes	Yes	Medium	Low	Low	Tier 3
Airport Subdivision	Basin 12	Low	No	Yes	Yes	Yes	High	High	High	Tier 3
Columbia Heights Trunk	Basin 10	Low	No	No	Yes	Yes	High	Medium	High	Tier 3
17th, 18th, and 19th Streets	Basin 10	Low	No	No	Yes	Yes	Medium	Low	Low	Tier 3

Flow Monitoring Data Available *
High – Data sufficient to make CIP recommendations
Medium – Basin data available but localized monitoring data needed
Low – Data not available and insufficient to make CIP recommendations

Problem Extent**
High – Hydraulic deficiency impacts a large number of pipes
Medium – Hydraulic deficiency impacts a more than 3 pipe segments but less than 8 number of pipes
Low – Hydraulic deficiency impacts a less than 3 pipe segments

SSO Risk***
High – SSO likely
Medium –SSO potential
Low – basement backup potential

Lateral Backup Risk****
High – Hydraulic deficiency likely to impact lateral
Medium – Hydraulic deficiency may impact laterals
Low – Hydraulic deficiency not likely to impact laterals

9.8.3 2066 Collection System Type A Problem Areas

All capacity limited pipes in Figure 9.32 that are not contained in a Type A area represent a Type B problem area or condition. Type B areas are isolated under capacity pipes that are not hydraulically connected to other problem locations.

Type B problems often result from isolated flat pipe slopes limiting the capacity of single pipe segments. Type B areas are locations where CCTV, localized flow monitoring, and invert survey are recommended to validate the problem extent before any design is begun. Based on the results from the capacity validation activities and actual upstream growth, they could be considered for capacity increases if necessary. In areas of the system with little upstream growth and future additional flow, some of the Type B problems may be addressed through decreased RDII contribution as the local and local collector systems are rehabilitated. Neither pipe improvement alternatives nor costs were developed for Type B problems.

9.8.4 I/I Reduction Strategy

The City is committed to an I/I reduction program. However, I/I reduction was not included as a modeled solution.

Reducing areas of high I/I can be an effective means to free up sewer main capacity, especially in areas of little upstream development potential. This section will briefly describe both the model and implementation approach to I/I reduction should further evaluation be desired for future projects.

9.8.4.1 I/I Reduction Strategy – Modeling

To simplify an approach to I/I reduction, the overall volume of I/I would be the focus of the analysis, which translates to the ‘R’ in the RTKs values used to estimate RDII contributions. For most areas, R can be reduced up to 10 percent to 25 percent. However, there is a diminishing return on investment that needs to be considered. Eventually the costs associated with treating high volumes of RDII exceed the costs of capacity improvements. The general approach for I/I reduction candidate areas and associated steps are as follows:

1. Address worst performing sewer basins first:
    a. Basins with the greatest percent of GWI and RDII
    b. Basins with the highest number of sump pumps
    c. Basins with the worst observed condition
    d. Basins with the most capacity constraints and limited future development
2. Modeling approach for these basins:
    a. Assume in modeling that 10 to 25 percent removal possible (in actuality, 10 to 50 percent removal could be possible) by reducing the RDII volumes (R in RTK)
    b. Consider removing known sump pump contributions and determine a reasonable timeframe in which to do so (in the next 5 years?)
    c. Assume a 25 percent reduction in a 10 year period for the top 5 worst performing basins that were calibrated for RDII.

d. Assume a 10 percent reduction in a 10 year period for the next 5 basins that were calibrated for RDII.

To illustrate the impact of I/I reduction, the model was executed with a system wide R (inflow volume in the RTK method) reduction of 15 percent. 15 percent represents the minimum reduction that should be achievable through I/I reduction methods. While model results illustrate that this reduction alone will not solve any of the Type A problem areas entirely, it can reduce the extent of deficiency. I/I reduction can also mitigate some of the isolated Type B problem areas.

9.8.4.2 I/I Reduction Strategy – Implementation

To implement I/I reduction, the following are suggested:

- Begin with worst performing basins for GWI and RDII
- Remove sump pumps and roof drain connections from system
- Flow monitoring before and after rehabilitation on sewer basin / sub-sewer basin levels to determine the reduction in RDII volume
- Combine flow monitoring data with condition inspection data
- Pipe CIPP lining and defect repair
- Address manholes and laterals connections with pipe CIPP
- Consider private I/I reduction program (public outreach, rebates for lateral inspection/rehabilitation, etc.)
- Develop Public and Private I/I Reduction Programs and Toolboxes of Inspection and Corrective Action Options

9.9 Summary Existing System Improvements for Tiers 1-4, 50-Year Build-out (2066) Conditions

Based on the model development described in Chapter 5, the existing collection system was analyzed for hydraulic limitations under existing and future conditions. However, the problem extents in the 2026 and 2036 planning years were also examined (Table 9.50). For most of the Type A, Tier 1 areas, the 2026 problem areas are the same as the 2066 planning year.

Table 9.51 summarizes the existing system improvements based on 2066 projected flows. Future development expansion scenarios were also analyzed with a preferred alternative developed for each planning year.

Table 9.50 Problem Extent Comparisons for Type A, Tier 1 Problem Areas Between Planning Years

Problem Area	2015	2026	2036	2066
Lower Riverside Trunk Sewer	Problem extent restricted to a few pipes	Problem extent similar to 2015	Problem extent similar to 2015	Problem extent similar to 2015
Central Main	No issue	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem
Southeastern Drive	Problem extent restricted to a few pipes	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem

Table 9.50 Problem Extent Comparisons for Type A, Tier 1 Problem Areas Between Planning Years

Problem Area	2015	2026	2036	2066
Sioux River North Upstream of PS 215	No issue	Backups start	Backups get worse	Backups get worse
Pam Road (Southside Interceptor)	Existing Problem (not as extensive as 2066)	Problem extent adds a pipe	Problem extent similar to 2066	2066 Problem
Sioux River South	No issue	d/D criteria gets violated	Some surcharging close to LS	Surcharging along the line with no impact to sewer laterals.
Richmond Estates Trunk	Problem extent similar to 2066	Problem extent similar to 2066	Problem extent similar to 2066	2066 Problem

Table 9.51 Summary Existing System Improvements for Tiers 1-4, 50-Year Build-out (2066) Conditions

Problem Location	Existing Pipe diameter(s)	Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size	CIP Cost Developed
Lower Riverside Trunk Sewer	10-,12-,15-inch	21-inch	657	Need to monitor degree of surcharge and necessary repairs -there is no appreciable change in flow from 2013 to 2066 from growth. Problem area remains without John Morrell flows. However, primary impact is permitted point load discharge from John Morrell which is not currently utilized.
		24-inch	332	
		36-inch	47	
Central Main	8-, 18-, 24-,48- and 60-inch	60-inch	369	None – Continue to monitor and evaluate; no impact to adjacent services
		66-inch	2,458	
		72-inch	536	
Southeastern Drive	15-,18- and 24-inch	CIPP Lined	2,926	Yes – CIP is lining and allow minimal surcharging along profile; no impact to adjacent services
Sioux River North Upstream of PS 215	8-,10-,12-,18-, 30-, 36-, and 42-inch	1.6 MG of Equalization Recommended – Long-term.		Yes
		15-inch	460	
Pam road (Southside Interceptor)	18-inch	18-inch	428	None – flow can be relieved at Duluth, surcharging will continue to surcharge along profile
		24-inch	540	
Sioux River South	10-, 15-, 24-, 36-, 48-, and 54-inch	2.4 MG of Equalization would be required to eliminate surcharging. Not recommended as there is no impact to service laterals.		None - no impact to adjacent services

Table 9.51 Summary Existing System Improvements for Tiers 1-4, 50-Year Build-out (2066) Conditions

Problem Location	Existing Pipe diameter(s)	Diameter(s)	Project Extents: Pipe Length per Diameter Size	CIP Cost Developed
Richmond Estates Trunk	8-inch	12-inch	1,990	Yes

Chapter 10 – Summary of the WRF Plant of the Future

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Table of Contents

Tables

Figures

Appendices

Chapter 10 Summary of the WRF Plant of the Future

This chapter presents the recommended improvements along with a preliminary capital improvements plan that reflects the timing for the following needs:

- Provide reliability and avert risk for failure,
- Improve treatment operations,
- Increase hydraulic and/or organic capacity for growth,
- Meet future regulations along with growth.

The recommended WRF plan provides a long-term master plan for ultimate expansion of the plant, while identifying a phased construction program to meet capacity and treatment requirements for the next 20 years. The plan will be refined as part of preliminary design efforts with project costs to match the further defined scope(s).

The City requested evaluation of alternative phasing considerations to better match capital spending with anticipated revenue. This further adjusted phasing is addressed in the executive summary Section ES 5.6.

The most notable technology-based changes are the long-term switch to Biological Nutrient Removal to meet new regulations, the recommended change by the addition of FOG handling facilities to improve WRF's energy sustainability and biosolids dewatering to improve operability and practicality of the sludge handling operation. All of the recommended improvements involve conventional, commonly used wastewater treatment technologies.

Chapter 3 -Existing Wastewater System Facilities contains a summary of the age and condition related needs, recommended operational improvements and organic and hydraulic capacity related limitations. For further information on individual work items, refer to the Condition Assessment Technical Memorandum, which provides comprehensive descriptions for the recommended facility age and condition and operational improvements along with detailed cost breakdowns.

The growth/regulatory related capacity needs were considered and projects were identified for liquid treatment and solids handling in Chapters 7 and 8, respectively.

10.1 WRF Drivers for Improvements

Based on the alternative evaluation that includes factor weighting, alternative scoring and cost-benefit development, the preferred alternative for this project is Alternative 1-1, 5-Stage Bardenpho Biological Nutrient Removal at WRF. This alternative is comprised of expansion of activated sludge to provide biological nutrient removal for phosphorus and nitrogen and further polishing with chemical phosphorous removal, final clarification, tertiary filtration and chlorine contact basin expansion.

When fully constructed, the Alternative 1-1 biological nutrient removal and polishing scheme will provide treated effluent of a quality suitable to meet the expected ammonia, total nitrogen and total phosphorus design effluent criteria.

1. The long term recommended improvements and ultimately the capital improvements plan envisions the capital improvements described in the following sections. The implementation programming is designed to provide timely construction of the necessary improvements at the plant by integrating preliminary design for all projects required by 2025, also referred to as Phase 1 project improvements. The recommended liquid process improvements are those that will be necessary to meet the federally adopted ammonia criteria. At this point, Phase 1 ammonia removal and related solids handling improvements would need to be constructed by 2025 to meet expected growth.

Included in the Phase 1 projects are the liquid and solids plant process improvements, "reliability" improvements, and FOG facilities as FOG becomes available.

2. The improvements address treatment capacity upgrades for treatment through 2036 along with the other noted high and medium priority reliability improvements. Phase 1 liquid improvements generally include screenings, primary clarifier influent diversion facilities, increased activated sludge, filtration and chlorine contact capacity. The trickling filter train will continue to be used until nutrient removal regulations are in place. However, due to timing, a Phase 1a project needs to be constructed immediately including grit influent piping, diversion of peak flows directly from grit removal to the aeration basins and incorporating step-feed into the aeration basins. Also included in Phase 1a is rehabilitating the final clarifiers and existing filtration high priority items, and new biosolids dewatering/handling improvements.
3. Biosolids handling improvements are recommended, as detailed in Chapter 8. The biosolids handling improvements address sludge thickening, post-digestion storage, dewatering, thermal drying and dewatered and dried sludge storage.

Anticipating that regulatory requirements will change in the future, the plan provides flexibility to incorporate the plan in phases and also includes provisions for future process changes. No costs are allocated in the long-term improvement program for potential future needs beyond the WRF Design Criteria stipulated in the following section.

10.1.1 WRF Design Criteria

The design criteria for the proposed WRF Improvements are based on flow and loading data from the existing WRF while using the flow and loading assumptions for new growth, which is fully described in Chapter 4. Projected flows are summarized in Table 10.1.

Table 10.1 Projected Flows

Area	2013 to 2015 Ave	2021	2026	2031	2036
	Flow MGD	Flow MGD	Flow MGD	Flow MGD	Flow MGD
Average Day	16.1	22.2	23.8	27.2	30.1
Maximum Month	23.7	31.1	34.0	38.7	42.7
Equalized Peak	35	35	50	57	57

Projected design year 2036 flows and loads are summarized in Table 10.2.

Table 10.2 Option 1: Expand Existing WRF 2036 Design Year Flows and Loads

	Flow	BOD	TSS	NH3-N	TKN
	MGD	lb/d	lb/d	lb/d	lb/d
AADF	30.1	66,700	65,200	7,200	11,700
MMF	42.7	75,000	81,600	8,300	13,200
	MGD	mg/L	mg/L	mg/L	mg/L
AADF	30.1	265	259	29	46
MMF	42.7	210	229	23	37

AADF: Annual Average Day Flow

MMF: Maximum Month Flow

Prospective effluent limits are summarized in Table 10.3.

Table 10.3 Prospective Effluent Limits

	Ammonia (Permit #2) 30-day Average / Daily Max mg/l	BOD/TSS 30-day Average / Max. 7-Day mg/l	Dissolved Oxygen (D.O.) mg/l	E. Coli. Limit Colonies / 100 milliliters[3]	Total Nitrogen (TN) Permit #3 Max. Month mg/l	Total Phosphorus (TP) Permit #3 Max. Month mg/l
January - March	2.1	30/45	5.5	126	10	1
April - August	1.0	30/45	5.0	126	10	1
September - October	1.3	30/45	5.0	126	10	1
November - December	2.1	30/45	5.5	126	10	1

Note:
pH limits are 6.5-9.0.
Total Residual Chlorine (mg/L) are not measurable (≤ 0.1).
Current Fecal Coliform limit is 200 Colonies / 100 milliliters.

The basis for the prospective effluent limits is presented in detail in Chapter 6. All prospective effluent limits should be thoroughly reviewed, when permits are issued, with action items listed in Chapter 6 in mind i.e. evaluate if incorporating river flow based and mass vs. concentration limits are beneficial to the WRF.

10.1.2 Regulatory Triggers

Table 10.4 identifies the anticipated regulatory activity, which were considered and identified in Chapter 6 Regulatory Planning. The regulatory timeline reflects the anticipated schedule for approval and implementation of nutrient standards.

Table 10.4 Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit	NA	Plan for anticipated more stringent ammonia standards. Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability.
		Schedule for construction –major projects will be dependent upon issuance of a new discharge permit and its compliance schedule.
		Proactively evaluate if incorporating river flow based and mass vs. concentration limits are beneficial to the WRF.
Permit #1 2022	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Phase 1a and Phase 1 Project to be constructed by 2021 and 2025, respectively.
Permit #2 2027	New Ammonia Standards	Assuming required improvements for ammonia removals complete.
		Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2029.
Permit #3 2032	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty.
		Track potential proposed changes in the nutrient standards.
Permit #4 2037	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

The above permitting schedule reflects discussions with SD DENR and progress in similar states.

10.1.3 Reliability Improvements

A condition assessment of the WRF was conducted to determine the estimated remaining useful life of the facilities' components and was documented in Chapter 3 - Existing Wastewater System Facilities. The condition assessment included review of the following areas:

- Process equipment and operation
- Architectural condition
- Structural condition
- Mechanical condition
- Electrical condition
- Instrumentation condition

Based on the assessment, the WRF is in generally good condition; however, the WRF has facilities that are over 30 years old and have significant signs of age related deterioration. As part of the condition assessment, a schedule for replacement and/or renovation was developed. The drivers for the schedule are the estimated remaining useful life, reliability, and risk of failure for each item and coordination with future improvements.

It is prudent to continue to maintain and replace equipment as required rather than schedule complete replacement if that equipment is going to be obsolete in the future plans for the facility. For example, it would not be prudent to invest in additional trickling filter intermediate clarifier capacity, as future nutrient standards will drive replacement of the trickling filters with activated sludge process capacity as currently envisioned.

It is recommended that the estimated remaining useful life of items be reviewed annually and the replacement/renovation schedule revised accordingly.

Appendix Table A.10.1 categorizes age and condition driven needs determined by onsite condition assessment which are reflected in Chapter 3 and described in detail in the associated appendices. Within the guidelines presented in that chapter, it also presents the timeline and incorporates an order of magnitude budget in terms of project costs for each.

Improvements for the existing aging facilities were identified from the WRF condition assessment and reliability review were ranked with a priority system based on the following rankings.

- High Priority (0 – 5 Years) Capital Improvements: High priority items are recommended to be addressed immediately and completed within the next 5 years (2017 – 2021) as the CIP budget allows. These are improvements required to reliably continue to treat the flow to meet the current permit. These improvements address items such as safety, treatment and hydraulic capacity items, reliability, operations and energy minimization.
- Medium Priority (5 – 10 Years) Capital Improvements: Medium priority items are to be completed by 2026. These are phased improvements required to reliably continue to treat the flow to meet the current permit. These improvements also address safety, treatment and hydraulic capacity items, reliability, operations and energy minimization but were allocated at least five more years of life.
- Low Priority Plant Modifications to meet Other Needs: Low Priority improvements that are necessary to continue to meet the needs for the WRF to operate

effectively and meet the effluent permit limits. These items have been given Low Priority designations due to the remaining life. Low priority items are planned for completion in 2027 – 2036. These items should be monitored during project planning, as it may be prudent to include various items in larger projects to take advantage of the economy of scale.

The high and medium priority items will be included in Phase 1 improvements, as both high and medium items need to be constructed by 2025.

Select high priority items including grit influent piping and primary clarifier influent diversion structure and piping will be included in the Phase 1a project in order to provide the required hydraulic capacity to pass the peak flow events. Also included in Phase 1a is rehabilitating the final clarifiers and existing filtration high priority items, and new biosolids dewatering/handling improvements.

10.2 Recommended WRF Improvements

This section presents the recommended facility improvements for the proposed WRF. The ultimate liquids treatment scheme is comprised of influent screening, grit removal, primary clarification, nutrient removal using the 5-Stage Bardenpho process for nitrogen and phosphorus removal, final clarification, filtration, and chorine disinfection improvements.

Note that building numbers have been included with each itemized improvement as referenced from Figure 10.1.

For process residuals, onsite solids handling includes thickening followed by anaerobic digestion. Following digestion, biosolids handling and disposal consists of dewatering via screw presses followed by thermal drying for Class A sludge to be disposed on the current land application sites and a portion through potential sale for domestic use.

For visual reference, the site layout for the proposed WRF is shown in Figure 10.1 and the process flow diagram for the proposed WRF is shown in Figure 10.2.

The specific improvements are designed to provide adequate capacity for the projected 20-year nominal 2036 planning year average flow of 30.1mgd, maximum month flow of 42.7 mgd and peak equalized flow of 57 mgd. The equalization volume included at the WRF assumes that a new 20 million gallon basin is constructed at the Chambers and Cliff site.

Note that costs have been rounded and are in terms of 2016 project costs with the exception of the FOG and Microturbines projects, which are in 2013 dollars.

Phase 2 improvements are included for new screenings and grit removal followed by new primary clarifiers. These recommended 20-year and beyond improvements allow for the elimination of a secondary pump station. The design duty point for all existing pump stations/forcemains discharging into the new facilities would have to be reevaluated to add the roughly 6 feet of additional head required to flow through these facilities. These facilities are shown as dashed as they are not included in the 20-year CIP planning costs.

10.2.1 General Civil/Site

The Phase 1 improvements include clearing and grubbing, earthwork, erosion control, site drainage, site demolition, new roadways, new concrete sidewalks, site fencing, additional site lighting, site restoration, and any required modifications to the site utilities required to install the new secondary treatment facilities. The nonpotable water system will be extended to the new basins with yard hydrants for wash down. Influent and effluent piping to the proposed treatment processes are included in unit process cost estimates.

Phase 1 Cost $3,500,000

10.2.1.1 General Civil/Site: Medium Priority Items

Additional recommended medium priority improvements include removal and replacement of the concrete roadway pavement throughout the WRF. Removal of existing concrete sidewalks and replacement with minimum 6 feet wide sidewalks. Removal of the steps in the sidewalks by the Filter Building, from the Primary Clarifiers to the Digester Building, and at Manhole No. 8 and No. 10 and reconfiguring the sidewalks considered, allowing removal of the steps.

Site Construction Medium Priority Cost......................................$5,700,000

10.2.1.2 Site Electrical: High Priority Item

A high priority item is to replace the electrical duct bank feed loop from the activated sludge side of the plant.

Site Electrical High Priority Cost..$420,000

10.2.2 Cliff and Chambers Equalization and Waste Receiving

Equalization at Cliff and Chambers is currently 12 million gallons with an additional 20 million gallons in the process of being designed for a total of 32 million gallons.

Cliff and Chambers improvements include the following:

- Construct 20 million gallons of additional equalization.
- Expand building to cover dumping pits.
- Replace MCC.
- Replace light fixtures in Bldg.
- Replace conduit supports in clarifier basin.
- Expand and upgrade facilities.

The majority of the scope of these facility upgrades is included in an active project and is being refined as part of that project.

Cliff and Chambers Site High Priority Cost $8,400,000

10.2.3 WRF Equalization

Equalization improvements include converting the existing biosolids lagoons to equalization basins at the WRF. A total of 47 million gallons of equalization is required including Cliff and Chambers. With 32 million gallons at Cliff and Chambers, a 15 mg equalization basin is required at the WRF.

Preliminarily WRF improvements include the following:

- Construct 15 million gallons of equalization within the existing biosolids basin.

- Construct tee and isolation valve at 42-inch forcemain.
- Construct an automated valve to equalization basins.
- Construct a dry-pit style 7 mgd return pump station complete with valving and metering to 42-inch forcemain.
- Update gate controls at headworks structure.
- Update SCADA for coordinating Main Pump Station metering with headworks metering to provide a set diversion rate.

WRF Equalization High Priority Cost..$6,900,000

Peak flows should continue to be monitored to determine if improvements to these processes need to be budgeted for in long-term planning.

10.2.4 Preliminary Treatment (Headworks) (Building #3)

10.2.4.1 Fine Screening

The recommended Phase 1 Improvements for preliminary treatment for the WRF will consist of new higher capacity fine screens installed in a new Grit and Screenings Building. Phase 1 will also include new grit removal followed by new primary clarifiers to eliminate secondary pumping in the long-term.

WRF Screenings Improvements Cost $6,300,000

If funding does not allow for new headworks facilities, the Phase 1 Interim Improvements for preliminary treatment for the WRF will consist of new higher capacity fine screens installed in the existing Grit and Screenings Building.

