Engineering Cost Analysis of Current and Recently Adopted, Proposed, and Anticipated Changes to Water Quality Standards and Rules for Municipal Stormwater and Wastewater Systems in Minnesota

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Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota

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Acronyms and Abbreviations

Acronym	Description
ADW	Average Dry Weather
AML	Average Monthly Limit
AWQC	Ambient water quality criteria
AWW	Average Wet Weather
BCF	Bioconcentration Factor
BMP	Best management practice
BNR	Biological nutrient removal
BOD	Biological oxygen demand
BPR	Biological phosphorus removal
BWSR	Minnesota Board of Water and Soil Resources
CBOD	Carbonaceous Biochemical Oxygen Demand
CC	Chronic Criterion
CS	Chronic Standard
CWF	Clean Water Fund
DMR	Discharge Monitoring Report
DO	Dissolved oxygen
EDA	Environmental Data Access
EDR	Electrodialysis reversal
ERU	Equivalent Residential Unit
FAV	Final Acute Value
FC	Fecal coliform
HPO	High-purity oxygen
IBI	Index of Biotic Integrity
IFAS	Integrated fixed-film activated sludge
IUP	Intended Use Plan
LTA	Long Term Average
MBR	Membrane bioreactors
MCL	Maximum Contaminant Limit Level
MDEED	Minnesota's Department of Employment and Economic Development
MDL	Maximum Daily Limit
MLE	Modified Ludzack-Ettinger
MMB	Minnesota Management and Budget
MPCA	Minnesota Pollution Control Agency
MS	Maximum Standard (also known as the Acute Standard)
MS4	Municipal separate storm sewer system
NF	Nanofiltration
NLCD	National Land Cover Dataset
NPDES/SDS	National Pollutant Discharge Elimination System/State Disposal System

O&M	Operation and maintenance
PAO	Phosphate accumulating organisms
PEQ	Projected Effluent Quality
PFA	Public Facilities Authority
POCs	Pollutants of Concern
PPL	Project Priorities List
RBC	Rotating biological contactors
RES	River Eutrophication Standard
RO	Reverse osmosis
RPE	Reasonable Potential to Exceed
SDS	State Disposal System
SID	Stressor identification
SWPPP	Stormwater pollution prevention program
TALU	Tiered Aquatic Life Use
TBEL	Technology Based Effluent Limits
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TP	Total phosphorus
TPC	Total present cost
TSD	EPA Technical Support Document (Effluent limit reference)
TSS	Total Suspended Solids
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
VFA	Volatile fatty acids
WIF	Wastewater Infrastructure Fund
WLA	Wasteload Allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WQBEL	Water Quality Based Effluent Limit
WQS	Water Quality Standard
WQV	Water quality volume
WWTF	Wastewater Treatment Facility
ZID	Zone of Initial Dilution

Glossary Terms

5 Day Carbonaceous Biochemical Oxygen Demand ($CBOD_5$): method defined test that lasts 5 days measured by the depletion of dissolved oxygen by biological organisms in a body of water in which the contribution from nitrogenous bacteria has been suppressed

Alkalinity, bicarbonate, as HCO_3: alkalinity is a measurement of the capacity of water or any solution to neutralize or buffer acids. The bicarbonate ion (HCO_3) is the principal alkaline constituent in almost all water supplies.

Ambient water quality criteria: water criteria required by the Clean Water Act that accurately reflects the latest scientific knowledge on the impacts of pollutants on human health and the environment.

Antidegradation rules: regulations that require states to adopt antidegradation policy and identify implementation procedures that maintain and protect existing uses, prevent unnecessary degradation of existing high water quality and maintain and protect the quality of waters identified for their outstanding value

Average Dry Weather: the average daily flow when the groundwater is at or near normal and a runoff condition is not occurring

Average Monthly Limit (AML): limit based on average monthly discharge concentrations

Average Wet Weather: the daily average flow for the wettest 30 consecutive days for mechanical plants or for the wettest 180 consecutive days for controlled discharge pond systems. The 180 consecutive days for pond systems should be based on either the storage period from approximately November 15 through May 15 or the storage period from approximately May 15 through November 15.