WRF Screenings Rehabilitation Improvements Cost $2,100,000

10.2.4.2 Grit Removal (Headworks) (Building #3)

The purpose of grit removal is to remove particles that cannot be decomposed by the treatment process and that may damage pumps or other machinery in downstream processes. At the WRF, grit removal includes an aerated grit removal system. The grit that settles into the hopper is removed by grit pumps. The design capacity for the grit removal is sufficient as it is in excess of 70 mgd, as presented in Chapter 3.

The recommended Phase 1 Improvements for preliminary treatment for the WRF will consist of new higher capacity grit removal installed in a new Grit and Screenings Building. Improvements will also include new grit removal followed by new primary clarifiers to eliminate secondary pumping in the long-term.

Phase 2 WRF Grit Improvements Cost .... …$8,300,000

Phase 1a improvements will include increasing the grit tank influent piping size to provide for 60+mgd as currently this piping is a critical hydraulic bottleneck.

Phase 1a Grit Building (Headworks) Influent Pipe Cost......$1,670,000

If funding does not allow for new headworks facilities, the Phase 1 Interim Improvements for preliminary treatment for the WRF will consist of rehabilitating the following in the existing Grit and Screenings Building:

- Sampler and Piping
- Grit Chambers/Control Gates
- Concrete Floor Rehabilitation
- Building Structure Miscellaneous Rehabilitation
- New Concrete Stairway and Railing
- Electrical Rehabilitation
- Replace Grit Blowers #1 and 3
- Replace grit piping and valves

Grit Building (Headworks) High and Medium Priority Items $1,250,000

10.2.4.3 Influent Sampling

Influent sampling will be modified to be flow proportional and the sampling equipment will be removed and replaced as part of normal maintenance.

10.2.5 Primary Treatment

Primary treatment for the WRF will continue the physical removal of solids from the influent wastewater with the existing conventional primary clarifiers.

10.2.5.1 Primary Clarifiers (Building #5)

Screened wastewater contains suspended solids that have not yet settled out due to the turbulence of the process stream. Passing the wastewater through a conventional clarifier slows down the flow rate and allows the heavy particles to settle to the bottom where sludge rakes operate to remove the settled sludge. Conventional clarification not only removes the readily settleable solids but also the floating materials through surface skimmers. Overflow weirs allow the clarified liquid stream to pass to the next downstream process. Approximately 50 to 70 percent of the suspended solids and 25 to 60 percent of the BOD are removed in the primary clarifiers.

The primary clarifiers have a rated capacity of 35 mgd. The proposed plan is for Grit Basin effluent in excess of 35 mgd directly to the activated sludge system.

10.2.5.1.1 Primary Clarifiers

The recommended Phase 1 Improvements for preliminary treatment for the WRF will consist of new primary clarifiers. Improvements will include new grit and screenings followed by new primary clarifiers to eliminate secondary pumping in the long-term.

Phase 1 WRF New Primary Clarifiers Improvements with Domes Cost…$18,800,000

If funding does not allow for new primary clarifier facilities, the Phase 1 Interim Improvements for primary treatment for the WRF will consist of rehabilitating the existing Primary Clarifiers.

WRF Existing Primary Clarifiers Rehabilitation Cost.............. …$3,400,000

10.2.5.1.2 Summary of Costs for Preliminary and Primary Treatment

Optional Rehabilitation Improvements:

Grit Building (Headworks) Rehab. Influent Pipe Cost $1,670,000
Grit Building (Headworks) High and Medium Priority Items $1,250,000
WRF Existing Screenings Rehabilitation Cost $2,100,000
WRF Existing Primary Clarifiers Rehabilitation Cost.............. …$3,400,000

*Subtotal Headworks (Screenings and Grit) .... …**$8,420,000***

Recommended Improvements (shifted to Phase 2 – See Section ES 5.6):

WRF New Screenings Improvements Cost.................................$6,300,000
WRF New Grit Improvements Cost .... …$8,300,000
New Primary Clarifiers with Domes Improvements Cost ...... …$18,800,000

*Subtotal New Headworks (Screenings and Grit) & New Primary Clarifiers.. …**$33,400,000***

10.2.5.2 Sludge Pumping Building (Building #4) Building

10.2.5.2.1 High Priority

Sludge Pumping Building improvements include the following high priority items:

- Extend fiber optic line.
- Replace electrical.

Sludge Pumping Building High Priority Cost $1,100,000

10.2.5.2.2 Medium Priority

Sludge Pumping Building improvements include the following medium priority items:

- New Air compressor.
- Repaint interior.

Sludge Pumping Building Medium Priority Cost.....................$110,000

10.2.5.3 Primary Clarifier Influent Diversion

To address peak events, it is recommended to construct an automatically controlled weir diversion structure on the primary clarifier influent line to direct flow exceeding the capacity of the primary clarifiers directly to the aeration basins. This is recommended in Phase 1a. As indicated in Figure

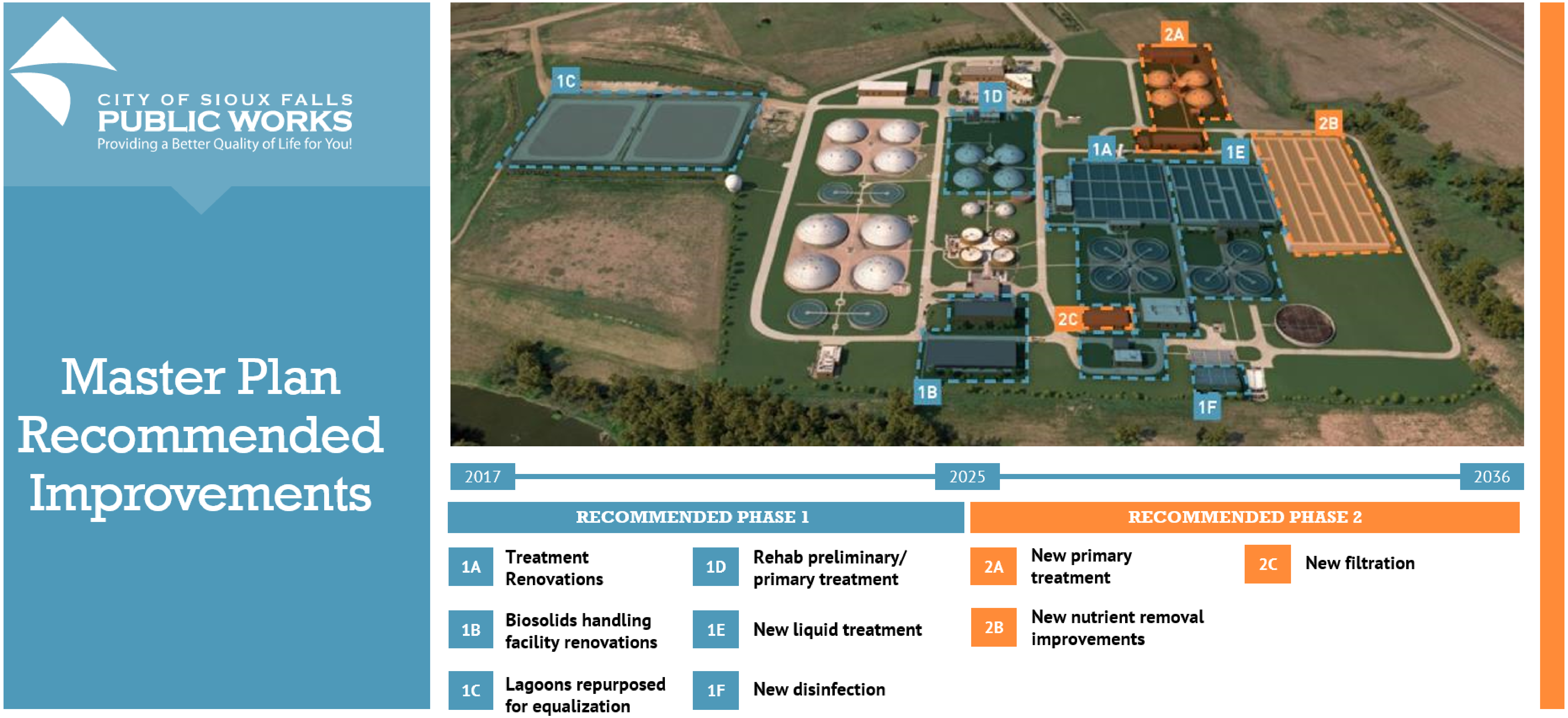
10.2, this will allow for 35+ mgd through the trickling filter train with 22 mgd diverted through the activated sludge system.

In Phase 2, new headworks and primary clarifiers ultimately become part of the recommended 5-Stage Bardenpho treatment flow scheme.

These improvements will support an increase in the plant capacity to 57 mgd in Phase 1 and will ultimately direct all of the flow to the activated sludge process in Phase 2.

Primary Clarifier Influent Diversion Cost $1,900,000

Figure 10.1 Proposed WRF Preliminary Site Layout Plan



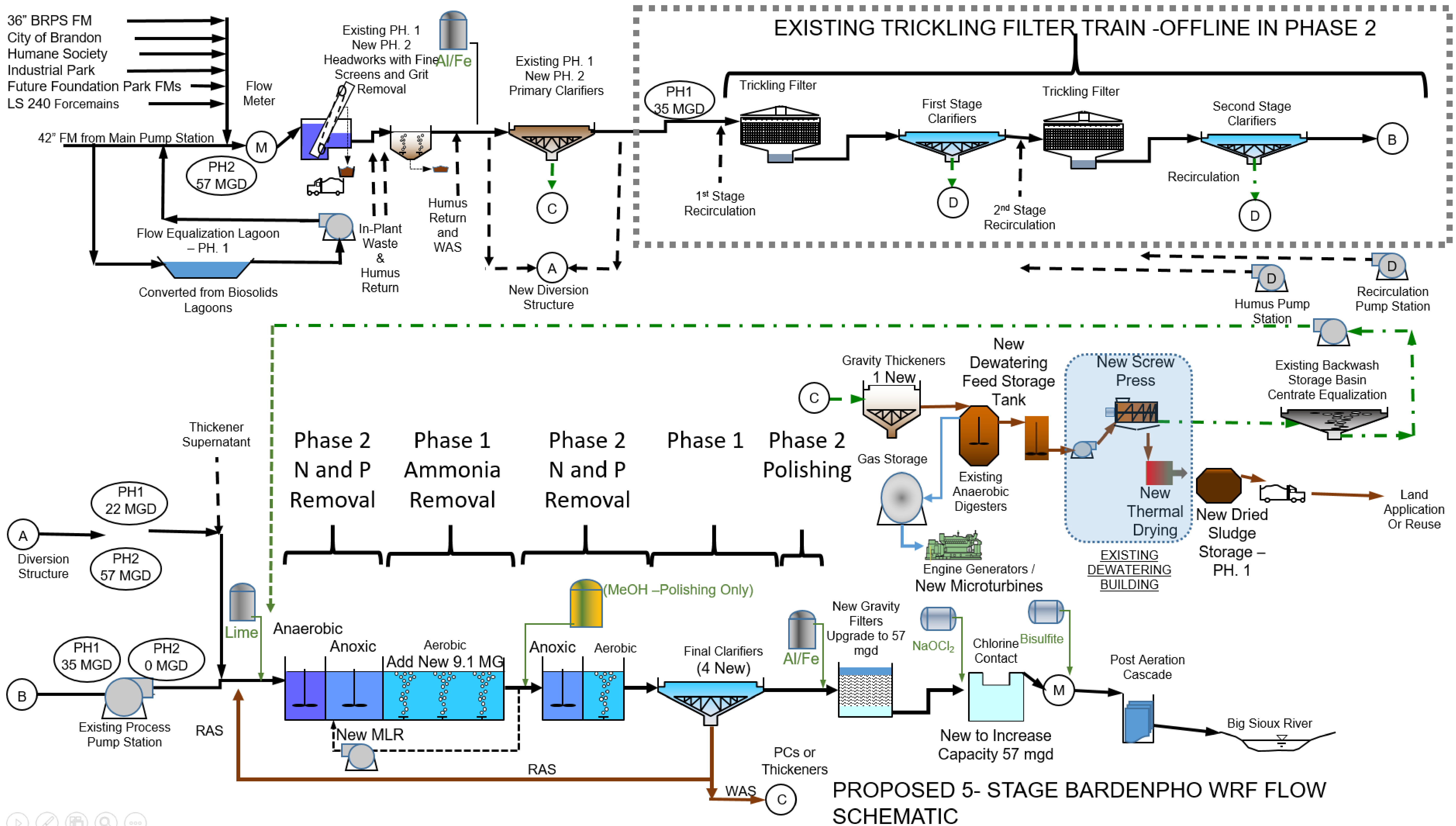


Figure 10.2 Proposed WRF Process Flow Diagram

10.2.6 Secondary Treatment

The purpose of secondary treatment is to facilitate biological conversion of organics in the wastewater to biomass that can be removed by sedimentation and filtration. The selected secondary treatment configuration for the proposed WRF is the 5-Stage Bardenpho Process which includes anaerobic, anoxic and aerobic zones for both nitrogen and phosphorus removal followed by final clarification.

The trickling filter train will remain in service during Phase 1 to continue removing the carbonaceous biological oxygen demand, or CBOD, component of the wastewater with the following improvements.

10.2.6.1 First Stage Intermediate Clarifiers (Building #7)

10.2.6.1.1 High Priority

First Stage Intermediate Clarifier improvements include the following high priority items:

- Replace conduit and boxes on walkways.

First Stage Intermediate Clarifiers High Priority Cost.............. $50,000

10.2.6.1.2 Medium Priority

First Stage Intermediate Clarifiers improvements include the following medium priority items:

- Fill/grade under humus valve supports.

First Stage Intermediate Clarifiers Medium Priority Cost $4,000

10.2.6.2 Second Stage Intermediate Clarifiers (Building #9)

10.2.6.2.1 High Priority

Second Stage Intermediate Clarifiers improvements include the following high priority items:

- Replace concrete at the guardrail posts.
- Replace conduit and boxes on walkways.

Second Stage Intermediate Clarifiers High Priority Cost $60,000

10.2.6.3 Process Pumping (Building #10)

10.2.6.3.1 High Priority

Process pumping improvements include the following high priority items:

- Seal joints & repair concrete between wetwell & drywell.
- Replace conduit and j-box near entrance.

Process Pumping High Priority Cost $260,000

10.2.6.3.2 Medium Priority

Process pumping improvements include the following medium priority items:

- Repair/ replace all exterior doors.
- Replace Sealant/backer rod. Tuck-point.
- Install a landing /stairs on the rear exit.
- Sealant/backer rod on all windows.

Process Pumping Medium Priority Cost................................$150,000

A new blower building will be constructed as part of the Phase 1 aeration basin improvements. The existing control building, aeration basins and splitter structures and RAS Pumping Building require the following improvements.

10.2.6.4 Control Building (Building #18)

10.2.6.4.1 High Priority

Control Building improvements include the following high priority items:

- Blower replacement included in Phase 1 Project Cost.
- Correct drainage on N & W sides of bldg.
- Replace exterior sealant and tuck-point.
- Replace the exterior access doors (2 single).
- Replace entire HVAC system.

Control Building (18) High Priority Cost..............................$1,300,000

10.2.6.5 Aeration Basin Splitter Structures (Building #18A&B)

10.2.6.5.1 Medium Priority

Aeration Basin Splitter Structures improvements include the following medium priority items:

- Cover concrete structure with aluminum tread plate to prevent splashing.

Splitter Structures Medium Priority Cost $260,000

10.2.6.6 Aeration Basins (Building #18C)

10.2.6.6.1 High Priority

Aeration Basins improvements include the following high priority items:

- Replace electrical J-boxes and conduit.

Aeration Basins High Priority Cost $160,000

10.2.6.6.2 Medium Priority

Aeration Basins improvements include the following medium priority items:

- Slope bottom of basins with grout.
- Repair basin bottom and wall surfaces.

- Replace dissolved oxygen sensor conduit.

Aeration Basins Medium Priority Cost................................$1,300,000

10.2.6.7 RAS Building (Building #19)

10.2.6.7.1 High Priority

RAS Building improvements include the following high priority items:

- Replace electrical J-boxes and conduit.
- Replace roof, coping, trim & flashing.
- Upgrade electrical conduit and wiring.
- Update/replace HVAC equipment.

RAS Building (19) High Priority Cost..................................$1,200,000

10.2.6.7.2 Medium Priority

RAS Building (19) improvements include the following medium priority items:

- Pump costs included in Phase 1.
- Mitigate settling.
- Seal drywell.
- Replace grating on north side of building.
- Replace sealant/backer rod. Tuck-point.
- Replace exterior double door.

RAS Building Medium Priority Cost.......................................$400,000

10.2.6.8 Phase 1 Activated Sludge Ammonia Removal

Secondary improvements will be required in order to meet the ammonia permit limits through 2036. Alternative 1-1, Phase 1 improvements will include new aeration tankage (total 18 million gallons), four new final clarifiers (total 8 units), and additional return activated sludge (RAS) facilities to be able to provide 100% of peak equalized flow at 57 mgd. The Phase 1 facility is comprised of the following major components:

- Existing Aeration Basin Upgrades (in addition to “high” and “medium” priority).
- Aeration Basin Splitter Box.
- Replace RAS and WAS Pumps.
- New Aeration basins configured for future BioP/ nitrification / denitrification (NDN).
- New RAS (mixed liquor) pumping.
- New WAS and scum pumping.
- New blowers and building for process aeration.

- New lime chemical feed to supply needed alkalinity.

Phase 1 Activated Sludge Ammonia Removal Cost $53,000,000

The Trickling Filters are eliminated from future nutrient treatment alternatives due to excessive operating costs for feeding an external carbon source. Improvements for the trickling filters through the process pump station have been limited as these processes are not part of the Plant of the Future unless high BOD industrial loads drive the need for use.

10.2.6.9 Phase 2 Biological Nutrient Removal to meet Permit #3

Phase 2 improvements will be necessary to meet anticipated nutrient criteria limit of 10 mg/l TN and 1 mg/L TP. These limits are planned to be operating by 2029; however, these limits are the most uncertain with respect to schedule and numeric criteria. Improvements primarily focus on an expanded activated sludge system. Phase 2 improvements are a notable change in operation and operational costs as the existing trickling filter treatment capacity will be replaced with activated sludge capacity. The trickling filter train will be retained for potential future industrial high organic loading and would be implemented back into the treatment train if necessary at that time.

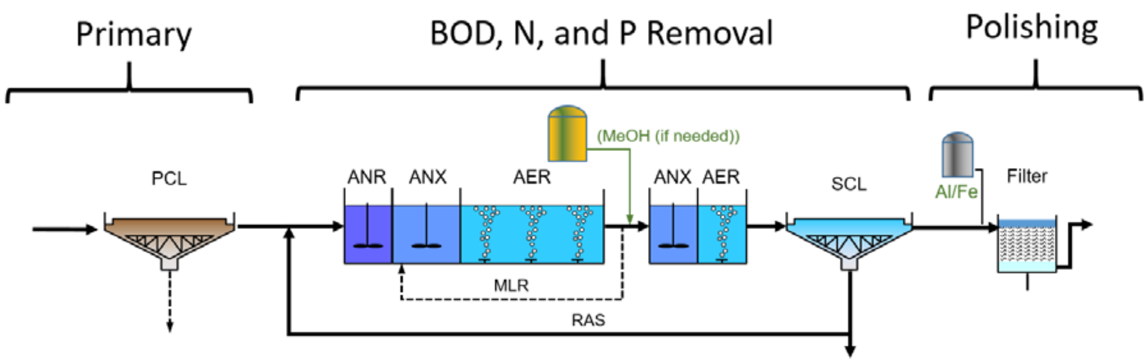
The selected BNR configuration for the proposed WRF is the 5-Stage Bardenpho Process which includes anaerobic, anoxic and aerobic zones for both nitrogen and phosphorus removal as shown in Figure 10.3. Biological phosphorus removal was used to provide substantial reduction in orthophosphorus, and chemical addition was modeled to provide phosphorus polishing. The effluent phosphorus meets the discharge limit in the model. Nitrates from the aerobic zone are returned to the anoxic zone and RAS is recycled to the head of the anaerobic zone to facilitate total nitrogen removal.

This system will be followed by chemical addition and filtration to achieve improved nutrient removal. This configuration provides a robust treatment process with flexibility for changing regulations and future non-potable reuse opportunities. Variations of the specific process arrangements as the project develops will likely occur as more information is generated and the future regulatory picture becomes clearer. The Alternative 1-1, 5-Stage Bardenpho, facility is comprised of the following major components:

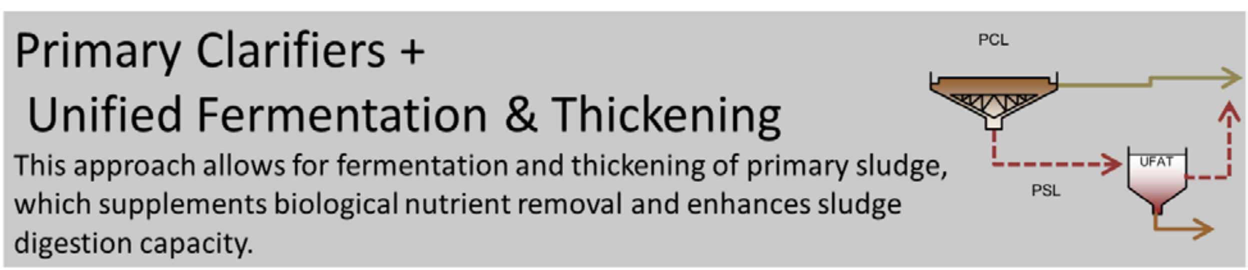
- Modify existing aeration basins.
- Aeration basins configured for BioP/ nitrification / denitrification (NDN).
- RAS (mixed liquor) pumping.
- Anoxic Recycle Pumping.
- Fermenters.
- Chemical feed and storage systems for ChemP and Carbon.

Phase 2 Biological Nutrient Removal Cost $101,000,000

Figure 10.3 Alternative 1-1 Process Flow Diagram – 5 Stage Bardenpho Biological Nutrient Removal with BioP



HDR recommends consideration of primary clarifiers plus unified fermentation and thickening, as shown in the following illustration, to be addressed during preliminary design. This approach allows for fermentation and thickening of primary sludge, which supplements biological nutrient removal and enhances sludge digestion capacity. Primary clarifiers (PCL) typically collect settled solids and convey the waste to the solids handling process. When downstream liquid processes, such as biological nutrient removal, need a carbon source (i.e., volatile fatty acids [VFAs]) for optimum treatment, wasting the primary clarification residuals starves the downstream process of available VFAs. Unified fermentation and thickening (UFAT) of primary clarification residuals allows these VFAs to be returned to the process downstream of the clarifiers and improves the nutrient removal performance. Additionally, the thickened residuals have a head-start for later solids treatment processes. Additionally, this may be more cost effective since there are existing conventional gravity thickeners which can be used to thicken the primary solids prior to anaerobic digestion.



A summary of the required sizing for Phase 1 and 2 improvements is outlined in Table 10.5.

Table 10.5 Alternative 1-1 – Planning Basis of Design for Phases 1 and 2

Description	Units	Existing	Total in Phase 1 (Existing + Ph. 1)	Total in Phase 2 (Ph. 1 + Ph. 2)
Average Day Flow	MGD	21	30.1	30.1
Peak Day Equalized Flow	MGD	35	57.0	57.0
Total WRF EQ Basin Volume	MG	-	15	15
PC Effluent Diversion Capacity	MGD	-	57.0	57.0
Total Aeration Basin Volume	MG	8.1	18.0 (9.9 MG additional)	46.0
EQ Basin At East Side Pump Station 240	MG		1.0	1.0
Aeration Basin Blower Capacity[1]	SCFM	45,000 (Coarse Bubble)	79,550 (Fine Bubble)	79,550 (Fine Bubble)
Total No. Final Clarifiers[2]	No.	4.0	8.0	8.0
RAS Pumping[2]	MGD	27.0	57.0	57.0
Total Filter Capacity	MGD	34.0	57.0	57.0

Notes:

1. Assumes Phase 1 and 2 blower capacity will be constructed in Phase 1 complete with a complete new fine bubble aeration system.
2. Existing Clarifiers and RAS Pumping will be refurbished.

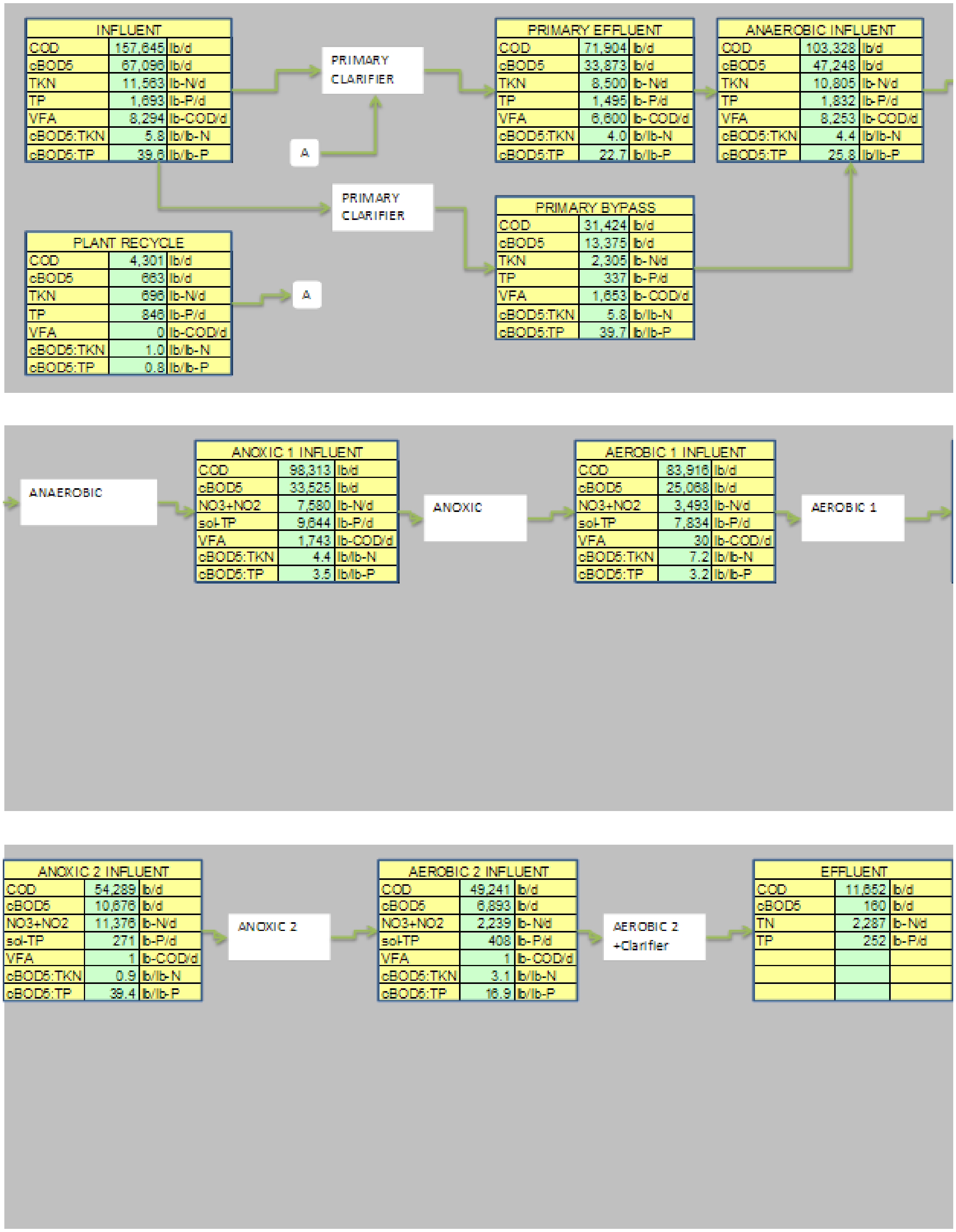
HDR recommends the following process considerations to be addressed during preliminary design as the recommended plan recommends chemical feed for "tying up" the phosphorus as the most economical solution to address the following:

- Reducing struvite accumulation in anaerobic digesters,
- Improving dewaterability of anaerobically digested biosolids and high phosphorus recycle loading from solids handling (up to 50% influent load).

The phosphorus recycle content and associated challenges with solids handling for a biological phosphorus removal process warrant further consideration. Phosphorus handling alternatives may be considered during predesign including the following Phosphorus release (P-Release) from waste activated sludge (WAS).

In HDR's analysis, supplemental carbon is not required under normal operating conditions. A mass balance for the average 2036 winter scenario is provided to illustrate. The CBOD to TKN ratio is a key element and could vary based future loads from industry.

Figure 10.4 Alternative 1-1 Process Mass Ballance Diagram –5 Stage Bardenpho Biological Nutrient Removal with BioP



INFLUENT		
COD	157,645	lb/d
cBOD5	67,096	lb/d
TKN	11,563	lb-N/d
TP	1,693	lb-P/d
VFA	8,294	lb-COD/d
cBOD5:TKN	5.8	lb/lb-N
cBOD5:TP	39.6	lb/lb-P

PRIMARY EFFLUENT		
COD	71,904	lb/d
cBOD5	33,873	lb/d
TKN	8,500	lb-N/d
TP	1,495	lb-P/d
VFA	6,600	lb-COD/d
cBOD5:TKN	4.0	lb/lb-N
cBOD5:TP	22.7	lb/lb-P

ANAEROBIC INFLUENT		
COD	103,328	lb/d
cBOD5	47,248	lb/d
TKN	10,805	lb-N/d
TP	1,832	lb-P/d
VFA	8,253	lb-COD/d
cBOD5:TKN	4.4	lb/lb-N
cBOD5:TP	25.8	lb/lb-P

PLANT RECYCLE		
COD	4,301	lb/d
cBOD5	663	lb/d
TKN	696	lb-N/d
TP	846	lb-P/d
VFA	0	lb-COD/d
cBOD5:TKN	1.0	lb/lb-N
cBOD5:TP	0.8	lb/lb-P

PRIMARY BYPASS		
COD	31,424	lb/d
cBOD5	13,375	lb/d
TKN	2,305	lb-N/d
TP	337	lb-P/d
VFA	1,653	lb-COD/d
cBOD5:TKN	5.8	lb/lb-N
cBOD5:TP	39.7	lb/lb-P

ANOXIC 1 INFLUENT		
COD	98,313	lb/d
cBOD5	33,525	lb/d
NO3+NO2	7,580	lb-N/d
sol-TP	9,644	lb-P/d
VFA	1,743	lb-COD/d
cBOD5:TKN	4.4	lb/lb-N
cBOD5:TP	3.5	lb/lb-P

AEROBIC 1 INFLUENT		
COD	83,916	lb/d
cBOD5	25,068	lb/d
NO3+NO2	3,493	lb-N/d
sol-TP	7,834	lb-P/d
VFA	30	lb-COD/d
cBOD5:TKN	7.2	lb/lb-N
cBOD5:TP	3.2	lb/lb-P

ANOXIC 2 INFLUENT		
COD	54,289	lb/d
cBOD5	10,676	lb/d
NO3+NO2	11,376	lb-N/d
sol-TP	271	lb-P/d
VFA	1	lb-COD/d
cBOD5:TKN	0.9	lb/lb-N
cBOD5:TP	39.4	lb/lb-P

AEROBIC 2 INFLUENT		
COD	49,241	lb/d
cBOD5	6,893	lb/d
NO3+NO2	2,239	lb-N/d
sol-TP	408	lb-P/d
VFA	1	lb-COD/d
cBOD5:TKN	3.1	lb/lb-N
cBOD5:TP	16.9	lb/lb-P

EFFLUENT		
COD	11,652	lb/d
cBOD5	160	lb/d
TN	2,287	lb-N/d
TP	252	lb-P/d

10.2.6.10 Final Clarification

Following the aeration basins, the flocculated biomass is removed from the process water by sedimentation in the final clarifiers. Overflow weirs allow the clarified liquid stream to pass to the next downstream process and solids to settle to the bottom of the clarifiers. Settled solids are either wasted for disposal (Waste Activated Sludge) or returned to the biological process (Return Activated Sludge). During secondary treatment, a well-designed and operated system may be expected to achieve average concentrations less than 10 mg/L for both BOD5 and TSS with maximum concentrations of approximately twice.

As summarized in Table 10.5, the equivalent of four (4) new final clarifiers is required.

New Final Clarifiers Medium Priority Cost.........................$17,100,000

The existing final clarifiers consist of original equipment and require the following upgrades.

10.2.6.11 Final Clarifiers (20)

10.2.6.11.1 Medium Priority

Final Clarifiers improvements include the following medium priority items:

- Basin - Repair concrete structure (Included in Phase I Improvements).
- Mechanism (Included in Phase I Improvements).
- Construct new in-board launder off external wall (Included in Phase I Improvements).
- Replace concrete steps and sidewalks as part of Facility Sidewalk Replacement Plan.
- Replace with new mechanisms as part of the Phase I Improvements.
- Replace piping as part of new mechanisms (Included in Phase I Improvements).

Existing Final Clarifiers Medium Priority Cost $6,500,000

10.2.7 Tertiary Treatment

Tertiary treatment is used to further remove suspended solids and/or nutrients beyond what is achieved in secondary treatment.

10.2.7.1 Filter Building (Building #21)

At the WRF, gravity filtration will be expanded to provide an additional barrier for suspended solids at the increased flow of 57 mgd. The main benefit of tertiary filtration is that performance is predictable and repeatable even during short-term plant upsets. Phase 2 filtration effluent filter media type needs to be evaluated to provide media which best accommodates solids capture for phosphorous removal.

New Filter Building Expansion High Priority Cost (shifted to Phase 2 – See Section ES 5.6): $7,100,000

In addition, the following improvements will be constructed at the existing filter building as part of the immediate Phase 1a project, primarily due to reliability, age and condition.

10.2.7.1.1 High Priority

Filter Building improvements include the following high priority items:

- Replace filter influent & effluent valve actuators.
- Raise filter bypass weir (hydraulic constraint).
- Update conduit and wiring.

Filter Building High Priority Cost..$1,000,000

10.2.7.1.2 Medium Priority

Filter Building (21) improvements include the following medium priority items:

- Repair masonry on south side of bldg.
- Repair cracks on the SW wall of building (inside and out).
- Replace sealant/backer rod. Tuck-point.
- Replace sealant/backer rod on windows
- Replace exterior doors (1 double door and 1 single).
- Repaint walls in lower pipe gallery.

Filter Building Medium Priority Cost $360,000

10.2.8 Disinfection

The flow leaves the filters and travels to a splitter box at the head of the chlorine contact basins. Weir gates in the splitter box split the flow evenly between the two chlorine contact basins. A Parshall flume is used to measure the chlorine contact basin effluent. Sodium hypochlorite is fed as the disinfectant upstream of the chlorine contact basins. Sodium bisulfite is fed to remove the residual chlorine prior to discharge to the river.

The Phase 1 recommendation is to add an additional 0.35 MG of capacity to the chlorine contact basins complete with ancillary influent splitting and site piping in order to achieve 15 minutes of detention time at the 2036 projected equalized peak flow. Improvements include a second sodium bisulfate tank, with the same capacity as the sodium hypochlorite (bleach) tanks.

New Chlorine Contact Basin Cost $3,200,000

The disinfection chemicals are fed from the Chemical Feed Building, which along with the chlorine contact tank will include the following reliability related improvements.

10.2.8.1 Chemical Feed Building (Building #22)

10.2.8.1.1 High Priority

Chemical Feed Building improvements include the following high priority electrical items:

- Replace transformer and update conduit and wiring.

Chemical Feed Building High Priority Cost $250,000

10.2.8.1.2 Medium Priority

Chemical Feed Building (22) improvements include the following medium priority items:

- Replace sidewalk as part of Sidewalk Replacement Plan.
- Rehab exterior west stairway.
- Replace exterior doors (1 double door and 3 single).

Chemical Feed Building Medium Priority Cost $50,000

10.2.8.2 Chlorine Contact Basin (Building #23)

10.2.8.2.1 High Priority

Chlorine Contact Basin improvements include the following high priority items:

- Replace transformer and update conduit and wiring.

Chlorine Contact Basin High Priority Cost............................. $250,000

10.2.8.2.2 Medium Priority

Chlorine Contact Basin improvements include the following medium priority items:

- Replace sidewalk as part of Sidewalk Replacement Plan.
- Rehab exterior west stairway.
- Replace exterior doors (1 double door and 3 single).

Chlorine Contact Basin Medium Priority Cost $50,000

10.2.9 Effluent Flow Measurement

Effluent flow measurement to be upgraded to a magnetic flow meter complete with structure.

Effluent Flow Measurement Cost $420,000

10.2.10 Solids Handling

The selected solids handling alternative includes processing the solids at the WRF to a sufficient level to meet Class A biosolids and hauling them by truck to the City's land application sites. The purpose of the solids mass balance calculation is to account for solids movement, production and destruction through the treatment process and ultimately determine the amount of anaerobically digested solids that must be dewatered, stored, or land applied. Chapter 8 presents the calculated quantities of sludge projected to be produced at the WRF and provides design criteria for the sludge storage facility. The projected sludge production under maximum month flow conditions was used to check sizing for the solids processing equipment.

The existing solids dewatering building will house the thickening, dewatering equipment; the polymer feed system(s), sludge pumps, and a truck bay for loading the dewatered biosolids.

10.2.10.1 Solids Thickening

Waste activated sludge (WAS) from the secondary treatment processes will be thickened either by converting the existing gravity thickeners to dissolved air flotation units (DAFs), utilizing a gravity belt thickeners, rotary drum thickeners, or by utilizing the selected dewatering equipment. Primary solids will continue to be thickened separately in the gravity thickeners. If gravity belts or rotary drum style thickening is selected, thickener feed will either be from the gravity thickeners or a WAS holding tank with capacity of three days of storage prior to thickening.

New Thickening Cost...$3,300,000

The existing gravity thickeners require rehabilitation and the recommended improvements are as follows.

10.2.10.2 Gravity Thickeners/ Tunnel (Building #11)

10.2.10.2.1 High Priority

Gravity Thickeners/ Tunnel improvements include the following high priority items:

- Restore interior and exterior concrete surfaces.
- Replace mechanisms.
- Rehab support for odor control blowers.
- Repair stairs and landing.
- Install drainage system above tunnel.
- Replace brick/tuck-point exit stair tower.
- Replace roof, coping, trim & flashing on exit stair tower.
- Replace the single access door at the tunnel tower exit.
- Sandblast and recoat piping.
- Replace Thickened Sludge Pumps.
- Update HVAC system to meet NFPA 820.
- Replace conduit at thickener platforms.
- Replace conduit/supports and wiring in tunnel.

Existing Gravity Thickeners/ Tunnel High Priority Cost……..$2,300,000

10.2.10.3 Anaerobic Digestion

Thickened solids will be stabilized through the existing anaerobic digestion, which allows the WRF to take advantage of gas production and energy recovery. The digesters will be configured as a single-stage system with four primary digesters. The primary digesters are to be heated and mixed via high rate pumping. Traditional anaerobic digestion alone cannot process solids to Class A standards, but it is an accepted means of producing Class B solids. Dewatering followed by thermal drying, as discussed below, will supplement the digesters for processing the solids sufficiently for Class A classification.

The existing digestion complex requires the following reliability and code improvements.

10.2.10.4 Digesters (Building #12)

10.2.10.4.1 High Priority

Digesters improvements include the following high priority items:

- Remove electrical from existing electrical room due to code restraints.

Digesters High Priority Cost ....Completed

This was part of an on-going project.

10.2.10.4.2 Medium Priority

Digester Gas Storage Sphere improvements include the following medium priority items:

- Sandblast and Recoat Interior and Exterior Surfaces.

Digester Gas Storage Sphere Medium Priority Cost.............$640,000

10.2.10.5 Biosolids Handling

To achieve a Class A solids, stabilization can be facilitated by dewatering, heating and drying to achieve a high quality product. Digestion and thermal drying both attain vector attraction reduction and significant pathogen reduction.

The recommended process type remains the same as existing through Primary Anaerobic Digestion (AD) i.e. Gravity Thickeners (GTH) followed by AD. However, in the long term, mechanical thickening is required which includes either drawing directly off the thickeners or separately storing and thickening WAS based on the increase WAS with the treatment change to activated sludge and continuing to thicken primary clarifier sludge via the gravity thickeners.

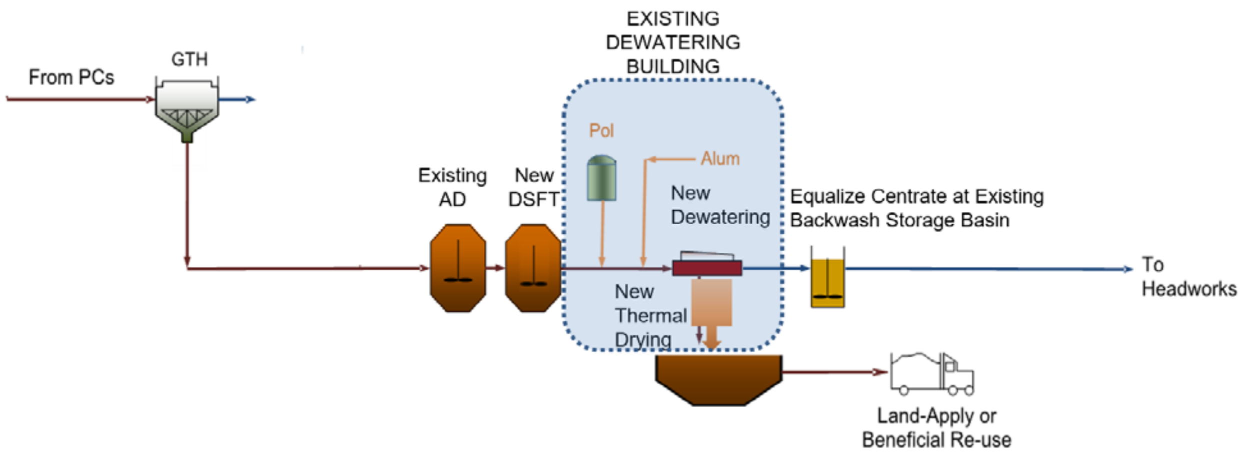
With the existing Biosolids Lagoons converted to equalization, primary digested sludge will be sent to a new mixed Dewatering Sludge Feed Tank (DSFT) with a minimum of 3 days of storage at approximately 300,000 gallons. Next, polymer will be fed and an alum feed point would be provided ahead of dewatering to promote phosphorous precipitation and removal in the dewatered sludge which is then fed to the Dewatering Unit (Screw Press).

Solids dewatering reduces the volume in solids processing to minimize the trucking requirements needed for hauling to the land application sites. The anaerobically digested solids will be fed to the screw presses at approximately four percent solids, and the screw press will dewater the solids to produce a 15-20% cake, reducing the volume to be thermally dried and hauled away.

Currently, it is assumed the solids processing system will have two separate polymer make-up and feed systems: one for thickening and one for dewatering. A chemical containment area will be necessary around any storage tanks. It may be determined after some bench scale testing that one polymer will work for both thickening WAS and dewatering anaerobically digested solids. If two polymers are necessary, the compatibility with one another should be evaluated to determine if separate feed systems are necessary.

The centrate will be collected and transferred to the existing backwash storage tank for aeration/equalization and ultimately returned to the head of the plant via the backwash return pumps. Dewatered sludge will normally be thermally dried with provisions to send dewatered sludge directly to storage.

Figure 10.5 Preliminary Schematic for Recommended Improvements



Required improvements for the design condition include:

- New conveyors to transfer cake from the dewatering unit to the sludge load-out area, plus additional conveyors as needed for additional dewatering unit. The assumption is that each dewatering unit will have a dedicated conveyor for transfer of cake to the thermal drying and sludge load-out area.
- Sludge load-out conveyor to even distribution of dewatered sludge in the roll-off containers.
- New liquid polymer feed and storage system, plus additional liquid polymer feed and storage system for additional dewatering units. The assumption is that each dewatering unit would have a dedicated polymer feed system.
- New dewatering unit feed pumps, plus additional feed pumps for additional dewatering units. The assumption is that each dewatering unit would have a dedicated sludge feed pump.
- New liquid sludge storage with new mixing.
- Electrical and instrumentation upgrades (costs for new equipment are estimated as a percentage of other construction costs).
- Automation of the controls for the centrate flow; a centrate flow meter; and a level-controlled centrate storage tank.
- New solids handling building standby generator and automatic transfer switch (ATS).
- Dry cake storage with conveyance.

Additional investigation and pilot testing is recommended before a final decision is made on a solids dewatering alternative. Investigation and pilot testing would provide the following:

- Potential for site visits to observe the alternatives evaluation in a full-scale operation at other facilities.

- Reliability of the alternatives to consistently meet the sludge dewatering performance goals.
- Determine the ability to operate the alternatives continuously on a 24-hour basis with minimal adjustments of the polymer and operator attention.

Handling of the sidestream ammonia for Phase 1 and nutrients for Phase 2 have been included in the Biowin model scenarios and the associated capital improvement costs have been included as part of the selected treatment processes. The selected activated sludge process is sized for the anticipated recycle loads. Due to the small relative ammonia recycle loading, the benefits of sidestream treatment targeted to ammonia is limited for the selected treatment process. The current process selection equalizes the ammonia load and minimizes additional process components that would be required for the alternative patented sidestream ammonia removal processes.