Beneficial Use Classifications: identification of how people, aquatic communities and wildlife use Minnesota waters of the state. Beneficial uses include: fishing, swimming, and other forms of recreation as well as sustaining aquatic life (healthy fish, bugs, and plant communities)

Best Management Practice (BMP) – one of many different structural or non–structural methods used to treat stormwater runoff, including such diverse measures as ponding, street sweeping, filtration through a rain garden and infiltration to a gravel trench.

Bioconcentration Factor (BCF): the accumulation of a chemical in or on an organism when the source of chemical is solely water. Bioconcentration can also be defined as the process by which a chemical concentration in an aquatic organism exceeds that in water as a result of exposure to a waterborne chemical.

Carbonaceous Biochemical Oxygen Demand (CBOD): method defined test measured by the depletion of dissolved oxygen by biological organisms in a body of water in which the contribution from nitrogenous bacteria has been suppressed

Chronic Criterion (CC) or Chronic Standard (CS): The highest water concentration or fish tissue concentration of a toxicant or effluent to which aquatic life, humans, or wildlife can be exposed indefinitely without causing chronic toxicity. CC and CS are further distinguished by the organisms they are developed to protect and medium in which they apply[1]

Class 2 Water: Minnesota's beneficial use classification identification number requiring the protection of aquatic life and recreation for surface waters

Compliance schedule – the stormwater pollution prevention program (SWPPP) requires that all MS4s not meeting a TMDL established WLA must generate a compliance schedule to outline progress towards meeting WLAs. Compliance schedules must include: (1) Interim milestones, expressed as BMPs or progress toward implementation of BMPs to be achieved during the term of this permit; (2) dates for implementation of interim milestones; (3) strategies for continued BMP implementation beyond the term of this permit; and (4) target dates the applicable WLA(s) will be achieved.

Controlling TMDL – the existing, draft, or anticipated future TMDL which is expected to establish the level of stormwater treatment an MS4 will need to provide in the future.

Critical low flows (i.e. 7Q10 and 30Q10): the flow of water in stream during prolonged dry weather. Many states use design flow statistics such as the 7Q10 (the lowest 7-day average flow that occurs on average once every 10 years) and the 30Q10 (the lowest 30-day average flow that occurs once every 10 years) to define low flow for the purpose of setting permit discharge limits

Developed area – land use areas that have been altered by human development. In the context of this study, developed areas specially refer to the four developed land use types defined by the NLCD dataset: developed, open space; developed, low intensity; developed, medium intensity; and developed, high intensity.

Discharge Monitoring Report (DMR): a United States regulatory term for a periodic water pollution report prepared by industries, municipalities, and other facilities discharging to surface waters under NPDES permits

Dissolved Oxygen (DO): microscopic bubbles of gaseous oxygen (O_2) that are mixed in water and available to aquatic organisms for respiration-a critical process for almost all organisms

Environmental Data Access: EPA database with data related to surface water, air quality, groundwater data, construction stormwater, contaminated sites, etc.

EPA Secondary Drinking Water Regulations: non-mandatory water quality standards for 15 contaminants. EPA does not enforce these and they are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations such as taste, color and odor.

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[1] https://www.revisor.mn.gov/rules/?id=7050.0218

Event mean concentration – the total constituent (pollutant) mass discharge divided by the total runoff volume.

Final acute value (FAV): an estimate of the fifth percentile of a statistical population represented by the set of Mean Acute Values (MAV) available for the material, a MAV being the concentration of the material that causes a specified level of acute toxicity to aquatic organisms in some taxonomic group.

Hardness, as $CaCO_3$: the amount of dissolved calcium and magnesium in the water.

Impaired waters – streams or lakes that do not meet their designated uses because of excess pollutants or identified stressors.

Impervious surface – means a constructed hard surface that either prevents or retards the entry of water into the soil and causes water to run off the surface in greater quantities and at an increased rate of flow than prior to development. Examples include rooftops, sidewalks, patios, driveways, parking lots, storage areas, and concrete, asphalt, or gravel roads.

Index of Biotic Integrity (IBI): a scientific tool used to identify and classify water pollution problems. An IBI associates anthropogenic influences on a water body with biological activity in the water body, and is formulated using data developed from biosurveys.

Long Term Average (LTA): a moving average that is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles

Maximum Contaminant Limit (MCL): the maximum allowable amount of a contaminant in drinking water which is delivered to the consumer

Maximum Criterion (MC) or Maximum Standard (MS): Means the highest concentration of a toxicant in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality. The MC equals the FAV divided by two.[2]

Maximum Daily Limit (MDL): limit based on maximum daily discharge concentrations

[2] https://www.revisor.mn.gov/rules/?id=7050.0218

Municipal separate storm sewer system (MS4) – A municipal separate storm sewer system is a conveyance or system of conveyances, owned or operated by a state, city, town, county, district, association, or other public body having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes that discharges to waters of the United States. Large and medium (Phase I) MS4s in Minnesota include the cities of Minneapolis and St. Paul, which have each been issued individual permits for stormwater discharges. There are three categories of regulated small (Phase II) MS4s: mandatory, discretionary and petition. MS4s are required to develop and implement a Stormwater Pollution Prevention Program (SWPPP) which must cover six minimum control measures and identify best management practices (BMPs) and measurable goals associated with each of these minimum control measures.

NPDES/SDS Permit: a provision of the Clean Water Act that prohibits discharge of pollutants into waters of the U.S. unless a special permit is issued by the EPA, a state, or a tribal government

Nutrient Region: Also called River Nutrient Regions, the regions are a geographical division of Minnesota's rivers based on shared characteristics for the purpose of implementing river nutrient criteria. The regions are North, Central, and South.

Pollutant of Concern (POC): pollutants for which water bodies are listed as impaired under CWA section 303(d), pollutants associated with the land use type of a development, and/or pollutants commonly associated with runoff.

Projected Effluent Quality (PEQ): the estimated level of a pollutant in an effluent

Reasonable Potential to Exceed (RPE): the point at which the permit writer decides that a point source discharger may exceed an applicable criterion/standard

Redevelopment – any construction, alteration, or improvement that disturbs greater than or equal to 5,000 square feet of existing impervious cover performed on sites where the existing land use is commercial, industrial, institutional, or residential.

River Eutrophication Standards (RES): new water quality standards adopted by the MPCA that address nutrient enrichment of rivers, streams, Mississippi River pools and Lake Pepin

Runoff – the portion of rainfall or snowmelt not immediately absorbed into the soil that drains or flows off the land and becomes surface flow.

Salinity – a measurement of salts dissolved in water. The major ions that contribute to salinity are chloride, sodium, magnesium, sulfate, calcium, potassium, bicarbonate, and sulfate.

Simple Method – a technique for estimating storm pollutant export delivered from urban development sites.

Stormwater – water that is generated by rainfall or snowmelt which causes runoff and is often routed into drain systems for treatment or conveyance.

Stressor identification (SID) – when it is determined that aquatic communities within a waterbody are biologically impaired, a stressor identification (SID) is performed to determine the cause(s) of biological impairment. SID is a formal analytical process defined by the US Environmental Protection Agency (USEPA) that identifies causes of biological impairment of aquatic ecosystems and provides a structure of organizing the scientific evidence supporting developed conclusions.

Structural BMP – defined in the MS4 General permit as "a stationary and permanent BMP designed, constructed and operated to prevent or reduce the discharge of pollutants in stormwater". For the purposes of the TMDL Annual Reporting form, a structural BMP refers specifically to a constructed basin, filter, infiltrator, swale or strip.