The current plan recommends chemical feed for "tying up" the phosphorus as the most economical solution to address phosphorus removal along with reducing struvite accumulation in anaerobic digesters. This also improves dewaterability of anaerobically digested biosolids and reduces high phosphorus recycle loading from solids handling (up to 50% influent load). However, the phosphorus recycle content and associated challenges with solids handling for a biological phosphorus removal process warrant further consideration during preliminary design. Phosphorus handling alternatives may be considered during predesign including processes that provide Phosphorus release (P-Release) from waste activated sludge (WAS).

10.2.10.6 Centrate/Supernatant Recycle Management

Compliance with the effluent limit for ammonia-nitrogen will be enhanced by returning centrate to the existing backwash storage basin and returning these flows to the liquid treatment stream during periods of low influent ammonia loading. The new system will include controls and metered pumping for the recycle return system. The aeration system capacity and any required chemical feed points (i.e. alkalinity) will be reviewed in preliminary design. A key element of preliminary design is providing sufficient sidestream treatment to meet the needs in the gap between Phase 1a completion and Phase 1 completion.

The total for the new solids dewatering process is as follows:

New Solids Dewatering High Priority Cost........................$18,100,000

Given the age and condition of the existing dewatering building, additional reliability items need to be addressed as follows.

10.2.10.7 Existing Solids Dewatering Building (Building #14)

10.2.10.7.1 High Priority

Solids Dewatering improvements include the following high priority items:

- Replace roofing.
- Replace the exterior access doors (5 single).
- Upgrade and rezone heat and add natural gas heating.
- Replace/upgrade electrical with dewatering project.

Solids Dewatering High Priority Cost..................................$1,200,000

10.2.11 FOG Facilities

FOG receiving and handling facilities are recommended per the 2013 FOG Study to be timed with FOG availability analysis and other FOG related action items detailed in Chapter 8.

New FOG Facilities Cost $3,000,000

10.2.12 Energy Recovery

Microturbines were recommended as part of the FOG Study. As noted in Chapter 8, further evaluation of final energy recovery/reuse should be completed.

New Microturbines Facilities Cost $4,200,000

10.2.12.1 Energy Recovery (Building #13)

10.2.12.1.1 High Priority

Energy Recovery improvements include the following high priority items:

- Engine generators (Under current CIP for replacement with microturbines).
- Replace south door w/rollup door.
- Replace the exterior access doors (2 double and 1 single).
- Replace the boilers.
- Replace the heat exchanger tubes.
- Replace the boiler hot water pumps.
- Replace the supply fans.
- Replace exhaust fans #3 & #4.

Energy Recovery High Priority Cost......................................$730,000

10.2.13 Energy Driven Needs

As part of a previous energy audit, HDR identified and evaluated 27 energy conservation measures (ECMs) for the Sioux Falls WRF. The following recommended ECMs have been included in the other recommended high and medium priority items:

- Aeration System Improvements:
  - Repair air leaks in aeration basin air piping at mechanical couplings.
  - Convert to fine bubble aeration and automate controls for throttling aeration basin blowers.
- Add VFDs for Nonpotable water pumps.
- Add VFDs on Return Activated Sludge (RAS) Pumping.

- Add VFDs to in-plant waste pumps.
- Increase biogas production by feeding fat, oil, and grease (FOG) to the digesters.

A key component of the Phase 1 improvements should be to incorporate a power Demand Management System and create a demand reduction protocol for the plant. A Demand Management System is built-in software to either alert personnel of the impacts of starting motors at the plant.

An example of a Demand Management System is GoFlex (Grid Operational Flexibility) which is a multipurpose real-time demand management platform that enables time shift power usage in real time to match the moment-to-moment fluctuations of electricity demand on the WRFs power system. High use motors are connected, such as aeration blowers, that have been identified for their flexibility in electricity use. The platform will receive real-time requests from the which will then be sent to the programmable logic controller; this can automatically adjust the blowers output without any noticeable impact on daily operations.

Some operator inconvenience to react to spikes in demand and alarms may be experienced, and optimization of demand reduction protocol will require careful documentation. The alarm and real-time monitoring will increase awareness of energy use and assist staff in identifying new opportunities to reduce the load, demand and resulting demand charge. The impact to the operational cost of shutting down energy recovery during peak loading could equal $5000 in one month alone, largely due to elevating the demand. The cost for the Demand Management System has been included in Phase 1 recommended improvements.

10.2.14 Solids Disposal

Ultimately, biosolids, will be land applied as currently implemented at the WRF but with significantly less volume. As mentioned above, solids at the WRF will be dewatered and dried to Class A standards, allowing for a wider range of acceptable disposal sites, in addition to greater robustness in the case of more stringent regulations on land application in the future. The recommended Biosolids Study plan is to store the dried cake in aboveground pad/bunker for giveaway (half) and for contracted land application (half) on existing land application sites.

10.2.15 In-Plant Pumping (Building #24)

10.2.15.1.1 High Priority

In-Plant Pumping improvements include the following high priority items:

- Replace roof, coping, trim & flashing.
- Update electrical complete.
- Replace HVAC system including heat recovery.

In-Plant Pumping High Priority Cost......................................$600,000

10.2.15.1.2 Medium Priority

In-Plant Pumping improvements include the following medium priority items:

- Replace Nonpotable pumps and motors.

- Add constant pressure pumping system to NPW Pumps.
- Replace NPW strainer #1.
- Replace NPW strainer #2.
- Replace NPW flow meter.
- Replace In-Plant Waste Pumps and motors.
- Add VFDs to In-Plant Waste Pumps.
- Replace in-plant waste flow meter.
- Replace/upgrade piping and valves.
- Repair brick on SW corner of bldg.
- Replace sealant/backer rod. Tuck-point.
- Replace exterior double door.

In-Plant Pumping (24) Medium Priority Cost..........................$360,000

10.2.16 Dumping Station (Building #16)

10.2.16.1.1 Medium Priority

Dumping Station (16) improvements include the following high priority items:

- The dumping station electrical is no longer used. Remove & demolish conduit/supports and wiring.

Dumping Station Medium Priority Cost $10,000

10.2.17 Maintenance Building (Building #2)

10.2.17.1.1 High Priority

Maintenance Building improvements include the following high priority items:

- Replace roof, trim, coping, & flashing.
- Replace missing ladder rail and missing toe plate.
- Replace HVAC system.

Maintenance Building High Priority Cost.............................$1,100,000

10.2.17.1.2 Medium Priority

Maintenance Building improvements include the following medium priority items:

- Replace air compressor.
- Sandblast maintenance bay walls and ceiling & repaint.

Maintenance Building (2) Medium Priority Cost.....................$100,000

10.2.18 Equipment Storage (Building #17)

10.2.18.1.1 High Priority

Equipment Storage improvements include the following high priority items:

- Expanding office area to NW part of bldg. to house additional employees.
- Updating HVAC system and expand to new office area.

Equipment Storage High Priority Cost.................................. $570,000

10.2.19 Odor Control/Site Buffer

The City should develop long-term plans for the WRF site and should begin implementation of the plans as soon as possible. As surrounding properties become further developed, it will become increasingly important that the City provide an attractive visual buffer between wastewater operations and surrounding uses. The closest development will likely be to the west and potentially north.

As growth occurs, odor control facilities should be considered for the following facilities:

- Pretreatment Building
- Primary Clarifiers (optional)
- Solids Handling Facilities including:
    - Dewatering area.
    - Dewatered Storage and Loading.

A plant-wide odor control system at the treatment plant would collect foul air from these process areas. The odorous air will be routed through a bio-filter bed for odor scrubbing or alternatively utilize a pre-engineered and customized packed bed odor control scrubbers and systems which utilizes hypochlorite with pH control to oxidize odorous compounds.

Planning costs have not been included at this time due to the significant distance to "neighbors".

10.2.20 Standby Power Engine Generator (Building #15)

The standby power planning includes provision for replacement of the unit based on size reliability, age, and condition.

10.2.20.1.1 High Priority

In the short term, Engine Generator improvements include the following high priority items:

- Install utility circuit bypass.

Engine Generator High Priority Cost..................................... $250,000

10.2.20.1.2 Medium Priority

Engine Generator improvements include the following medium priority items:

- Replace driveway and pavement.

- Rehabilitate enclosure and provide platform and stairs.

Engine Generator (15) Medium Priority Cost......................... $100,000

10.2.21 Automation and Controls

The expansion alternatives include integrating the process into a uniform, plant-wide solution complete with site electrical, automation and controls.

10.3 Cost Estimates and Implementation Schedule

This section presents the WRF cost estimates and implementation schedule for construction of the recommended improvements.

10.3.1 Capital Costs

The capital costs for the WRF are presented in two phases, which allows the Phase 2 nutrient removal project to be deferred and triggered by regulation.

The Phase 1 project includes liquid process improvements, solids handling improvements, and WRF high and medium priority “reliability” items. In addition, the initial Phase 1 project includes a Phase 1a initial aeration and hydraulics improvements project, which needs to be constructed immediately.

Table 10.6 provides a summary of the preliminary recommendations to upgrade the WRF to reliably treat the 2036 projected flows and loads. This table provides an overview of facility requirements, driving forces, and urgency/timing considerations.

Refer to Figure 10.6 for a graphic of the associated timeline. Figure 10.7 illustrates the timeline in terms of growth year and associated population and BOD and TKN loadings.

Table 10.6 Summary of Recommendations for Design Year 2036

		Proposed Process Component	Driving Force for Improvement					Recommended Improvements
			Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	
Phase 1A - Improvements		Phase 1a - Step Feed Improvement at Aeration Basins, Grit Influent Piping & PC Infl. Div. (1)	✓	✓	✓		✓	Construct piping and gates required to divert flow to second aeration basins during peak flows and loading to maintain D.O. Construct process gravity diversion structure from the grit effluent to the aeration basins to divert flow to secondary treatment train during peak flows. Grit Influent Piping Primary Clarifier Influent Diversion Final Clarifier Rehab Filter Building High Priority Items
Phase 1A - Improvements		Grit Influent Pipe Upsizing (1) (2)		✓				Increase grit influent pipe to be able to pass minimum of 60 mgd.
Phase 1A - Improvements		PC Influent Peak Diversion		✓				Construct pump station to function to divert peak PC influent or effluent flows.
Phase 1A - Improvements		Rehab Final Clarifiers					✓	Renovate the existing final clarifiers with Stamford Baffles™ and modern inboard weirs to provide for improved flow characteristics to limit short-circuiting.
Phase 1A - Improvements		Existing Filtration High Priority Items				✓	✓	Replace valves, electric etc.
Phase 1A - Improvements		Biosolids Dewatering/Handling Improvements		✓	✓	✓	✓	Construct a new mixed Dewatering Sludge Feed Tank (DSFT) with a minimum of 3 days of storage. Construct new polymer feed and an alum feed. Construct new dewatering units i.e. screw presses. Construct centrate transfer line to the existing backwash storage tank for aeration/equalization. Review sidestream impacts and construct lime feed as required based on final project phasing. Construct thermal drying with provisions to send dewatered sludge directly to storage. Construct dried cake aboveground pad/bunker storage for giveaway (half) and for contracted land application (half). Construct solids handling building standby generator and ATS.
		Phase 1 - Liquid Process Improvements	✓	✓	✓	✓	✓	
Phase 1 - Liquid Process Improvements	Preliminary	Screening Improvements		✓				Remove and replace screens complete with screenings dewatering to increase firm capacity to 57 mgd.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basin Upgrades (1)	✓		✓	✓	✓	Construct new fine bubble aeration system complete with new electrical and control system.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basin Splitter Box		✓				Construct new aeration basin influent splitter box for influent and RAS.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basins	✓	✓	✓		✓	Phase 1: Construct new aeration basins complete with fine bubble aeration. Renovate existing basins.
Phase 1 - Liquid Process Improvements	Aeration Basins	Aeration Basin Blowers	✓	✓	✓		✓	Construct new blowers complete with new blower building.
Phase 1 - Liquid Process Improvements	Aeration Basins	Replace RAS and WAS Pumps	✓		✓	✓		Replace existing RAS and WAS pumps.
Phase 1 - Liquid Process Improvements	Aeration Basins	Final Clarifiers	✓	✓	✓			Construct final clarifiers - equivalent of 4 new clarifiers.
Phase 1 - Liquid Process Improvements	Tertiary	Filter Expansion – shifted to phase 2.	✓	✓	✓			Construct filter building expansion to add capacity to treat to 57 mgd.
Phase 1 - Liquid Process Improvements	Tertiary	Chlorine Contact Expansion (1) (2)	✓	✓	✓		✓	Construct chlorine contact basin expansion to add capacity to treat to 57 mgd.

Table 10.6 Summary of Recommendations for Design Year 2036

	Proposed Process Component	Driving Force for Improvement					Recommended Improvements
		Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	
	Effluent Flow Meter Improvements		✓	✓		✓	Construct new flow metering to add capacity to measure flows to 57 mgd.
	Phase 1 - Solids Handling Improvements	✓	✓	✓	✓	✓	
Phase 1 - Solids Handling Improvements	New WAS Thickening	✓	✓	✓		✓	Construct WAS thickening final process to be determined with sludge dewatering evaluation update.
Phase 1 - Solids Handling Improvements	FOG Receiving – shifted to Phase 2.					✓	Construct a Feedstock Receiving and Processing Station to receive and co-digest FOG in the short term and to receive and co-digest food/higher solid waste materials with additional improvements in the future when the associated waste collection program is developed. Action Items: • Develop a food / higher solid waste collection program. • If source(s) are available, develop an updated Basis of Design to include facilities for receiving and process food / higher solid waste.
Phase 1 - Solids Handling Improvements	Convert Biosolids Lagoons to Equalization Basins		✓			✓	Equalization improvements include converting the existing biosolids lagoons to equalization basins at the WRF. WRF improvements include the following: • Construct tee and isolation valve off the 42-inch forcemain. • Construct an automated valve to equalization basins. • Construct a dry-pit style 7 mgd return pump station complete with valving and metering to 42-inch forcemain. • Update gate controls at headworks structure. Update SCADA for coordinating Main Pump Station metering with headworks metering to provide a set diversion rate.
Phase 1 - Solids Handling Improvements	Energy Recovery / Microturbines – shifted to Phase 2.					✓	Construct microturbines replacing engine generators for combined heat and power.
Phase 2 Improvements	WRF Phase 2 – Nutrient Project To Meet Permit #3 Total	✓		✓		✓	Construct folded aeration basins to allow anoxic recycle to be pumped over the wall complete with multiple trains, air piping and diffusers, mixers, internal recycle pumps, influent distribution and effluent launders. Construct a new anoxic recycle/RAS/WAS pump building. Construct anaerobic and anoxic basins as required within existing basins. Construct new alum feed system. Construct associated site work/demolition, site piping, and miscellaneous improvements.

Notes: (1) High priority/immediate need.
(2) Hydraulic improvement.
(3) These costs assume that a minimum 32 MG of equalization basin capacity is in place at the Cliff and Chambers site.
(4) Miscellaneous Improvements include: architectural, structural, HVAC, electrical, SCADA, miscellaneous site structures and process related improvements identified during the condition assessment (only equipment cost associated with the alternatives are included and those with a replacement timeframe of ten years or less).

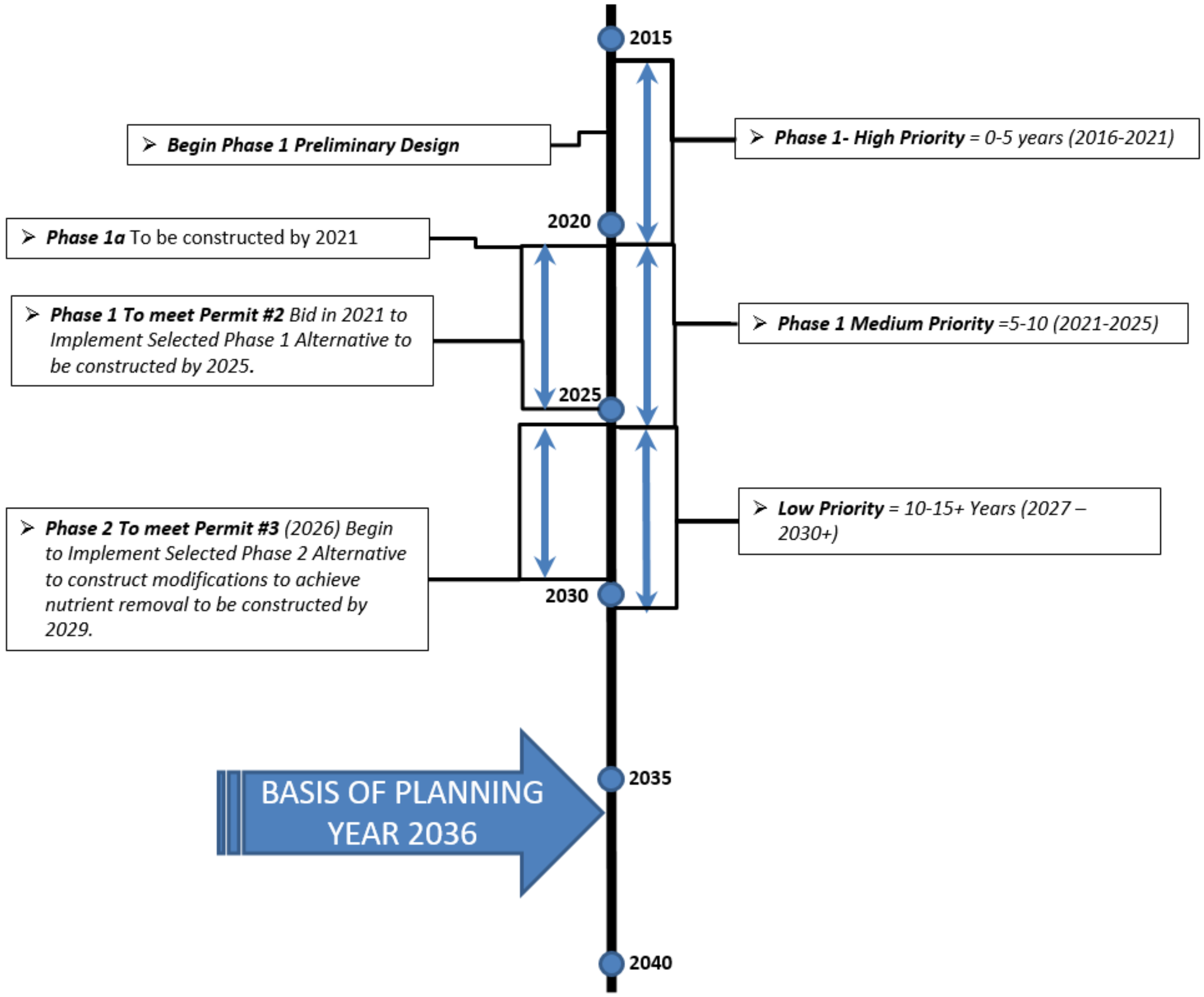


Figure 10.6. Sioux Falls WRF Recommended Improvements Timeline

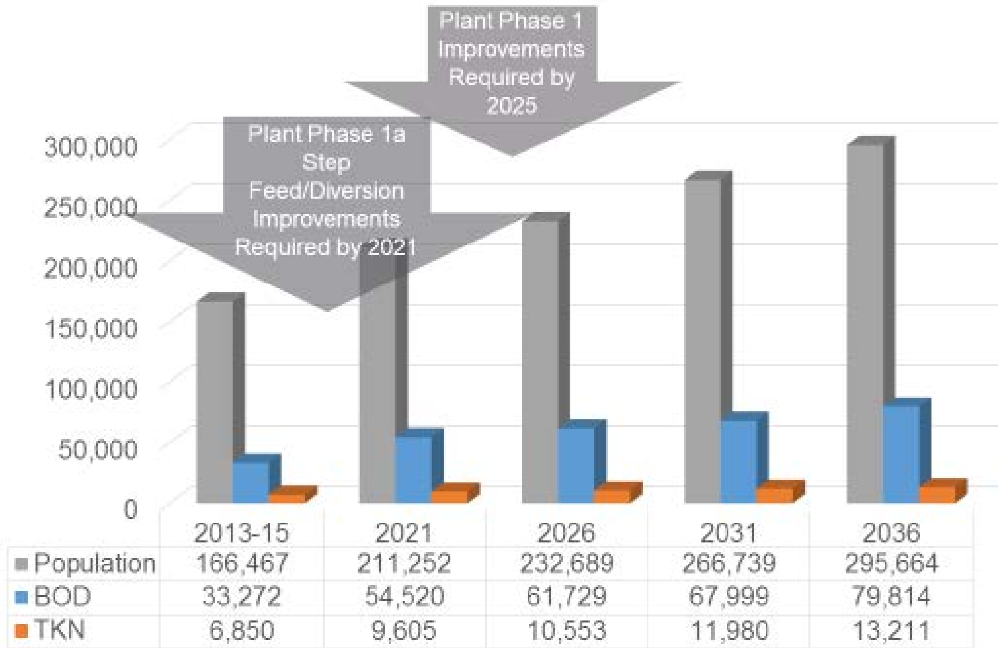


Figure 10.7. Sioux Falls WRF Recommended Improvements Timeline and Associated Loadings

The improvements have been compiled and presented herein in the form of a preliminary capital improvements plan included as Table 10.7 and footnoted accordingly.

Table 10.7 WRF Capital Improvements Plan

Improvements Phase	Proposed Capital Improvements	Recommended Project Cost*	
Phase 1a Improvements	Step Feed Improvement at Aeration Basins	$3,670,000	Immediate hydraulic and organic capacity need. 1. Phase 1a - Step Feed Exp. & PC Infl. Div. are immediate improvements required to extend plant capacity to allow Phase 1 to be constructed.
	Phase 1a Grit Influent Piping	$1,670,000	
	Primary Clarifier Influent Diversion	$1,900,000	
	Final Clarifier Rehab	$6,500,000	
	Filter Building High Priority Items	$1,000,000	
	Biosolids Dewatering/Handling Improvements	$18,100,000	
	Dewatering Building Rehab Items	$1,200,000	
	Phase 1a Subtotal	**$34,040,000**	
Phase 1 - WRF Improvements	Headworks	$14,600,000	Begin design in 2017 to meet 2025 construction date.
	Primary Clarifiers	$18,800,000	
	Aeration Basin Upgrades (1)	$4,000,000	
	Aeration Basin Splitter Box	$2,300,000	
	Aeration Basins	$38,600,000	
	Aeration Basin Blowers	$7,600,000	
	Replace RAS and WAS Pumps	$420,000	
	Final Clarifiers	$17,100,000	
	WRF - Filter Expansion	$7,100,000	
	Chlorine Contact Expansion (1) (2)	$3,200,000	
	Effluent Flow Meter Improvements	$420,000	
	Convert Biosolids Lagoons to Equalization Basins	$6,900,000	
	New Generator	$2,200,000	
	Site Piping	$2,700,000	
	WRF Phase 1 -New Thickening	$3,330,000	
	WRF – Microturbines	$4,150,000	
	WRF - FOG Receiving (Shifted from Phase 1)	$2,920,000	
	Phase 1 High Priority Items	*$15,094,600*	Identified as immediate needs by condition assessment.
	Phase 1 Medium Priority Items	*$10,400,000*	Identified as 5-10 year needs by condition assessment.
	Total Phase 1 Improvements Subtotal	**$161,900,000**	
	Total Phase 1a & Phase 1 Improvements Subtotal	**$195,900,000**	
Phase 2 - WRF Improvements	WRF - Phase 2 - Liquid Nutrient Improvements	$105,600,000	

- In 2016 project costs including design and engineering.