Technology Based Effluent Limits (TBEL): Technology-based effluent limitations (TBELs) in NPDES permits require a minimum level of treatment of pollutants for point source discharges based on available treatment technologies, while allowing the discharger to use any available control technique to meet the limits. For industrial (and other non-municipal) facilities, technology-based effluent limits are derived by:

- using national effluent limitations guidelines (ELGs) and standards established by EPA, and/or
- using best professional judgement (BPJ) on a case-by-case basis in the absence of national guidelines and standards.

Tiered Aquatic Life Use (TALU): a method of classifying rivers and streams (referred to collectively as streams) based upon what fish and invertebrates we expect to see in healthy streams. Better data and modeling tools allow agency staff to provide better stream management and protection of fish and invertebrates.

Total Dissolved Solids (TDS): inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water.

Total Kjeldahl Nitrogen (TKN): the sum of organic nitrogen, ammonia ($NH3$), and ammonium ($NH4+$) in the chemical analysis of soil, water and wastewater.

Total Maximum Daily Load (TMDL): the sum of the existing and/or projected point source, nonpoint source, and background loads for a pollutant to a specified watershed, water body, or water body segment. A TMDL sets and allocates the maximum amount of a pollutant that may be introduced into the water and still ensures attainment and maintenance of water quality standards (see wasteload allocation, below).

Total Nitrogen (TN): the sum of TKN, nitrate ($NO3$), and nitrite ($NO2-$) in the chemical analysis of soil, water and wastewater.

Total present cost (TPC) – the total present cost is the sum of total construction cost and the equivalent present cost of annual O&M costs over a defined discount period.

Total Suspended Solids (TSS): solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage.

Unionized ammonia: ammonia in the neutral form of NH_3, which is toxic to aquatic life, and is dependent upon pH and temperature.

Wasteload allocation (WLA): the portion of a receiving water's assimilative capacity that is allocated to one of its existing or future point sources of pollution. WLAs can influence the establishment of water quality based effluent limits for point source discharge facilities.

Water Quality Based Effluent Limit (WQBEL): value determined by selecting the most stringent of the effluent limits calculated using all applicable water quality criteria (e.g., aquatic life, human health, and wildlife) for a specific point source to a specific receiving water for a given pollutant.

Water Quality Standard (WQS): A law or regulation that consists of the beneficial use or uses of a waterbody, the numeric and narrative water quality criteria/standards that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement. Numeric or narrative water quality protections are referred to as standards in Minnesota state rules and are referred to as criteria in federal rules.

Water quality volume – The volume of water that is treated by a BMP.

Waters of the state: surface or underground waters, except surface waters that are not confined but are spread and diffused over the land. Waters of the state includes boundary and inland waters.

Watershed – a topographically defined area within which all water drains to a particular point.

Watershed Restoration and Protection Strategies (WRAPS): a process developed by the MPCA to identify and address threats to water quality in each of the major watersheds of Minnesota

Wet detention pond – a permanent pool of water for treating incoming stormwater runoff.

Zone of Initial Dilution (ZID): That area within a lake or stream where the discharge from an outfall first mixes with the receiving water.

1.0 Executive Summary

1.1 Purpose and Scope

The Minnesota State Legislature requested an engineering analysis to determine the cost of complying with current and future water quality regulations to communities in Minnesota. The legislature request required:

- The study to include a diverse, representative sample of at least 15 communities;
- The study to estimate the infrastructure costs required to upgrade wastewater and stormwater systems to meet current and future water quality standards; and
- The study to estimate the incremental change in water quality as a result of those upgrades;

Five pollutants were identified for inclusion in this study by the legislature:

- Total suspended solids. Solids are the most visible indicators of water quality. Excessive solids cause cloudy water, and can inhibit use by humans and aquatic life.
- Chloride. Chloride gets into wastewater and stormwater in a myriad of ways, and can be toxic to aquatic life.
- Nutrients (Phosphorus and Nitrogen). Excess nutrients in freshwater ecosystems can cause algal blooms, which can decrease the aesthetic value of a water way and adversely affect aquatic life.
- Nitrate. Nitrate is form of nitrogen and high levels of nitrates in drinking water are harmful to human and animal health. In some areas, nitrate contributes to freshwater algal blooms. Nitrate is also the primary cause of dead zones in the Gulf of Mexico.
- Sulfate. Sulfates have the potential to impact production of wild rice.