10.3.2 Operational Driven Needs

Table 10.8 identifies recommended operational improvements. A digital intranet based operations manual should be considered to facilitate continuous update and central access to SOP's and equipment manuals. Equipment Asset Management Software Updates (EAM), Computerized Maintenance Management Software (CMMS) should be developed to better manage renewal decisions. There are several short term alternatives which would be to implement a separate EAM system such as AWWA's Plant Infrastructure Manager or HDR's AM Tools that are based on an MS Access database. However, the WRF should upgrade to a commercial version, as this would further assist with annual budgeting and implementation of the recommended high and medium priority improvements.

Table 10.8 Operations Improvements Summary – Monetary

Priority	Assessment Category	Opportunity	Opportunity Description	Implemented Within	Cost
Medium	Operational Capabilities and Procedures	Operations Manuals	Development of a facility level O&M Manual is recommended. A digital intranet based manual should be considered to facilitate continuous update and central access to SOP's and equipment manuals.	2–5 Years	$200,000
Medium	Maintenance Procedures	Equipment Asset Management Software Updates (EAM)	Consider developing an EAM system to better manage renewal decisions. There are several short term alternatives to implement this initiative either by; enhancing the current CMMS system to include EAM features described earlier or implementing a separate EAM system such as AWWA's Plant Infrastructure Manager or HDR's AM Tools that are based on an MS Access database.	2–5 Years	$50,000
Medium	Maintenance Procedures	Computerized Maintenance Management Software (CMMS)	Consider the eventual replacement of the existing CMMS with a commercial version. Based on the updates made to the asset spreadsheet; the migration of the asset registry and historical data should be straightforward. Implementation is estimated to be $80,000 subject to final negotiations and changes to the scope of work. The licensing for a model includes an annual cost of $15-30K assuming 20 individual users.	5–10 Years	$80,000
					$330,000

10.3.3 Project Schedule

Per Figure 10.7 the vision is for the Phase 1a and Solids Handling coming online by the year 2021 and the Phase 1 projects reaching substantial completion in 2025.

The schedule presented (see Figure 10.6) shows the Phase 1 facilities beginning service in the second quarter of 2025. To meet this schedule, it is recommended that the preliminary design begin in early 2018. Some of the activities that are scheduled for the 3-year period from 2018 to 2021 include:

• Public outreach

• Compliance with City Ordinance as Facility has surpassed 70% design capacity.

The schedule shows design beginning in 2018 with preliminary design for all Phase 1 projects. As shown on the schedule, the design periods can be staggered to allow City staff ample opportunity for input and coordination. It is estimated that the WRF construction will take about 3 years, with the PS 240 equalization and forcemain constructed by 2022.

10.3.4 Consequences of Inaction

Failure to implement the recommended improvements in a timely manner could have significant adverse impacts on the City of Sioux Falls WRF, including:

- Limitations on City and Regional growth.
- Non-compliance with discharge permit requirements.
- Non-compliance with City Treatment Capacity per Ordinance.
- Raw sewage spills, and associated public health impacts.
- Water quality impairment of the Big Sioux River.
- Inability to handle wastewater generated by the community.

These consequences would likely lead to regulatory enforcement actions and fines, and may result in a moratorium on new construction within the City's service area.

10.3.5 Recommended Staffing

The Water Reclamation Facility is staffed with wastewater treatment and collection system team members. The wastewater treatment plant is staffed 24 hours a day, seven days a week, by a team of operations, maintenance, lab, supervisors and administration staff. The operations and maintenance team functions are to operate, maintain, and monitor the plant's mechanical and biological processes, and make adjustments to plant operations when needed. The wastewater treatment plant also includes one chemist and two lab analysts (environmental technicians) that work seven days a week, performing 48 main chemical and biological analytical tests per day. A biosolids team is responsible for the disposal of wastewater biosolids through land application.

A collections team is comprised of 22 employees who operate and maintain the cities collection system for the sanitary and storm sewer systems.

The WRF is currently staffed by these main work groups:

- 1 Division Superintendent
- 2 Administrative Assistants
- 14 Plant Operations
    - 1 Plant Operations Supervisor
    - 10 Plant operators
    - 3 Lab staff (1 Chemist and 2 Environmental Technicians (lab analysts))
- 12.5 Plant Maintenance
    - 1 Plant Maintenance Supervisor
    - 6 Plant Maintenance Mechanics
    - 1 Electrician
    - 1.5 Controls Technicians
    - 1 Laborer
    - 1 Custodian
- 4 Plant Biosolids
    - 1 Residue Coordinator
    - 3 Equipment Operators (Biosolids)

The collections team is currently staffed by these main work groups:

- 2- Sewer Collection Supervisor
- 4- Lead Sewer Collection Technicians
- 16- Sewer Collection Technicians

The overall Water Reclamation division is comprised of 55.5 employees responsible for the conveyance and treatment of wastewater.

OPERATIONS

Operators perform daily tasks of monitoring and evaluating plant operations. Operators also assist with lab sampling and analysis; i.e. settleometer /SVI, and reading 5-day BOD results on weekends.

MAINTENANCE

The WRF is staffed with a maintenance supervisor who provides technical expertise in planning, scheduling, and coordinating preventive and corrective (non-recurring) maintenance. Maintenance mechanics maintain mechanical, electrical, instrumentation, and SCADA process equipment in the plant and in the collection system.

An electrician position is assigned to the WRF staff and provides technical expertise for the maintenance of power distribution, electrical, and control systems. The team is also comprised of 1.5 controls technicians that maintain and coordinate all the instrumentation and SCADA equipment needs in the plant and collection systems. Laborers and custodian are utilized to maintain the plant site and buildings.

LABORATORY

All laboratory work is performed onsite at the WRF. Lab staff provide special study support as needed during any required analysis. Lab staff maintain composite samplers and verify calibration of all permit related analyzers. Lab staff perform thousands of sample collections and analysis each year.

10.3.5.1 Existing Staffing Requirements

A preliminary analysis was conducted to estimate the number of additional staff that will be required to operate and maintain the expanded plant. The first step of this analysis was to benchmark the City's current staffing for treatment functions against other publicly and privately operated wastewater utilities across the country utilizing the EPA Staffing Model. The collections team was not benchmarked against an EPA model. The collections team growth is dependent upon the additional pipelines and structures added to the collection systems annually and therefore future employee growth is a function of pipeline and structure growth.

Note that the EPA Staffing Model only gives a general measure of nation-wide staffing levels and the detailed breakdown of employee classifications will differ. EPA staffing recommendations have set categories including "Operations", "Maintenance", "Supervisory", "Clerical", "Laboratory" and "Yard Work and Miscellaneous". These categories may or may not fit different cities organizational structures. The following Table 10.9 presents current WRF staffing classifications corresponding to the predefined EPA staffing categories.

As presented in Table 10.9, for existing plant flow, the totals for Supervisory and O&M are very close with 29 recommended and a total of 27.5 existing staff in these areas. In addition, the overall all EPA recommended staff totals correspond closely with existing staff at 35 total versus 33.5 existing.

Table 10.9 Sioux Falls WRF EPA Staffing Estimate Worksheet for Existing Plant Flow

EPA Staffing Categories	EPA Recommended Staff Totals	Corresponding Water Reclamation Categories	Existing Staff Totals
Operations	22	Plant Operators	10
		Biosolids Operators	3
Maintenance	5	Maintenance	10.5
Supervisory	2	Supervisory	4
Supervisory and O&M Subtotals	**29**		**27.5**
Clerical	1	Administrative Assistants	2
Laboratory	3	Laboratory Chemist and Environmental Technicians	3
Yard work & Misc.	2	Laborer	1
Totals	**35**		**33.5**

The staffing review provides an indication that the City is currently providing just below the proper number of employees in accordance with the EPA Staffing Model.

10.3.5.2 Design Year 2036 Staffing Requirements

The second step of the analysis was to adjust the EPA model to determine future treatment staff needs. The EPA Staffing Model was used to project requirements for the projected planning year WRF employing the selected activated sludge process complete with solids handling including anaerobic digestion, dewatering and thermal drying.

As presented in Table 10.10, for design year 2036 plant flow, 8.5 total additional employees are projected for "Supervisory and O&M" and an additional three (3) employees for clerical, laboratory and yardwork are recommended. The EPA model results recommend an additional 11.5 employees, with the total number of employees for the 2036 design year at 45 compared to the current number of plant employees of 33.5.

Table 10.10 Sioux Falls WRF EPA Staffing Estimate Worksheet for Design Year Plant Flow

EPA Staffing Categories	EPA Recommended Staff Totals	Corresponding Water Reclamation Categories	Existing Staff Totals	Additional Staff Required
Operations	30	Plant Operators	10	
		Biosolids Operators	3	
Maintenance	3	Maintenance	10.5	
Supervisory	3	Supervisory	4	
Supervisory and O&M Subtotals	**36**		**27.5**	**8.5**
Clerical	2	Administrative Assistants	2	
Laboratory	4	Laboratory Chemist and Environmental Technicians	3	1
Yard Work & Misc.	3	Laborer	1	2
Totals	**45**		**33.5**	**11.5**

Staffing levels should be built up gradually as summarized in Table 10.11. Additional employees will be needed for the biosolids dewatering and drying facility as well as the plant expansion projects that are scheduled to be completed by 2025 and will require additional maintenance and operations team members.

The candidate pool for qualified wastewater treatment operators and mechanics is limited. With increasing technology and improved implementation of SCADA, WRF will require technicians with advanced skills and problem solving abilities. For example, many facilities are employing energy demand software, which requires vigilant controls personnel.

A plan should be put into place to maintain trained and skilled to personnel to reliably operate the WRF.

Table 10.11 Sioux Falls WRF Staffing Recommendations

Year	Staffing Category	Corresponding Water Reclamation Categories	Additional Staff Required
By or Before 2025	Operations	Certified Operators	2
By or Before 2025	Maintenance	Controls Technician	2
By or Before 2025	Maintenance	Electrician	1
By or Before 2025	Maintenance	Plant Mechanic	1
By or Before 2025	Maintenance	Laborer	1
By or Before 2030	Operations	Environmental Technician	1
By or Before 2036	Operations	Certified Operators	1
By or Before 2036	Maintenance	Plant Mechanic	2
Totals			**11**

ENVIRONMENTAL STAFFING

The environmental team was not benchmarked or evaluated with the EPA modeling software for staffing. It is recommended that the City budget for a pretreatment employee to handle the additional workload requirements for monitoring mercury best practices at dental offices. The proposed pretreatment standards apply to wastewater discharges to the WRF from offices where dentistry is performed, including institutions, permanent or temporary offices, clinics, mobile units, home offices, and facilities, including dental facilities owned and operated by federal, state, or local governments.

The proposed changes to 40 CFR 403 reflect EPA's recognition that the current regulatory framework needs to be adjusted for the effective implementation and enforcement of these pretreatment requirements on the dental industry. Therefore, EPA is proposing a new classification of CIU, specifically the tailored to the proposed rule - Dental Industrial User (DIU). The extent of the impact to the WRF workload is not final and the rulemaking should continue to be monitored.

Additional environmental staff will also be needed as the city and regional customers continue to grow and create more demands on the environmental staff.

10.3.6 Recommended Studies

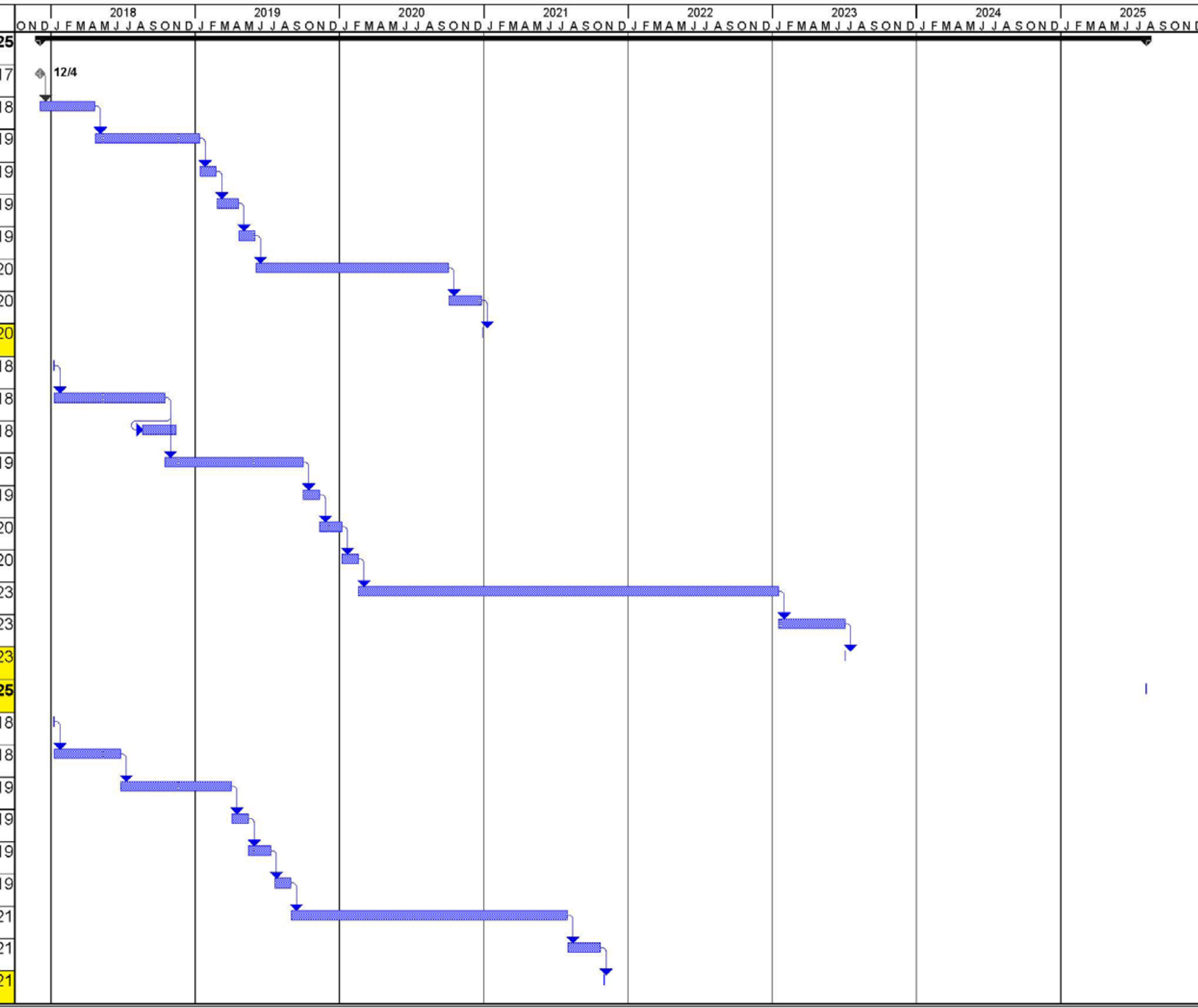
The following studies are recommended to augment this 2016 Master Planning Effort:

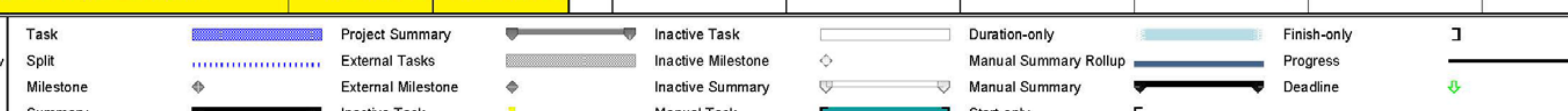
- Buried Piping Condition Assessment
  Buried Piping Condition Assessment Study Cost $100,000
- Biogas End Use Study
  Biogas End Use Study Cost $70,000
- Hauled Waste Cost of Service Analysis
  Hauled Waste Cost of Service Analysis Cost........................... $40,000
- ARC Flash/Short Circuit Study
  ARC Flash/Short Circuit Study Cost....................$100,000 – $200,000
- Harmonic Study
  Harmonic Study Cost.. $50,000
- FOG Study -Address Master Plan Action Items
  FOG Study -Address Master Plan Action Items Cost…$50,000-$100,000

Figure 10.8 WRF Project Implementation Schedule

Sioux Falls WRF Master Plan Projections
Project Schedule

ID	Task Name	Start	Finish
1	**Water Reclamation Facility - Master Plan**	**Mon 12/4/17**	**Mon 8/4/25**
2	Notice to Proceed	Mon 12/4/17	Mon 12/4/17
3	Preliminary Design Phase 1A Improvements	Mon 12/4/17	Fri 4/20/18
4	Final Design	Mon 4/23/18	Fri 1/11/19
5	Bid Document Preparation/Review	Mon 1/14/19	Fri 2/22/19
6	Advertise	Mon 2/25/19	Fri 4/19/19
7	Contract Award	Mon 4/22/19	Fri 5/31/19
8	Construction Phase 1A Improvements	Mon 6/3/19	Fri 10/2/20
9	Startup and Training	Mon 10/5/20	Fri 12/25/20
10	**Phase 1A Improvements Project Completion**	Mon 12/28/20	Mon 12/28/20
11	Notice to Proceed For Remainder of Phase 1	Mon 1/8/18	Mon 1/8/18
12	Preliminary Design Remainder of Phase 1	Tue 1/9/18	Mon 10/15/18
13	Geotechnical	Tue 8/21/18	Mon 11/12/18
14	Final Design	Tue 10/16/18	Mon 9/30/19
15	Bid Document Preparation/Review	Tue 10/1/19	Mon 11/11/19
16	Advertise	Tue 11/12/19	Mon 1/6/20
17	Contract Award	Tue 1/7/20	Mon 2/17/20
18	Construct Phase 1 Improvements	Tue 2/18/20	Mon 1/16/23
19	Startup and Training	Tue 1/17/23	Mon 7/3/23
20	**Phase 1 Improvements Project Complete**	Tue 7/4/23	Tue 7/4/23
21	**Phase I Improvements Needed**	**Mon 8/4/25**	**Mon 8/4/25**
22	Biosolids Phase 1 Notice to Proceed	Mon 1/8/18	Mon 1/8/18
23	Preliminary Design Biosolids Phase 1	Tue 1/9/18	Mon 6/25/18
24	Final Design	Tue 6/26/18	Mon 4/1/19
25	Bid Document Preparation/Review	Wed 4/3/19	Wed 5/15/19
26	Advertise	Thu 5/16/19	Wed 7/10/19
27	Contract Award	Mon 7/22/19	Fri 8/30/19
28	Construct Biosolids Phase 1	Mon 9/2/19	Fri 7/30/21
29	Startup and Training	Mon 8/2/21	Fri 10/22/21
30	**Biosolids Phase 1 Project Complete**	Mon 11/1/21	Mon 11/1/21





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Page 1

Chapter 11 – Summary of Collection System Improvements

Wastewater Treatment and
Collection System Master Plan

Sioux Falls, SD
February 2018

Contents

Tables

Figures

Appendices

Chapter 11 Summary of Collection System Improvements

11.1 Introduction

This chapter summarizes recommended improvements to the City of Sioux Falls' existing and future sanitary collection system. Recommendations are identified for the existing system and for future growth areas and grouped by basin for sanitary sewer, pump station, forcemain, and equalization.

Opinions of probable construction cost are identified for each improvement, and summarized into a Capital Improvements Plan (CIP). Further studies are also recommended to help further refine the extent and timing of recommended improvements as the direction of development becomes apparent.

The focus of the CIP criteria was to focus on a program that implements responsible capital spending that minimizes early and excessive cash flow programs with broad system reliability and still maintains flexibility for long-term choices.

The long-term selected alternative allowed for a future satellite WRF(s) plan; included how, where, and when to integrate equalization basins, how to plan for future industrial flows (Foundation Park), how to plan for non-City (Regional) flows, while allowing for development growth.

11.2 Related Chapters

Related Chapters to the City's CIP for wastewater collection system facilities include:

- Existing Wastewater System Facilities (Chapter 3 includes lift station assessments)
- Collection System Model Development and Calibration (Chapter 5)
- Collection System Analysis and Improvement Alternatives (Chapter 9)

11.2.1 Improvement Periods

The Tiers used are broken down into four planning periods to conform to Chapter 2 and the shape Sioux Falls plan. Tier 4 growth areas are used for corridor planning and trunk line sizing.

The projected growth area is divided into the following tiers as indicated on the figures referenced throughout this chapter:

- Tier 1, or Immediate (2017 through 2021)
- Tier 2, or Near-Term (2022 through 2031)
- Tier 3, or Mid-Term (2032 through 2041)
- Tier 4, or Long-Term (2041 through 2066)

11.2.2 Summary Existing System Capacity Related Improvements

Based on the model development described in Chapter 5, the existing collection system was analyzed for hydraulic limitations under existing and future conditions. However, the collection system issues in the 2026 and 2036 planning years were also examined and summarized in Table 11.1. For most of the areas, the 2026 problem areas are the same as the 2066 planning year.

Model results for the recommended plan indicate a number of areas that have existing sanitary collection system capacity limitations. Sanitary sewer improvements were identified to address the deficiencies to the existing collection system described in Chapter 9.