The legislature request specifically identified "nutrients", which includes phosphorus and nitrogen. The legislature also specified that the study include nitrates, the dominant form of nitrogen in surface waters. Barr also evaluated current and future ammonia water quality standards because ammonia is another form of nitrogen. Ammonia has the potential to be toxic in freshwater ecosystems, and can be turned into nitrate by biological processes in natural waters.

The Legislature also specified that the study address total maximum daily load analyses, the recently adopted antidegradation rule, and the potential future tiered aquatic life use rule. In completing the study, Barr also evaluated the recently adopted variance rules. A 20-year planning timeframe was used as a boundary for the study.

1.2 Background Information

This section provides background information about some of the general concepts used in this study and discussed in this report.

1.2.1 Water Quality Standards

The Clean Water Act establishes the basic structure for regulating discharges of pollutant to surface waters in the United States and regulating quality standards for surface waters. While the Clean Water Act establishes the requirements and the procedures to develop and implement water quality standards, the State of Minnesota is responsible for developing detailed water quality protections for Minnesota's surface waters. In Minnesota, all surface waters have designated beneficial uses, which include use categories such as domestic consumption, aquatic life and recreation, industrial consumption, agricultural and wildlife, aesthetic enjoyment and navigation, other uses and protection of border waters, and limited resource value waters. To protect those designated uses, the Minnesota Pollution Control Agency has the authority and obligation to develop and implement water quality standards in the state. These standards can be either numeric or narrative.

Numeric water quality standards describe the qualities or properties of the waters that are necessary to protect the designated beneficial uses and represent the allowable concentrations of specific pollutants in a water body. Numeric standard exceedances indicate potential for a polluted condition considered potentially deleterious, harmful, detrimental, or injurious with respect to a water's designated use.

Narrative standards also describe the qualities that protect designated uses and cover a broad range of requirements to protect waters from developing impaired conditions. Narrative standards are statements of unacceptable conditions in and on the water.

Where pollutant loading to a water body results in an exceedance of a water quality standard, the agency conducts a total maximum daily load study and develops a wasteload allocation designed to restore the water body to conditions that meet the water quality standards.

For more information about the water quality standards specifically applicable to this study, see Section 3.0.

1.2.2 Wastewater Permits and Treatment

Wastewater discharges to surface water are regulated through the National Pollutant Discharge Elimination System program, which is administered and implemented in Minnesota by the Minnesota Pollution Control Agency. The program requires the agency to issue discharge permits for wastewater discharges. There are several different types of permits for different categories of dischargers within the program. These permits establish specific limits and requirements based on the state's water quality standards. These limits and requirements could include effluent limits, monitoring, regular reports to the state, emergency preparedness procedures, or a number of other types of provisions. The specific permit terms are developed by the agency based on discharge type, receiving water information, including the total maximum daily load wasteload allocation described above, and applicable water quality standards.

This study addresses municipal wastewater discharges to surface water and does not address the other categories of discharges, such as industrial discharges or municipal discharges to land-based soil treatment systems. Approximately 680 Minnesota cities and sanitary districts own and operate wastewater treatment and collection systems, although not all discharge effluent to surface waters, some discharge to land-based soil treatment systems. For more detailed information about the development of effluent limits for municipal wastewater permits, refer to Section 4.0 of this report

Municipal wastewater treatment facilities' foremost objective is to remove pollutants from sanitary wastewater. Historically, removal of organics was the primary objective. The treatment technology currently in use at most municipal wastewater treatment facilities was selected primarily to meet this objective. Existing treatment technology also removes solids, and can remove some nitrogen and phosphorus, but technology updates would be needed to remove the other parameters of interest for this study or to meet lower limits for nitrogen and phosphorus.