Tier 1 project areas are considered high priority improvements as they identified to resolve larger hydraulic capacity limitations and are anticipated to have a high benefit to the collection system. The Type A problem areas, grouped by tier, are shown in Table 11.1. This table also rates problem extent, SSO risk, and lateral backup risk

Table 11.1 Collection System – Type A Deficient Areas Grouped by Priority Tier

Problem Area	Basin	Flow Monitoring Data Available*	CIP	2015 Problem Area? d/D Exceeded	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded	Problem Extent**	SSO Risk***	Lateral Backup Risk****	Priority Tier
Type A, Tier 1 Hydraulically Deficient Areas Areas where Model Confidence is Medium or High and Pipe Diameters are 18 Inches and Greater										
Lower Riverside Trunk Sewer	Basin 3	High	Further Monitoring	Yes	Yes	Yes	Medium	High	High	Tier 1
Central Main	Basins 3 & 4	High	Further Monitoring	No	Yes	Yes	Medium	Medium	Low	Tier 1
Southeastern Drive	Basin 5	High	Yes	Yes	Yes	Yes	Medium	Low	Low	Tier 1
Sioux River North Upstream of PS 215	Basins 10 & 11	High	Yes	No	No	No	High	Low	Low	Tier 1
Pam Road (Southside Interceptor)	Basin 8	High	No – Investigate profile via survey.	Yes	Yes	Yes	Low	Low	Low	Tier 1
Sioux River South	Basins 6 & 7	Medium	No	No	No	Yes	Medium	Low	Low	Tier 1
Richmond Estates Trunk	Basin 1	Medium	Yes	Yes	Yes	Yes	High	High	High	Tier 1
Type A, Tier 2 Hydraulically Deficient Areas Areas where Model Confidence is Medium and Pipe Diameters are Less than 15 Inches NO CIP Projects Alternatives are Developed Areas Should be Monitored and be a Target for I/I Reduction										
I-90 Place Addition	Basin 9	Medium	No	No	No	Yes	Medium	Low	High	Tier 2
Sioux Empire Development Park	Basin 9	Medium	No	No	No	Yes	High	Low	Low	Tier 2
Hilltop Trunk	Basin 4	Medium	No– monitor and target for I/I reduction	Yes	Yes	Yes	Low	Medium	High	Tier 2
12th St and Marion Rd	Basin 11	Medium	No – monitor and target for I/I reduction	Yes	Yes	Yes	High	Medium	Medium	Tier 2
Ebenezer Avenue	Basin 11	Medium	No	No	No	Yes	Low	Low	Medium	Tier 2

Table 11.1 Collection System – Type A Deficient Areas Grouped by Priority Tier

Problem Area	Basin	Flow Monitoring Data Available*	CIP	2015 Problem Area? d/D Exceeded	2026 Problem Area? d/D Exceeded	2036 Problem Area? d/D Exceeded	Problem Extent**	SSO Risk***	Lateral Backup Risk****	Priority Tier
30th Street and Lake Avenue	Basin 8	Medium	No	No	Yes	Yes	Low	Low	High	Tier 2
I-229 Trunk	Basin 7	Medium	No	No	No	No	Low	Medium	Low	Tier 2
Rustic Hills Subdivision	Basin 5	Medium	No	No	Yes	Yes	High	Low	Medium	Tier 2
Morningside Trunk Extension	Basin 5	Medium	No	No	Yes	Yes	Medium	Low	Low	Tier 2
Type A, Tier 3 Hydraulically Deficient Areas Areas where Model Confidence Low NO CIP Projects Alternatives are Developed Flow Monitoring Data Should be Obtained with the Capture of a Significant Wet Weather Event										
Basin 17A Trunk (Lewis Road)	Basin 17	Low	No	Yes	Yes	Yes	High	High	High	Tier 3
Western Interceptor Trunk	Basin 10	Low	No	Yes	Yes	Yes	Medium	Low	Low	Tier 3
Airport Subdivision	Basin 12	Low	No	Yes	Yes	Yes	High	High	High	Tier 3
Columbia Heights Trunk	Basin 10	Low	No	No	Yes	Yes	High	Medium	High	Tier 3
17th, 18th, and 19th Streets	Basin 10	Low	No	No	Yes	Yes	Medium	Low	Low	Tier 3

Flow Monitoring Data Available *
- High – Data sufficient to make CIP recommendations
- Medium – Basin data available but localized monitoring data needed
- Low – Data not available and insufficient to make CIP recommendations

Problem Extent**
- High – Hydraulic deficiency impacts a large number of pipes
- Medium – Hydraulic deficiency impacts a more than 3 pipe segments but less than 8 number of pipes
- Low – Hydraulic deficiency impacts a less than 3 pipe segments

SSO Risk***
- High – SSO likely
- Medium –SSO potential
- Low – basement backup potential

Lateral Backup Risk****
- High – Hydraulic deficiency likely to impact lateral
- Medium – Hydraulic deficiency may impact laterals
- Low – Hydraulic deficiency not likely to impact laterals

For Tier 1 project areas, existing and future (2066) potential hydraulic capacity limitations are analyzed separately. Existing condition hydraulic improvement alternatives are developed to satisfy the 0.8 d/D hydraulic criteria for the Collector/Interceptor system for existing flows and then to not surcharge under future (2066) condition flows. Existing condition hydraulic improvement alternatives only focus on the extent of the existing conditions hydraulically limited areas. If upstream and downstream pipes have future capacity limitations, only pipes that are under capacity under current conditions are altered for short term improvements (next 1-10 years). Future (2066) condition hydraulic improvement alternatives are developed to prevent surcharging under future (2066) condition flows.

The CIP is developed for the identified Tier 1 hydraulic improvements.

These areas are illustrated in Figure 11.1 and identified. Table 11.2 summarizes the existing system improvements based on 2066 projected flows.

Figure 11.1 Tiers 1-4, 50-Year Build-out (2066) Collection System Type A Problem Areas

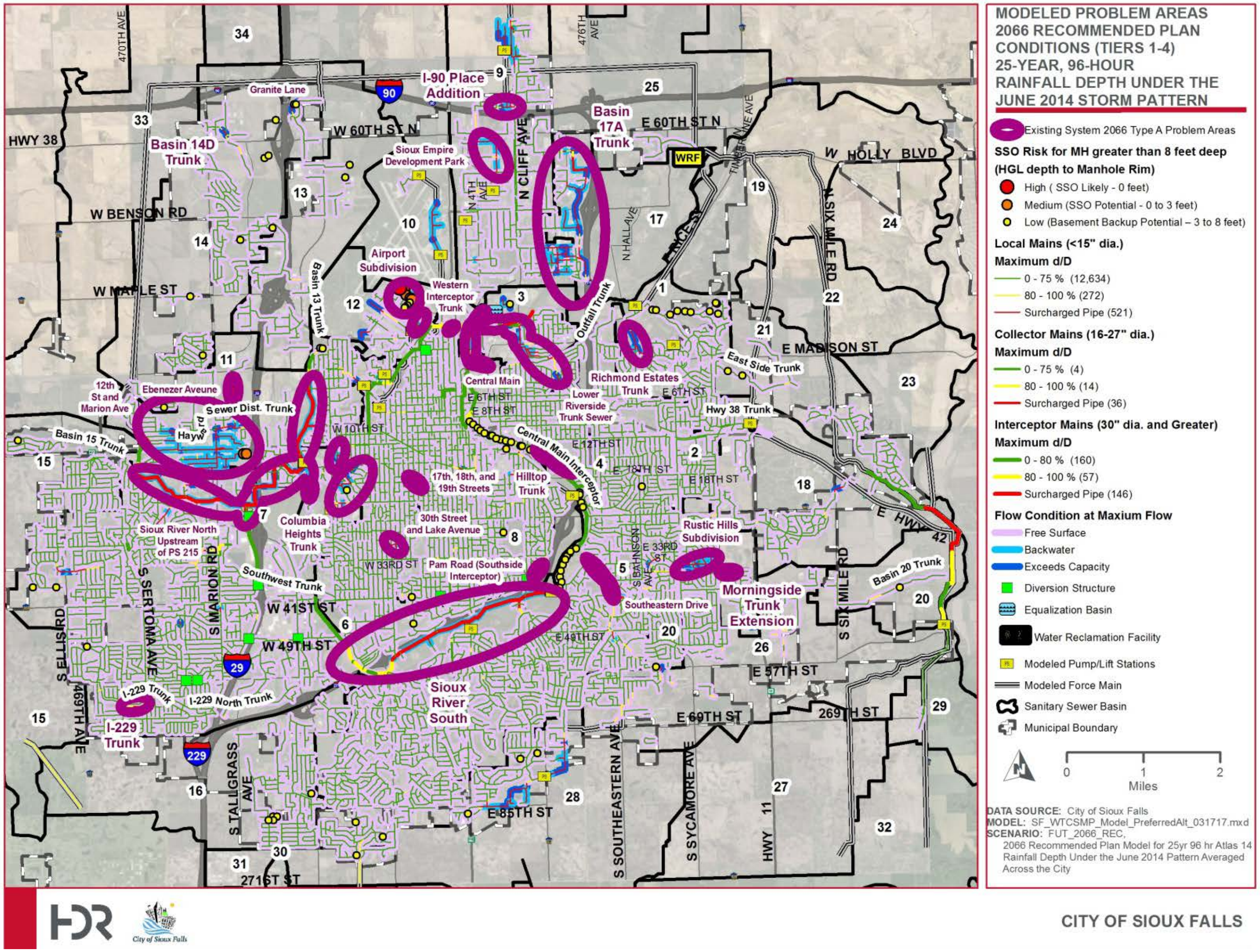

Table 11.2 Summary Existing System Capacity Related Improvements

Problem Location	Existing Pipe Diameter(s)	Recommended Diameter(s)	Project Extent: Pipe Length per Diameter Size	CIP Cost Developed
Lower Riverside Trunk Sewer	8-,10-,12-,15-, 30-and 36-inch	12-inch	787	None - Need to Monitor Degree of Surcharge - There is no appreciable change in flow from 2013 to 2066 from growth. Surcharging shows on Cliff Ave. without John Morrell flow. Primary impact is permitted point load discharge from John Morrell.
		15-inch	936	
		18-inch	2,998	
		21-inch	1,289	
		24-inch	332	
		36-inch	971	
Central Main	8-, 18-, 24-,48- and 60-inch	60-inch	369	None – Continue to monitor and evaluate; no impact to adjacent services. Problem Area has minimal impact on connecting laterals other than the East Side Trunk Sewer.
		66-inch	2,458	
		72-inch	536	
Southeastern Drive	15-,18- and 24-inch	CIPP Lined	2,926	Yes – CIP is lining and allow minimal surcharging along profile; no impact to adjacent services.
Sioux River North Upstream of PS 215	8-,10-,12-,18-, 30-, 36-, and 42-inch	1.6 MG of Equalization Recommended		Yes
		15-inch	460	
Pam Road (Southside Interceptor)	18-inch	18-inch	428	None – Flow can be relieved at Duluth. Surcharging to be investigated via survey along profile. No impact to adjacent services.
		24-inch	540	
Sioux River South	10-, 15-, 24-, 36-, 48-, and 54-inch	2.4 MG of Equalization Alleviates but Not recommended at this time.		None - no impact to adjacent services.
Richmond Estates Trunk	8-inch	12-inch	1,990	Yes
Diamond Valley		Increase PS size - Pumps, motors and controls.		Yes

11.2.3 Growth Related Improvements Prioritization Approach

The overall future service approach is as follows:

11.2.3.1 For Planning Year 2116

- Size gravity extensions for 100-year flows

11.2.3.2 For Planning Year 2066

- Size relief sewers, pump stations and equalization for 20 to 50-year flows
- Select major west side improvement approach
(Westside WRF or pump around forcemains)

11.2.3.3 For Planning Year 2036

- Prioritize CIP improvements

11.2.3.4 For Planning Year 2026

- Select major eastside improvement approach
- Solutions to current local deficiencies
- Prioritize CIP improvements

For hydraulic deficiencies to the existing collection system, priority improvements have been included in this chapter, which are represented by Type A Tier 1 projects.

For future trunk sewer extensions to serve development expansion areas, alternatives for growth scenarios were developed and evaluated in Chapter 9 and reviewed with the City through a series of workshops. The final recommendations from that effort are included herein.

Final implementation of projects need to consider the actual timing of development in growth areas.

11.3 2036 Recommended Collection System

A preferred alternative is developed in Chapter 9 based on the discussion of advantages and disadvantages as well as discussions with the City. The preferred alternative is to implement Alternative G (Scenario 12) through 2036 and Alternative C (Scenario 6) for 2036 and beyond.

Figures 11.2 through 11.4 provide overall maps of the interim Alternative G (2026, 2036) Options and the Long-Term Alternative C Preferred (2036 and Beyond) Option.

The benefits through 2036 for Alternative G are as follows:

- Does not require long forcemain for Basin 15 and Basin 34 through 2036.
- Accommodates Basin 33 (Foundation Park) through existing system via a 6.6 mile force main.

- Allows early opening of Basins 30 and 31 sent through the existing system via Basin 6 with a 1.4 mile force main (least cost option).
- Upsizing of Basin 26 not specifically required for future trunk extensions (may be required for future local basin development).
- Minimizes short-term equalization (EQ) needs (high cost item).

The benefits for beyond 2036 for Alternative C are as follows:

- Basin 33 (Foundation Park) forcemain could eventually be tied into Basin 15/34 forcemain.
- Avoids need to upsize Sioux River North.
- Avoids need to construct large EQ at PS 215.
- Minimizes long-term EQ needs (high cost item).
- Leaves flexibility for long-term eastside (2036-2116).
  And west side (2066-2116) WRFs.

The impact to Pump Station 240 and the East Side WRF are as follows:

- By 2020 - Equalization Storage Needed
  - 1-3 MG
- By 2022 - Pump Station 240 Upgrade and 2nd 30-inch Forcemain
- 2036 – 2116 - Satellite Eastside WRF Alternative (North or South Options) OR
- By 2036 – 2116 - 2nd Pump Station Upgrade and 3rd Forcemain

This preferred alternative is the basis for the recommended plan associated with each development group for trunk sewer extensions.

Table 11.3 summarizes the recommendations associated with each development group for trunk sewer extensions with a graphical presentation in Figures 11.2 through 11.4.

Figure 11.2 Selected 2026 Capital Improvements Map

2026 Future Trunk Sewer Extensions Recommended Plan

Basin	Diameter	Length (ft)
Basin 7	12-in	3,707
	18-in	10,517
	30-in	720
Basin 7 Total		**14,944**
Basin 9	8-in	4,926
Basin 9 Total		**4,926**
Basin 14	54-in	1,202
Basin 14 Total		**1,202**
Basin 15	12-in	15,895
	21-in	2,406
	42-in	17,902
Basin 15 Total		**36,203**
Basin 16	21-in	1,000
	24-in	2,925
	30-in	4,948
Basin 16 Total		**8,873**
Basin 17	18-in	20,332
Basin 17 Total		**20,332**
Basin 18	8-in	2,800
	12-in	11,807
	21-in	3,067
	24-in	241
	42-in	2,198
Basin 18 Total		**20,113**
Basin 19	12-in	12,580
	27-in	11,462
	42-in	755
Basin 19 Total		**24,797**
Basin 21	8-in	1,049
Basin 21 Total		**1,049**
Basin 22	12-in	13,397
Basin 22 Total		**13,397**
Basin 23	12-in	6,552
Basin 23 Total		**6,552**
Basin 25	48-in	340
Basin 25 Total		**340**

Basin	Diameter	Length (ft)
Basin 26	8-in	177
	12-in	5,226
	24-in	89
	30-in	47,781
Basin 26 Total		**53,273**
Basin 27	12-in	43,167
	18-in	12,250
	21-in	2,000
	27-in	22,276
	36-in	109
Basin 27 Total		**79,803**
Basin 28	12-in	31,646
	15-in	3,561
	21-in	7,000
	27-in	20,777
Basin 28 Total		**62,985**
Basin 29	8-in	3,181
	12-in	7,272
Basin 29 Total		**10,454**
Basin 30	8-in	7,253
	12-in	7,901
	18-in	9,447
	27-in	4,434
	36-in	21
Basin 30 Total		**29,056**
Basin 31	12-in	5,000
Basin 31 Total		**5,000**
Basin 33	8-in	9,336
	10-in	10,551
	12-in	11,340
	15-in	6,747
	21-in	3,149
Basin 33 Total		**41,122**
	54-in	43
		43

Existing System 2026 CIP

Basin	Type A Hydraulic Deficiency Area for CIP	Diameter	Length (ft)
1	Richmond Estates Trunk	12-in	1,989
3	Lower Riverside Trunk Sewer	12-in	787
		15-in	936
		18-in	2,998
		21-in	1,289
		24-in	332
		36-in	971
5	Southeastern Drive	Lining Project	2,926
7	Southwest Trunk	15-in	557
		18-in	226
10	Sioux River North Upstream of PS 215	15-in	460

2026 Recommended Plan Future Development Trunk Sewer Extension Components	
Basins 30 and 31	**Option 1 (Basin 30 and 31 to Basin 6 Trunk):** • Basin 30/31 PS and EQ • Forcemain from PS and EQ to upstream point of 15-inch Basin 6 Trunk Sewer • Gravity sewer upgrades from upstream point of 15-inch Basin 6 Trunk Sewer to Sioux River South Interceptor
Westside	**Option 4 (Flow through the City with EQ prior to entering)** • Basin 15/34 EQ at connection • Max Flow through City
Basin 28	**Option 3 (Tie to the Basin 27 and 28 PS and EQ):** • Gravity main to Basin 27/28 PS and EQ
Basins 27 and 28	**Option 2 (Basin 27 and 28 directly to PS240):** • Basin 27/28 PS and EQ • Forcemain from PS and EQ directly to PS240
Tea and Basin 16 Flows	**Option 2 (Tie into and parallel I-229 Trunk):** • Tea Flows are equalized to max day flow; Basin 16 future flows are NOT equalized • I-229 Trunk upsized or paralled to carry future flows
Basin 33	**Option 2 (Transfer Flow through Basin 13):** • EQ • Flow through Basin 13
Renner	**Option 2 (Flow to Basin 25):** • Flow through Basin 25

HDR

2026 FUTURE DEVELOPMENT EXTENSION RECOMMENDED PLAN WITH 2026 CIP ON THE EXISTING SYSTEM

FUTURE 2026 CONDITIONS, RECOMMEND PLAN FOR FUTURE EXTENSIONS
FUTURE 2026 BASE SANITARY FLOW WITH TIERS 1 AND 2 DEVELOPMENT EXTENT

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2036 Future Trunk Sewer Extensions Recommended Plan

Basin	Diameter	Length (ft)
Basin 7	12-in	3,707
	18-in	10,517
	30-in	720
Basin 7 Total		**14,944**
Basin 9	8-in	4,926
Basin 9 Total		**4,926**
Basin 14	54-in	1,202
Basin 14 Total		**1,202**
Basin 15	12-in	35,678
	21-in	2,406
	30-in	1,063
	36-in	2,778
	42-in	21,845
Basin 15 Total		**63,770**
Basin 16	21-in	6,000
	24-in	2,925
	30-in	4,948
Basin 16 Total		**13,873**
Basin 17	18-in	20,332
Basin 17 Total		**20,332**
Basin 18	8-in	2,800
	12-in	11,807
	18-in	559
	21-in	3,067
	24-in	241
	42-in	2,198
Basin 18 Total		**20,672**
Basin 19	12-in	16,730
	27-in	11,462
	42-in	2,426
	48-in	1,012
Basin 19 Total		**31,630**
Basin 21	8-in	1,049
Basin 21 Total		**1,049**
Basin 22	12-in	13,397
Basin 22 Total		**13,397**
Basin 23	12-in	6,552
	15-in	2,416
	18-in	6,378
	21-in	1,934
Basin 23 Total		**17,281**
Basin 25	12-in	31,325
	27-in	12,099
	30-in	1,000
	36-in	4,709
	48-in	3,825
	56-in	3,341
Basin 25 Total		**56,299**

Basin	Diameter	Length (ft)
Basin 26	8-in	177
	12-in	5,226
	24-in	89
	30-in	47,781
	42-in	2,054
Basin 26 Total		**55,327**
Basin 27	12-in	43,167
	18-in	12,250
	21-in	2,000
	27-in	22,276
	36-in	109
Basin 27 Total		**79,803**
Basin 28	12-in	42,308
	15-in	3,561
	21-in	7,000
	27-in	20,777
Basin 28 Total		**73,646**
Basin 29	8-in	3,181
	12-in	7,272
Basin 29 Total		**10,454**
Basin 30	8-in	7,253
	12-in	7,901
	18-in	9,447
	27-in	4,434
	36-in	21
Basin 30 Total		**29,056**
Basin 31	12-in	5,000
Basin 31 Total		**5,000**
Basin 33	8-in	9,336
	10-in	10,551
	12-in	11,340
	15-in	6,747
	21-in	3,149
Basin 33 Total		**41,122**
Basin 34	12-in	13,714
	18-in	827
	21-in	1,246
	24-in	2,349
	27-in	17,700
	30-in	10,426
	36-in	3,400
	42-in	5,435
	48-in	4,929
	54-in	12,661
Basin 34 Total		**72,645**

Existing System 2036 CIP

Basin	Type A Hydraulic Deficiency Area for CIP	Diameter	Length (ft)
1	Richmond Estates Trunk	12-in	1,989
3	Lower Riverside Trunk Sewer	12-in	787
		15-in	936
		18-in	2,998
		21-in	1,289
		24-in	332
		36-in	971
5	Southeastern Drive	Lining Project	2,926
7	Southwest Trunk	15-in	557
		18-in	226
10	Sioux River North Upstream of PS 215	15-in	460

2036 Recommended Plan Future Development Trunk Sewer Extension Components	
Basins 30 and 31	**Option 1 (Basin 30 and 31 to Basin 6 Trunk):** • Basin 30/31 PS and EQ • Forcemain from PS and EQ to upstream point of 15-inch Basin 6 Trunk Sewer • Gravity sewer upgrades from upstream point of 15-inch Basin 6 Trunk Sewer to Sioux River South Interceptor
Westside	**Option 4 (Flow through the City with EQ prior to entering)** • Basin 15/34 EQ at connection • Max Flow through City
Basin 28	**Option 3 (Tie to the Basin 27 and 28 PS and EQ):** • Gravity main to Basin 27/28 PS and EQ
Basins 27 and 28	**Option 2 (Basin 27 and 28 directly to PS240):** • Basin 27/28 PS and EQ • Forcemain from PS and EQ directly to PS240
Tea and Basin 16 Flows	**Option 2 (Tie into and parallel I-229 Trunk):** • Tea Flows are equalized to max day flow; Basin 16 future flows are NOT equalized • I-229 Trunk upsized or paralled to carry future flows
Basin 33	**Option 2 (Transfer Flow through Basin 13):** • EQ • Flow through Basin 13
Renner	**Option 2 (Flow to Basin 25):** • Flow through Basin 25

2036 FUTURE DEVELOPMENT EXTENSION RECOMMENDED PLAN WITH 2036 CIP ON THE EXISTING SYSTEM

FUTURE 2036 CONDITIONS, RECOMMEND PLAN FOR FUTURE EXTENSIONS
FUTURE 2036 BASE SANITARY FLOW WITH TIERS 1, 2, AND 3 DEVELOPMENT EXTENT

Figure 11.3 Selected 2036 Capital Improvements Map

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2066 Future Trunk Sewer Extensions Recommended Plan