Wastewater treatment plants consist of primary treatment and secondary treatment. Some plants also include tertiary treatment processes to provided additional treatment prior to discharge. The levels of treatment are described below:

- Primary treatment consists of physical methods to remove large objects, sand, grit, oils, and particles from the water.
- Secondary treatment processes remove dissolved organic material from wastewater using biological degradation.
- Tertiary treatment processes can be added to meet more stringent effluent limits. Tertiary treatment refers to any additional treatment needed to improve effluent water quality.

Wastewater treatment systems must also provide disinfection and sludge handling. Disinfection removes harmful pathogens that could spread disease. Sludge handling referred to the stabilization and disposal of any solids generated during the treatment process. For more detailed information about the types of technologies that accomplish each component of wastewater treatment, refer to Section 5.0 of this report.

1.2.3 Stormwater Permitting and Treatment

In accordance with the Clean Water Act and under authority from Minnesota Statutes, the Minnesota Pollution Control Agency has established rules and National Pollutant Discharge Elimination System permitting programs to regulate discharges of stormwater from municipal separate storm sewer systems, construction activities, and industrial activities for the purposes of abating water pollution associated with stormwater discharges from these point sources. This study addresses municipal separate storm sewer systems.

Municipal separate storm sewers are publicly owned or operated stormwater infrastructure, used solely for stormwater, and which are not part of a publicly owned wastewater treatment system. Examples of stormwater infrastructure include curbs, ditches, culverts, stormwater ponds, and storm sewer pipes. Common owners or operators of municipal separate storm sewer systems include cities, townships, and public institutions. Owners and operators of municipal separate storm sewer systems which are required to obtain a permit are identified in one of three ways: the federal Clean Water Act, state rule, or by public petition to the Minnesota Pollution Control Agency. Stormwater in communities not subject to stormwater permits is managed according to nonpoint source best management practices, non-point sources are not regulated and are not addressed in this study.

The number of regulated municipal separate storm sewer systems in Minnesota is growing as urban areas expand. As of November 2016, 260 municipal separate storm sewer systems are regulated for their stormwater discharges under a municipal separate storm sewer systems permit. This study addresses the 164 municipal/city owners of municipal separate storm sewer systems.

The General Permit for municipal separate storm sewers requires the operator or owner to create and implement a Stormwater Pollution Prevention Program with six important components:

1. Public education and outreach, which includes teaching citizens about stormwater management
2. Public participation to include citizens in solving stormwater pollution problems.
3. A plan to detect and eliminate illicit discharges to the storm sewer system
4. Construction-site runoff controls
5. Post-construction runoff controls
6. Pollution prevention and municipal "good housekeeping" measures.

Where a total maximum daily load study for a particular body requires a wasteload allocation for regulated stormwater to meet the water quality standard in an impaired water, Minnesota Pollution Control Agency guidance specifies the procedures for establishing that allocation. For each applicable wasteload allocation not met, a compliance schedule is required, which must include:

- Dates for implementation of interim milestones, expressed as progress toward implementation of best management practices
- Strategies for continued best management practice implementation
- Target dates the applicable wasteload allocation will be achieved.

1.3 Study Methodology

A case study approach was used to evaluate costs and incremental water quality benefits. Minnesota Management and Budget initially identified 20 municipal wastewater treatment facilities for the study. They were selected primarily because the Minnesota Pollution Control Agency had completed memoranda setting preliminary phosphorus effluent limits to address the recently adopted river eutrophication rules or existing lake eutrophication rules. In order to provide more complete geographical coverage across the state and its watersheds, Barr worked with Minnesota Management and Budget to select and include five additional facilities in the study. In total, 25 wastewater treatment facilities were included in the study and effluent limits for current and current and future water quality standards were developed.