Basin	Diameter	Length (ft)
Basin 7	12-in	3,707
	18-in	10,517
	30-in	720
Basin 7 Total		**14,944**
Basin 9	8-in	8,148
Basin 9 Total		**8,148**
Basin 14	24-in	39,434
	54-in	1,202
Basin 14 Total		**40,636**
Basin 15	12-in	56,245
	15-in	3,580
	18-in	40
	21-in	20,848
	24-in	8,799
	30-in	1,811
	36-in	2,778
	42-in	21,845
Basin 15 Total		**115,947**
Basin 16	12-in	6,104
	15-in	2,000
	18-in	3,000
	21-in	7,111
	24-in	2,925
	30-in	4,948
Basin 16 Total		**26,087**
Basin 17	18-in	18,922
Basin 17 Total		**18,922**
Basin 18	8-in	2,800
	12-in	11,807
	21-in	3,067
	24-in	241
	42-in	2,198
Basin 18 Total		**20,113**
Basin 19	12-in	16,730
	27-in	11,462
	42-in	2,426
	48-in	1,012
Basin 19 Total		**31,630**
Basin 21	8-in	1,049
Basin 21 Total		**1,049**
Basin 22	8-in	5,492
	12-in	13,397
Basin 22 Total		**18,888**
Basin 23	12-in	6,552
	15-in	2,416
	18-in	6,511
	21-in	1,934
Basin 23 Total		**17,414**
Basin 25	12-in	31,325
	27-in	12,099
	30-in	1,000
	36-in	4,709
	48-in	3,825
	56-in	3,341
Basin 25 Total		**56,299**

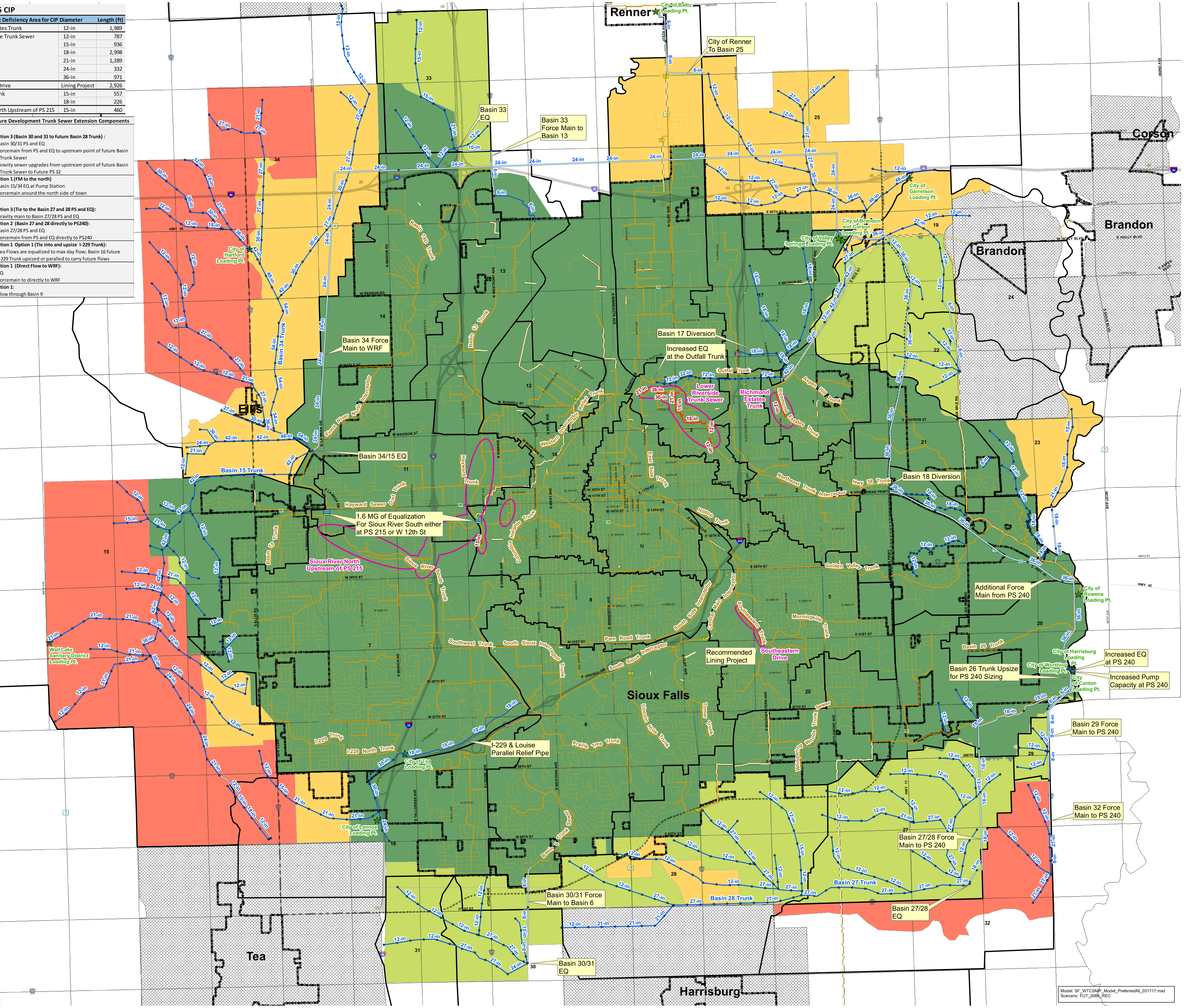
Basin	Diameter	Length (ft)
Basin 26	8-in	3,844
	8-in	177
	12-in	6,340
	18-in	1,410
	24-in	89
	36-in	47,781
Basin 26 Total		**59,641**
Basin 27	12-in	43,167
	18-in	12,250
	21-in	2,000
	27-in	22,276
	36-in	109
Basin 27 Total		**79,803**
Basin 28	12-in	42,308
	15-in	3,561
	18-in	9,447
	21-in	7,000
	27-in	20,777
Basin 28 Total		**83,093**
Basin 29	8-in	3,181
	12-in	7,272
Basin 29 Total		**10,454**
Basin 30	8-in	7,253
	12-in	7,901
	24-in	1,673
	27-in	8,434
	36-in	21
Basin 30 Total		**25,282**
Basin 31	12-in	10,000
	27-in	1,000
Basin 31 Total		**11,000**
Basin 32	8-in	16,159
	12-in	11,267
	21-in	2,000
	27-in	1,508
Basin 32 Total		**30,933**
Basin 33	6-in	7,996
	10-in	2,555
	12-in	10,227
	15-in	6,747
	18-in	914
	21-in	3,149
Basin 33 Total		**31,587**
Basin 34	12-in	43,958
	18-in	2,491
	21-in	7,984
	24-in	27,215
	27-in	31,679
	30-in	19,029
	36-in	5,400
	42-in	7,489
	48-in	4,929
	54-in	12,618
	60-in	120
Basin 34 Total		**162,912**

Existing System 2066 CIP

Basin	Type A Hydraulic Deficiency Area for CIP	Diameter	Length (ft)
1	Richmond Estates Trunk	12-in	1,989
3	Lower Riverside Trunk Sewer	12-in	787
		15-in	936
		18-in	2,998
		21-in	1,289
		24-in	332
		36-in	971
5	Southeastern Drive	Lining Project	2,926
7	Southwest Trunk	15-in	557
		18-in	226
10	Sioux River North Upstream of PS 215	15-in	460

2066 Recommended Plan Future Development Trunk Sewer Extension Components

Basins 30 and 31	**Option 3 (Basin 30 and 31 to future Basin 28 Trunk) :** • Basin 30/31 PS and EQ • Forcemain from PS and EQ to upstream point of future Basin 28 Trunk Sewer • Gravity sewer upgrades from upstream point of future Basin 28 Trunk Sewer to Future PS 32
Westside	**Option 1 (FM to the north)** • Basin 15/34 EQ at Pump Station • Forcemain around the north side of town
Basin 28	**Option 3 (Tie to the Basin 27 and 28 PS and EQ):** • Gravity main to Basin 27/28 PS and EQ
Basins 27 and 28	**Option 2 (Basin 27 and 28 directly to PS240):** • Basin 27/28 PS and EQ • Forcemain from PS and EQ directly to PS240
Tea and Basin 16 Flows	**Option 1 Option 1 (Tie into and upsize I-229 Trunk):** • Tea Flows are equalized to max day flow; Basin 16 future • I-229 Trunk upsized or paralled to carry future flows
Basin 33	**Option 1 (Direct Flow to WRF):** • EQ • Forcemain to directly to WRF
Renner	**Option 1:** • Flow through Basin 9



LEGEND

- 2066 CIP Equalization
- 2066 CIP Pipe Replacment
- 2066 Type A, Tier 1 Hydraulically Deficient Area
- Future Model Junctions
- Future Outfalls
- Force Main
- Gravity Main

2066 FUTURE MODEL SCENARIO COMPONENTS

- Future Regional Customer Loading Location
- Major Sanitary Sewer Basins Extended to Future

EXISTING SYSTEM MODELING

- Existing Major Lift Station
- Trunk Sewers (2016)
- Modeled Sewers (2016)
- Force Main (2016)

ROADWAYS

- INTERSTATE
- PRIMARY ARTERIAL
- MINOR ARTERIAL
- MAJOR COLLECTOR
- COLLECTOR
- MINOR COLLECTOR
- Future West Corridor Alignment
- Future Highway 100 Alignment
- Municipal Boundaries
- Regional Growth Areas
- PLSS Section Lines

FUTURE GROWTH TIERS

- Tier 1 (0 - 5 years)
- Tier 2 (2026)
- Tier 3 (2036)
- Tier 4 (2066)

HDR

0 3,000 6,000
Feet

2066 FUTURE DEVELOPMENT EXTENSION RECOMMENDED PLAN WITH 2066 CIP ON THE EXISTING SYSTEM

FUTURE 2066 CONDITIONS, RECOMMEND PLAN FOR FUTURE EXTENSIONS
FUTURE 2066 BASE SANITARY FLOW WITH TIERS 1, 2, 3, AND 4 DEVELOPMENT EXTENT

Figure 11.4 Selected 2066 Long-Term Improvements Map

PATH: H:\GIS\PROJECTS\CITY_SIOUX_FALLS\275541_SF_COLLECTIONS_MASTERPLAN\7.0_GIS_MODELS\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\TM FIGURES\TM_11\MODEL2066_REC_PLAN_WITH2066CIP.MXD - USER: KVANDEKA - DATE: 2/20/2018

Table 11.3 Future Trunk Sewer Extensions for the Recommended Plan

Major Development Group	Preferred Alt. C (2066) Option	Interim Alt. G (2026,2036) Option
City of Tea and Basin 16	Tie into and upsize or parallel I-229 Trunk (needed by 2036 with Tea) *(Option 1 or 2)*	Same as preferred 2066 option
Westside Basin 15 and Basin 34	Pump station and force main to the north (with EQ) *(Option 1)*	Flow through the City with EQ *(Option 4)*
Basin 33 (Foundation Park)	EQ (by 2066), pump station and force main to transfer flow through Basin 13 *(Option 2)*	Same as preferred 2066 option
City of Renner	Pump station and force main to future Basin 25 Trunk *(Option 2)*	Pump station and force main to future Upgraded Basin 9 Trunk *(Option 1)*
Basins 30 and 31	Pump station and force main to transfer flow through Basin 6 *(Option 1)*	Same as preferred 2066 option
Basin 28	Gravity to future Basin 27 Trunk *(Option 3)*	Same as preferred 2066 option
Basins 27 and 28	Direct connection to PS 240 with pump station and force main *(Option 2)*	Same as preferred 2066 option
ESSS and PS 240	Flows from ESSS and Basins 27/28/29/32 with pump station and force main to WRF *(Option 1)*	Flows from ESSS and Basins 27/28/29/30/31/32 with pump station and force main to WRF *(Option 2)*

The following sections further describe the rational for the selected future trunk sewer extensions for the recommended plan as graphically depicted in Figure 11.5.

11.3.1 City of Tea and Basin 16

Tying into I-229 Trunk allows a flexible solution to timing and extent of Tea flows into system.

11.3.2 Westside Basins 15 / 34

The selected plan for the West Side basins allows the basins to flow through the City by integrating EQ for the next 20-years at the projected growth rates. This allows the West Side options to be flexible up until 2036 while allowing the projected growth to the west. However, after 2036, it is recommended to construct pumping and dual forcemains (with a combined total required capacity) around the north side of the City, extending to the WRF.

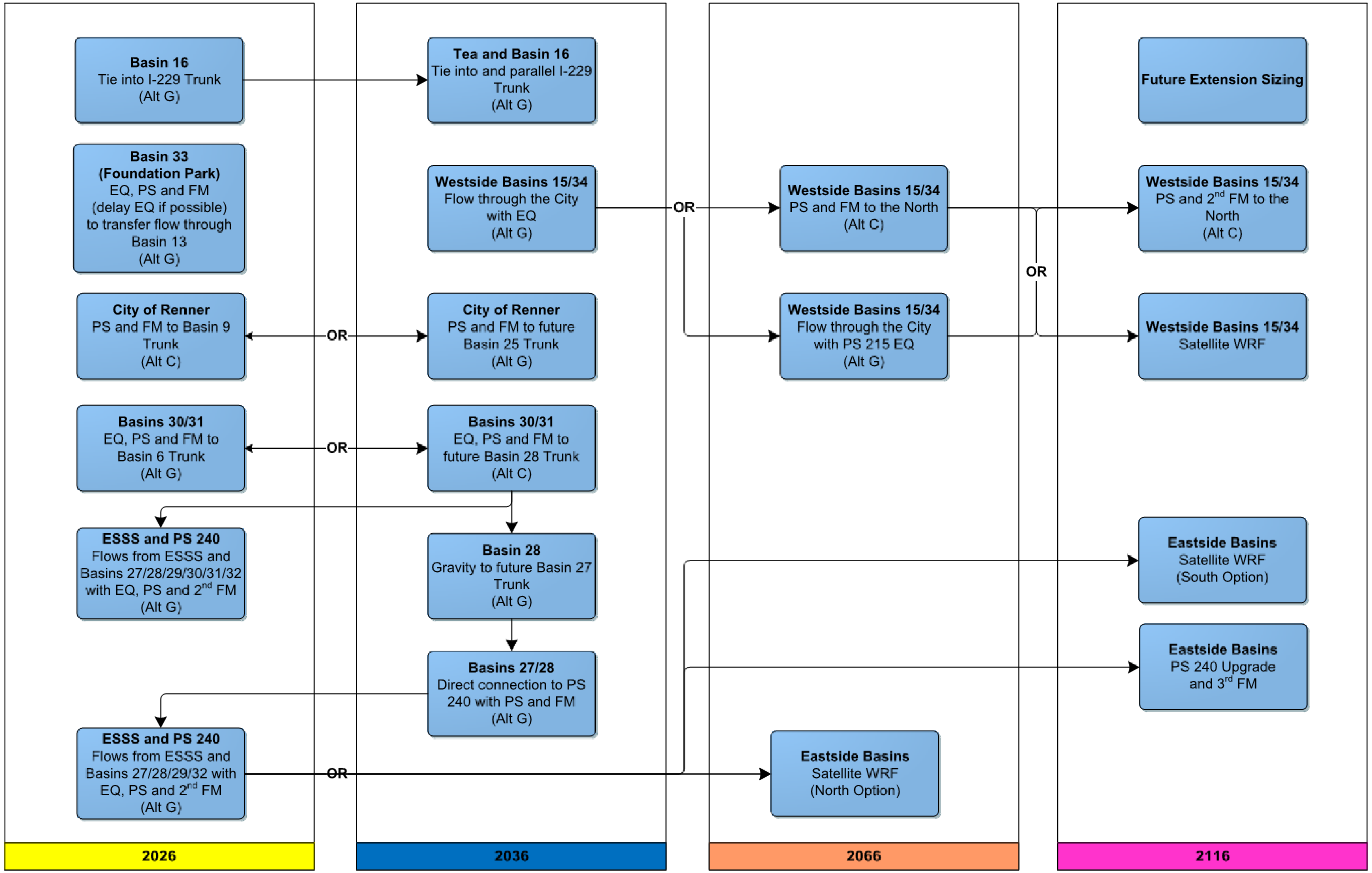


Figure 11.5 Graphical Summary for the Selected Alternatives for 2026, 2036, 2066 through 2116

11.3.3 Basin 33 (Foundation Park)

Implementing a pump station with EQ and a forcemain to transfer flow through Basin 13 allows for a shorter forcemain and use of existing system for least cost solution through 2036 for Basin 33 (Foundation Park).

11.3.4 City of Renner

Based on the planning projections for Baltic and Renner, the goal is to implement a pump station or pump station upgrades and a forcemain to transfer flows to the future Basin 25 Trunk but this depends on timing of growth upstream. If growth occurs sooner, a new pump station, equalization and force main to future upgraded Basin 9 trunk could be considered, but this would require additional study to locate equalization and verify the required Basin 9 Trunk improvements. This was not considered further as the current planning numbers do not show significant growth in these areas in the short-term.

In the long term, the selected alternative eliminates future Renner and Baltic flow from Central Main Trunk Sewer and frees up capacity for both south and west side growth.

11.3.5 Basins 30 and 31

The sanitary sewer system can be configured for Basins 30 and 31 to be served through the existing Basin 6 Trunk Sewer. This configuration will require equalization, pump station and forcemain. This will provide for development of Basins 30 and 31 prior to 2036 but contributes to Tuthill PS upstream surcharging. This surcharge is considered to be manageable without impact to service connections.

11.3.6 Basin 28

Numerous options were reviewed for Basin 28 but ultimately the selected alternative was to build gravity trunk sewers to the future Basin 27 trunk sewer to be collectively pumped to PS 240. Future limited capacity in the ESSS drives the need to develop the Basin 27 and Basin 27/28 pump station and forcemain, which avoids an extra interim pump station and forcemain. The Diamond Valley Lift Station that currently discharges in to Basin 26 will ultimately be incorporated into Basin 28.

11.3.7 Basins 27 and 28

As discussed in the previous section, Basin 28 will be served by gravity and combined with Basin 27. Basin 27 and 28 are planned with equalization, pump stations and forcemain directly to PS 240. Future limited capacity in the ESSS requires pumping directly to PS 240 rather than into existing Basin 26 Trunk. Basin 28 will include the area served by the Diamond Valley Lift Station.

11.3.8 East Side Basins 29 and 32

East Side Basins 29 and 32 need to be individually served with equalization, pump stations and forcemains to pumping to Pump Station 240.

11.3.9 East Side Pump Station 240

The pump station has reached capacity and has backed up into the system under current peak storm flow conditions. An equalization basin, increased pump station capacity and second forcemain are recommended immediately.

11.4 Beyond 2036 Recommended Collection System

11.4.1 Westside Basins 15 and 34

The long term recommendation for West Side Basins 15 and 34 is to pump around the City to the north via dual forcemains and connect to the WRF. This recommendation is primarily due to the significant EQ volume needed upstream of Pump Station 215. There is still the alternative to continue flow through City with equalization, therefore careful flow monitoring should be continued for right-sizing equalization capacity.

11.4.2 Eastside Basins and Pump Station 240

Significant long-term growth is projected in the Eastside Basins. Given the uncertainty of both treatment regulations and growth beyond 20-years; the City has the flexibility to continue pumping with a third new forcemain to the WRF or to construct an Eastside WRF.

The long term (2036 – 2116) solution is to evaluate growth and implement a Satellite Eastside WRF either at the PS 240 site or South at the extension of the Tier 5 trunk sewer west of Harrisburg or provide a second pump station upgrade and at third forcemain.

11.4.3 Westside Basins and Pump Station 215

In the long-term, significant growth is also projected in the West Side Basins. Given the uncertainty of both treatment regulations and growth beyond 20-years; the City has the flexibility to implement one of three options (1) the recommended improvements to pump around the City to the north with a new forcemain to the WRF; or (2) construct significant volumes of equalization (once the capacity of the Sioux River North is increased, 41 MG equalization at PS 215 is required), or (3) construct a new West Side WRF.

11.4.4 Main (Brandon Road) Pump Station

The Brandon Road Lift Station and dual forcemains will handle future 50-year flows with a capacity of 65 MGD. This capacity includes the Cliff Avenue Equalization Basin which will total 32 MG after the construction of an additional 20 MG basin.

11.5 Summary of Recommended Growth Infrastructure

Pump stations with associated equalization and force main improvements were identified to address the system deficiencies described in Chapter 9. Table 11.4 presents a summary of the recommended growth-based infrastructure, itemized by basin with required pump stations, equalization, and associated forcemain infrastructure and the timeframe for implementation.

Table 11.5 presents a summary of the recommended growth-based trunk sewer infrastructure itemized by basin with the required sewer size and length of infrastructure and the timeframe for implementation.

To account for additional capacity for storms exceeding the design event, a multiplication factor of 1.25 was applied to the model results to calculate the equalization volumes shown in the table, which were used in the cost estimates.

Table 11.4 Summary of Recommended Growth Pump Station, Equalization (EQ), and Forcemain Infrastructure

Description	Recommended Near-Term Improvements (Scenario G Interim Model Scenario 12 through 2036)						Scenario C (Long-Term Model Scenario 6 2036 and Beyond)		
	Tiers 1 and 2			Tier 3			Tiers 4 and 5		
Facilities Sizing Summary	Pump Station Flow GPM (MGD)	Force Main Size/Length (IN/FT)	EQ Volume[3] (MG)	Pump Station Flow GPM (MGD)	Force Main Size/Length (IN/FT)	EQ Volume[3] (MG)	Pump Station Flow GPM (MGD)	Force Main Size/Length (IN/FT)	EQ Volume[3] (MG)
LS 218 (Tuthill) Equalization	-	-	-	-	-	-	-	-	Allowed to Surcharge
LS 240	13,200 GPM Expansion	30 IN 47,800 FT	0.4						2.7
Basin 15	-	-	{0.9} -EQ tied to Basin 34	-	-	{2.0} - EQ tied to Basin 34	PS shared with Basin 34	-	{5.5} - EQ tied to Basin 34
Basin 16	-	-	-	-	-	-	Ideal Pump	12 IN 6,700 FT	-
Basin 22	Ideal Pump	8 IN 5,500 FT	-	Ideal Pump	8 IN 5,500 FT	-	Ideal Pump	8 IN 5,500 FT	-
Basin 23[4]	-	-	-	Ideal Pump	18 IN 4,450 FT	-	Ideal Pump	18 IN 4,450 FT	-
Basins 27/28[4]	4,861 (7.0)	18 IN 21,700 FT	1.4	4,861 (7.0)	18 IN 21,700 FT	2	4,861 (7.0)	18 IN 21,700 FT	3.3
Basin 29	300 (0.4)	8 IN 7,050 FT	-	300 (0.4)	8 IN 7,050 FT	-	300 (0.4)	8 IN 7,050 FT	-
Basins 30/31	764 (1.1)	8 IN 7,300 FT	1	764 (1.1)	8 IN 7,300 FT	1.1	764 (1.1)	8 IN 7,300 FT	1.1
Basin 32	-	-	-	-	-	-	700 (1.0)	8 IN 16,200 FT	-
Basin 33 (Foundation Park)	1,250 (1.8)	10 IN 6,500 FT	0.8	1,250 (1.8)	10 IN 6,500 FT	0.8	1,250 (1.8)	10 IN 6,500 FT	0.9
Basin 34[4]	-	-	1	-	-	6.2	3,470 (5.0)	24 IN 64,300 FT	10.7
LS 215 (Sioux River North) Equalization	-	-	-	-	-	3.3	-	-	-

Notes:

1. A multiplication factor of 1.25 was applied to the model results to calculate the EQ volumes shown in the table, which were used in the cost estimates.
2. Single force main sizes and lengths are listed in the table. Dual force mains with equivalent flow characteristics shall be used where feasible.
3. Total required equalization.
4. Costs include costs for equivalent dual forcemains.