Of those 25 facilities, 15 were selected for detailed analysis of wastewater treatment upgrade costs. Wastewater treatment facilities were selected for detailed cost analysis based on their willingness to participate in the study, and to provide a representative range of geographic locations, facility sizes, and facility types.

Six of the 25 municipalities are required to maintain and comply with municipal separate storm sewer system stormwater permits. The other municipalities in the study, due to their small size, are not required to obtain stormwater permits, nor have they been given total maximum daily load wasteload allocations. These six municipalities were selected for detailed analysis of stormwater infrastructure improvements, costs, and incremental water quality improvements.

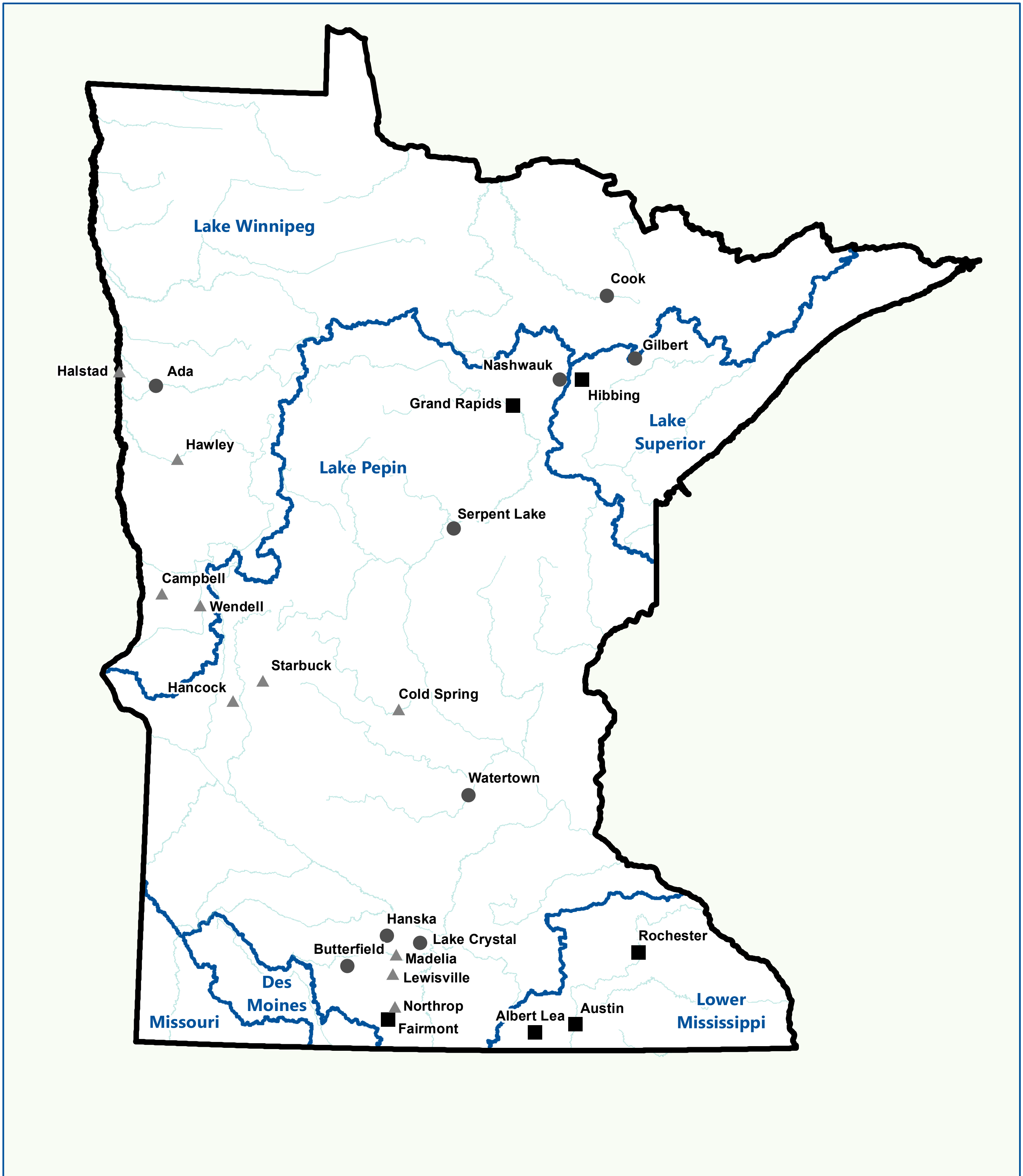
The 25 evaluated facilities, and the types of analyses performed on each, are shown in Figure 1-1.