Table 11.5 Summary of Expected Growth Trunk Sewer Infrastructure

Description	Scenario G (Interim Model Scenario 12 through 2036)		Scenario C (Long-Term Model Scenario 6 2036 and Beyond)
	Tiers 1 and 2	Tier 3	Tiers 4 and 5
	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)
Basin 15	-		
	12" - 15,900 Feet	12" - 35,300 Feet	12" - 55,900 Feet
	21" - 2,450 Feet	21" - 2,450 Feet	15" - 3,600 Feet
	42" - 17,950 Feet	30" - 1,100 Feet	18" - 50 Feet
		36" - 2,800 Feet	21" - 20,850 Feet
		42" - 21,900 Feet	24" - 8,800 Feet
			30" - 1,850 Feet
			36" - 2,800 Feet
			42" - 21,450 Feet
Basin 16	-		
	12" - 2,750 Feet	12" - 2,750 Feet	12" - 10,200 Feet
	18" - 10,400 Feet	18" - 10,400 Feet	15" - 2,000 Feet
	21" - 1,000 Feet	21" - 6,000 Feet	18" - 19,400 Feet
	24" - 3,150 Feet	24" - 3,150 Feet	21" - 7,100 Feet
	30" - 4,750 Feet	30" - 4,750 Feet	24" - 3,150 Feet
			30" - 4,750 Feet

Table 11.5 Summary of Expected Growth Trunk Sewer Infrastructure

Description	Scenario G (Interim Model Scenario 12 through 2036)		Scenario C (Long-Term Model Scenario 6 2036 and Beyond)
	Tiers 1 and 2	Tier 3	Tiers 4 and 5
	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)
Basin 18	-		
	12" - 6,900 Feet		
	18" - 7,200 Feet		
Basin 19 and 22			
	12" - 26,000 Feet	12" - 30,150 Feet	
	27" - 11,500 Feet	27" - 11,500 Feet	
	42" - 750 Feet	42" - 750 Feet	
Basin 21			
	8" - 1,050 Feet		0
Basin 23[4]	-		
	12" - 6,600 Feet	12" - 6,600 Feet	
	21" - 3,100 Feet	15" - 2,450 Feet	
	24" - 250 Feet	18" - 3,050 Feet	
	42" - 2,200 Feet	21" - 5,050 Feet	
		24" - 250 Feet	
		42" - 2,200 Feet	

Table 11.5 Summary of Expected Growth Trunk Sewer Infrastructure

Description	Scenario G (Interim Model Scenario 12 through 2036)		Scenario C (Long-Term Model Scenario 6 2036 and Beyond)
	Tiers 1 and 2	Tier 3	Tiers 4 and 5
	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)
Basin 25			
		12" - 31,350 Feet	
		27" - 12,100 Feet	
		30" - 1,000 Feet	
		36" - 4,750 Feet	
		48" - 3,850 Feet	
		56" - 3,350 Feet	
Basins 26			
	12" -6,100 Feet		
	24" - 100 Feet		
Basins 27/28[4]	12" -74,850 Feet	12" - 85,500 Feet	
	15" - 3,600 Feet	15" - 3,600 Feet	
	21" - 9,000 Feet	21" - 9,000 Feet	
	27" - 43,100 Feet	27" - 43,100 Feet	
	30" - 150 Feet	36" - 150 Feet	
Basin 29			
	12" -7,300 Feet		

Table 11.5 Summary of Expected Growth Trunk Sewer Infrastructure

Description	Scenario G (Interim Model Scenario 12 through 2036)		Scenario C (Long-Term Model Scenario 6 2036 and Beyond)
	Tiers 1 and 2	Tier 3	Tiers 4 and 5
	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)
Basins 30/31			
	12" - 12,900 Feet		12" - 12,900 Feet
	27" - 4,500 Feet		24" - 1,700 Feet
	36" - 25 Feet		27" - 4,500 Feet
			36" - 25 Feet
Basin 32			
			12" - 11,300 Feet
			21" - 2,000 Feet
			27" - 1,550 Feet
Basin 33 (Foundation Park)			
	12" - 11,350 Feet		
	15" - 6,750 Feet		
	21" - 3,200 Feet		
Basin 34[4]			
	54" - 45 Feet	12" - 13,200 Feet	12" - 44,000 Feet
		18" - 350 Feet	18" - 2500 Feet
		21" - 1,000 Feet	21" - 8,000 Feet
		24" - 2,350 Feet	24" - 2,350 Feet

Table 11.5 Summary of Expected Growth Trunk Sewer Infrastructure

Description	Scenario G (Interim Model Scenario 12 through 2036)		Scenario C (Long-Term Model Scenario 6 2036 and Beyond)
	Tiers 1 and 2	Tier 3	Tiers 4 and 5
	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)	Sewer Size/Length (IN/FT)
		27" - 17,700 Feet	27" - 31,700 Feet
		30" - 10,450 Feet	30" - 19,050 Feet
		36" - 2,700 Feet	36" - 5,400 Feet
		42" - 5,900 Feet	42" - 7,500 Feet
		48" - 3,850 Feet	48" - 4,950 Feet
		54" - 12,650 Feet	54" - 12,650 Feet

11.6 Opinion of Probable Costs

Planning-level opinions of probable construction cost of the recommended improvement projects are developed to assist in budgeting for implementation of the CIP. Cost data must be obtained or developed for each type of construction and system components laid out in sufficient detail to permit determination of budgetary project costs.

11.6.1 Cost Estimating Methodology

CIP cost estimates vary depending on the phase of the project when they are developed, which determines the level of detail and the expected accuracy of the estimate. The Association for the Advancement of Cost Engineering International (AACE International) Recommended Practices, specifically Document No. 18R-97, outlines typical cost estimate accuracies based on the overall status of the project. The cost estimates for this study's improvements should be considered Study or Feasibility (Estimate Classification 4) level estimates with an expected accuracy of +50 to -30 percent.

The total project cost necessary to complete a project consists of expenditures for land acquisition, construction costs, engineering design and inspection services, contingencies, and such overhead items as legal, administrative and financing services. Construction costs cover the material, equipment, labor, and services necessary to build the proposed project.

Prices used in this study were obtained from a review of provided costs and bids from the City of Sioux Falls, similar recent master plans within the region, and pertinent sources of construction cost information. Construction costs used in this report are not intended to represent the lowest prices, which may be achieved, but rather are intended to represent a median of competitive prices submitted by responsible bidders.

11.6.2 Markups and Contingencies

Markups and contingencies were added to all projects. A summary of markups and contingencies are provided in Table 11.6.

Table 11.6 Markups and Contingencies

Description	Markup or Contingency	Added to
Undeveloped Design Detail	25%	Construction Subtotal
General Conditions, Mobilization	5%	Construction Subtotal w/ Contingencies
Bonds and Insurance	2%	Construction Subtotal w/ Contingencies
Engineering, Admin, Legal, and Permitting	24%	Total Construction Cost

11.7 Existing System Sewer Capacity Related CIP Recommendations

11.7.1 Immediate (2017-2021)

Table 11.7 summarizes immediate projects through 2021.

Table 11.7 Existing System – Immediate Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Lower Riverside Trunk Sewer	Sanitary Sewer	Need to monitor degree of surcharge and necessary repairs - there is no appreciable change in flow from 2013 to 2066 from growth. Impact remains without John Morrell. However, additional impact is from permitted point load discharge from John Morrell which is not currently utilized.
Southeastern Drive	CIPP Line Sanitary Sewer	$1,400,000
Pam Road (Southside Interceptor)	Sanitary Sewer	Monitor, Survey Sewer Profile for Model and Continue to Maintain
Richmond Estates Trunk	Sanitary Sewer	$1,200,000
Pump Station 240 Forcemain	Forcemain	$36,000,000
Pump Station 240 Pump Upgrades	Growth	$2,800,000
Pump Station 240 Equalization	Growth	$2,900,000
Diamond Valley PS Upgrades	Growth	$250,000

11.7.2 Tier 2, or Near-Term (2022-2031)

Table 11.8 summarizes near-term projects.

Table 11.8 Near-Term Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Central Main	Sanitary Sewer	Monitor and Continue to Maintain

11.7.3 Tier 3, or Mid-term (2032-2041)

Table 11.9 summarizes mid-term projects.

Table 11.9 Mid-Term Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Sioux River South Trunk Relief	None	Monitor and Continue to Maintain

11.7.4 Long-term (2041-2066)

Table 11.10 summarizes long-term projects through 2066.

Table 11.10 Long-Term Improvements Summary

Project Description	Project Type	Opinion of Probable Project Costs
Sioux River North Upstream of PS 215	Sanitary Sewer	Monitor, Beyond CIP Planning Period
Sioux River North of PS 215	Equalization	$7,000,000
Renner Forcemain	Lift Station and Forcemain	Further Study Recommended

11.7.5 Summary of Recommended Lift Station and Force Main Condition Improvements

Table Table 11.11 is a summary of the High Priority and Medium Priority improvements and estimated project cost for the lift stations and forcemains. A condition assessment of the lift stations was conducted to determine the estimated remaining useful life of the facilities' components and was documented in Chapter 3 - Existing Wastewater System Facilities. The condition assessment included review of the following areas:

- Process equipment and operation
- Architectural condition
- Structural condition
- Mechanical condition
- Electrical condition
- Instrumentation condition

Many of the facilities are over 50 years old and have significant signs of age related deterioration. As part of the condition assessment, a schedule for replacement and/or renovation was developed. The drivers for the schedule are the estimated remaining useful life, reliability, and risk of failure for each item and coordination with future improvements.

It is recommended that the estimated remaining useful life of items be reviewed annually and the replacement/renovation schedule revised accordingly.

Appendix Table A.11.1 categorizes lift station age and condition driven needs determined by onsite condition assessment which are reflected in Chapter 3 and described in detail in the associated appendices. Within the guidelines presented in that chapter, it also presents the timeline and incorporates an order of magnitude budget in terms of project costs for each.

Improvements for the existing aging facilities were identified from the lift station condition assessment and reliability review were ranked with a priority system based on the following rankings.

- o High Priority (0 – 5 Years) Capital Improvements: High priority items are recommended to be addressed immediately and completed within the next 5 years (2017 – 2021) as the CIP budget allows. These are improvements required to reliably continue to treat the flow to meet the current permit. These improvements address items such as safety, treatment and hydraulic capacity items, reliability, operations and energy minimization.

- Medium Priority (5 – 10 Years) Capital Improvements: Medium priority items are to be completed by 2026. These are phased improvements required to reliably continue to treat the flow to meet the current permit. These improvements also address safety, treatment and hydraulic capacity items, reliability, operations and energy minimization but were allocated at least five more years of life.
- Low Priority Plant Modifications to meet Other Needs: Low Priority improvements that are necessary to continue to meet the needs for the WRF to operate effectively and meet the effluent permit limits. These items have been given Low Priority designations due to the remaining life. Low priority items are planned for completion in 2027 – 2036. These items should be monitored during project planning, as it may be prudent to include various items in larger projects to take advantage of the economy of scale.

It is recommended to include the high and medium priority lift station items in Immediate (2017-2021) category.

Table 11.11 Lift Stations Near-Term Summary

New Project No.	Proposed Capital Improvements	Construction Cost	Project Cost
Lift Station High/Medium Condition Items			
Lift Station PS-201, or 2nd & Brookings	Standby Generator	$65,000	$81,000
Lift Station PS-203, or Cherokee and "C"	Renovate and Upgrade Lift Station	$747,000	$926,000
Lift Station PS-204, or Modern Press	Upgrade Electrical and Provide Davit Crane Bases	$44,000	$55,000
Lift Station PS-205, or 6^{th} and Hawthorne	Safe Access Maintenance Lift	$65,000	$81,000
Lift Station PS-205, or 6^{th} and Hawthorne	Standby Generator and Controls Upgrades	$114,000	$141,000
Lift Station PS-206, or Burnside	Complete Lift Station Rebuild	$244,000	$303,000
Lift Station PS-213, or 23^{rd} and Kiwanis	Standby Generator	$65,000	$81,000
Lift Station PS-218, or Tuthill	Upgrade Lift Station to Address Flooding Issues and Electrical Panel Corrosion	$298,000	$370,000
Lift Station PS-220, or Rock Island, Riverside Park	Complete Short-term Improvements - Replace Wall Piping Seals and Relocate Heater.	$839,000	$1,040,000
Lift Station PS-221, or Madison and Vail	Standby Generator	$65,000	$81,000
Lift Station PS-224, or 50^{th} Street North	Replace Existing Pumps with Dry-Pit Flygt N-Pumps or Recessed Impeller Pumps	$122,000	$151,000
Lift Station Improvements Items		**$2,670,000**	**$3,310,000**

11.8 Growth Related Collection System Capital Improvement Recommendations

This section provides a summary of the capital improvements cost for the growth related projects by implementation timeframe. The CIP is broken down into three time steps to conform to Chapter 2 and the shape Sioux Falls plan.

The projected growth is in three tiers as indicated on the figures referenced throughout this chapter:

- Tier 1, or Immediate (2017 through 2021)
- Tier 2, or Near-Term (2022 through 2031)
- Tier 3, or Mid-Term (2032 through 2041)
- Tier 4, or Long-Term (2041 through 2066) (used only for sizing trunk lines)

Table 11.12 summarizes the description, and anticipated timeframe of the capital improvement cost recommendations.

For reference, Figures 11.2 through 11.4 show the location, description, and anticipated timeframe of the capital improvement recommendations.

Table 11.13 summarizes the cost per acre for recommended growth infrastructure at build-out and has been developed based on the following assumptions:

- Basin 15:
  - o 1,200 acres has been removed from Basin 15 area shown in map since cost recovery has been previously assessed at totaling $2,601,000 ($2,167.46/acre*1,200 acres).
  - o Maintained cost of 42 IN. and 12 IN as shown on map.
- Basin 17:
  - o Cost recovery previously set at $3,110 per acre in 2015.
- East Side Sanitary Sewer (ESSS):
  - o Cost recovery previously set at $4,297 per acre in 2004.

Table 11.12 Capital Improvements Summary for Recommended Growth Infrastructure

Description	Recommended Capital Improvements for Tiers 1-3 Infrastructure											
Facilities Costing Summary	Tier 1 and 2 Estimated Cost (Millions)						Tier 3 Estimated Cost (Millions)					
	Trunk Sewer	EQ Basin	Force Main	Pump Station	Total	Approx. Area Served (ACRE)	Trunk Sewer	EQ Basin	Force Main	Pump Station	Total	Approx. Acre Served (ACRE)
Basins 15	$19.1	EQ tied to Basin 34	-	-		1,146	$11.5	EQ tied to Basin 34	-	-		481
Basins 34	$0.2	$18.4	-	-		15	$55.1	-	-	-		3,464
Basins 15/34 Subtotal:	$19.3	$18.4	-	-	$37.7	1,161	$66.6	-	-	-	$66.6	3,945
Basin 16	$12.6	-	-	-	$12.6	287	$2.7	-	-	-	$2.7	368
Basin 17	$4.2	-	-	-	$4.2	1,063	NA					
Basin 18	$6.0	-	-	-	$6.0	611	NA					
Basins 19/22	$15.0	-	$6.7	$2.3	$24.0	1,386	$1.2	-	-	-	$1.2	555
Basin 23[1]	$6.2	-	-	-	$6.2	218	$2.5	-	$2.7	$4.8	$10.0	672
Basin 25	NA						$34.3	-	-	-	$34.3	2,442
Basin 26	$2.5	-	-	-	$2.5	304	NA					
Basins 27/28[1]	$54.3	$11.2	$20.3	5.6	$91.4	5,472	$3.1	-	-	-	$3.1	448
Basin 29	$2.5	-	$5.7	$1.9	$10.1	187	NA					
Basins 30/31	$6.2	$4.3	$3.1	$2.4	$16.0	1,410	NA					
Basin 32	NA											
Basin 33 (Foundation Park)	$7.3	$4.1	$4.6	$4.3	$20.3	1,598	NA					
Totals	$136.1	$38.0	$40.4	$16.5	$231.0	13,697	$76.1	$0.0	$2.7	$4.8	$83.6	5,988

Note: 1. Costs include costs for equivalent dual forcemains.

Table 11.13 Summary of Cost per Acre for Recommended Growth Tier 4 Infrastructure

Description	Capital Costs per Effective Acre Developed Tiers 1-4							
	Trunk Sewer	EQ Basin	Force Main	Pump Station	Total	Approx. Tier 4 Area Served (ACRE)	$/Acre	2066 Population
	(Millions)							
Basins 15[1]	$49.6	EQ tied to Basin 34	FM shared with Basin 34	PS shared with Basin 34	$214.9 (Basin 15 plus Basin 34)	5178	$17,600	22,034
Basins 34	$86.8	$22.5	$45.5	$10.5		7079		12,209
Basins 15/34 Subtotal:	$136.4	$22.5	$45.5	$10.5		12257		34,243
Basin 16	$23.6	-	$2.7	$1.4	$27.7	1075	$25,800	13,510
Basin 17[2]	$4.2	-	-	-	$4.2	1063	$3,110	1,388
Basin 18[3]	$6.0	-	-	-	$6.0	611	$4,300	16,689
Basins 19/22	$16.2	-	6.7	2.3	$25.2	1941	$13,000	9,980
Basin 23[3]	$8.7	-	2.7	4.8	$16.2	890	$4,297	2,684
Basin 25	$34.3	-	-	-	$34.3	2442	$14,100	2,735
Basin 26[3]	$2.5	-	-	-	$2.5	304	$4,300	25,925
Basins 27/28	$57.4	11.2	20.3	5.6	$94.5	5920	$16,000	34,598
Basin 29	$2.5	-	5.7	1.9	$10.1	187	$54,100	1,151
Basins 30/31	$11.0	4.3	3.1	2.4	$20.8	1491	$14,000	2,228
Basin 32	$5.2	-	8.3	1.9	$15.4	1288	$12,000	2,396
Basin 33 (Foundation Park)	$7.3	4.1	4.6	4.3	$20.3	1598	$12,800	42

Notes:

1. 1,200 acres has been removed from Basin 15 area shown in map since cost recovery has been previously assessed. Maintained cost of 42 IN. and 12 IN. as shown on map. A credit of $2,601,000 was applied to CIP cost ($2,167.46/acre*1,200 acres).
2. Basin 17 cost recovery previously set at $3,110 per acre in 2015.
3. East Side cost recovery previously set at $4,297 per acre in 2004.
4. Tier 4:Long-Term (2041 through 2066)

11.9 Further Study Recommendations

11.9.1 Odor Control Study

A comprehensive review of the City's odor issues should be considered for all suspected problem areas. The study should include an assessment of improvement necessary i.e. chemical feed, pump station operations, detention time, etc. A preventative operations program should provide clear recommendations for the extent, timing, and total project costs of identified odor/corrosion improvements.

The anticipated cost for the Odor/Corrosion Control Study report is approximately $65,000.

11.9.2 Sewer Condition Assessment and Rehabilitation Prioritization

A study should be considered to gain a better understanding of sewer and manhole conditions to assist in prioritization of rehabilitation activities. The study should include an overview of the City's existing inspection program, and provide recommendations for where to target future inspections, what technologies are appropriate based on the size and material of piping to be inspected, and a review of data collection methods and quality. Guidance on how to use the data collected to prioritize rehabilitation will also be provided in the report.

It is assumed that the City will use the recommendations from the report to complete the condition assessment activities on their own.

The anticipated cost for the sewer condition assessment study is approximately $100,000.

11.9.3 Service Connection Monitoring Program for Private Laterals

A study should be considered to monitor the integrity of private laterals for I/I contributions. The study will review existing I/I data to target monitoring locations; provide recommendations for the monitoring station setup, installation, and monitoring; and review the data collected to provide recommendations for mitigation of high I/I service connections.

The anticipated costs for the service connection monitoring program is $500,000.

11.9.4 Corridor and Right-of-Way Acquisition Siting Study

A study should be completed for corridor and right-of-way acquisition for future sewer and forcemain, equalization basin, and pump station improvements. The study will review potential sites and right-of-way to target land for acquisition; provide acreage recommendations; and adjust alignments and siting in GIS.

The anticipated costs for the Corridor and Right-of-Way Acquisition Siting Study $400,000.

11.9.5 Renner and Baltic Collection System Improvements Study

Renner is limited to no growth as the current collection system in Basin 9 is at capacity. Discussions with the planning team indicated that there have been requests for additional capacity and the connection to Basin 25 is not expected to occur in the next 10 years. Interim solutions considered could include equalization adjacent or upstream of the Renner pump station(s) or extending a forcemain to the WRF.

A brief review was completed and it was determined equalization would provide the benefit of reducing future peak flows. However, a practical siting location would be needed. A second solution would be to determine if the growth would warrant the cost of a new forcemain to the WRF.

11.9.6 Hydraulic Deficiencies to the Existing Collection System

There were numerous Type A Tier 1 and Tier 2 areas that did not have CIP projects developed. The Type A Tier 2 areas were generally locations where the model data was limited or areas where model confidence was relatively good but are represented by pipes that are smaller than 18 inches in diameter. There are also numerous Type B areas that are represented by single pipe lengths not meeting hydraulic criteria. These locations should be watched and monitored to determine if a CIP project is prudent. In addition, Type B projects could potentially be addressed concurrently with other utility and roadway projects.

The Type A Tier 3 areas represent hydraulically deficient areas in locations that were not in a flow monitoring basin and therefore were not calibrated to existing conditions. These locations used estimated parameters from adjacent basins and may not reflect the actual flow characteristics for the pipes within these problem areas. Therefore, it is recommended that in the immediate term these areas be sufficiently monitored to capture ADWF characteristics during the winter months and also capture a rainfall event with high a RDII flow response. These locations should then be calibrated to this flow monitoring data and the area reevaluated.