At a high level, the following steps were performed for facilities included in the study:

- Identified applicable current and future water quality standards (all 25 facilities)
- Gathered data about the identified facilities and the water bodies the facilities discharge to (all 25 facilities)
- Calculated effluent limits based on current and future water quality standards (all 25 facilities)
- Evaluated which wastewater treatment technologies would be required to meet the calculated effluent limits (15 facilities)
- Estimated costs for performing the recommended wastewater treatment facility upgrades (15 facilities) to meet:
    - effluent limits based on *current* water quality standards, and
    - effluent limits based on *current and future* water quality standards
- Evaluated the stormwater infrastructure requirements and estimated costs to meet the calculated effluent limits (6 cities)
- Examined the incremental downstream water quality impacts of implementing the recommended wastewater (25 facilities) and stormwater (6 facilities) infrastructure upgrades

1.4 Effluent Limit Development

Effluent limits were estimated for 25 municipal wastewater treatment facilities across Minnesota as part of this study. The current and future water quality standards were identified and the effluent limits for the facilities in the case study were calculated based on those standards.



Type of Analysis

- ■ Stormwater and Wastewater Cost Analysis, Effluent Limits and Water Quality Effect
- ● Wastewater Cost Analysis, Effluent Limits and Water Quality Effect
- ▲ Effluent Limits and Water Quality Effect

Minnesota State Boundary

Major Basins

0 25 50 75

Miles

BARR

CASE STUDY LOCATIONS

Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 1-1

1.4.1 Identifying Applicable Water Quality Standards

For this study, current and future water quality standards were identified by reviewing the following:

- Current Minnesota surface water quality standards and rules (Minnesota Rules, chapters 7050, 7052, and 7053)
- Special protections that apply to specific waterbodies or watersheds as a result of state water quality protection programs (i.e., total maximum daily load wasteload allocations, watershed restoration and protection strategy requirements, Minnesota Pollution Control Agency eutrophication memos, etc.)
- New Minnesota standards that have been proposed by the Minnesota Pollution Control Agency
- Minnesota standards that could reasonably be expected to be enacted within the 20 year planning timeframe of this study
- US Environmental Protection Agency ambient water quality criteria

Potential future water quality standards considered to be highly uncertain were not included in the study. Table 1-1 summarizes the current and future water quality standards included in this study. Full details are provided in Section 3.0 of this report.

Table 1-1 Current and future water quality standards considered for this study

	Current standards(1)	Anticipated future standards included/considered in this study	Potential future standards not included in this study
Low Uncertainty	Ammonia Chloride Total Suspended Solids Variances		
Medium Uncertainty	Sulfate (wild rice) Antidegradation Phosphorus(2)	Ammonia(3) Nitrate(4) Sulfate (wild rice)(5)	
High Uncertainty		Tiered Aquatic Life Use	Chloride

(1) Numeric surface water quality standards for Class 2, Class 3, and Class 4 waters, and antidegradation standards set forth in Minnesota Rules Chapter 7050. Also special protections that apply to specific waterbodies (or watersheds) such as total maximum daily load requirements, Minnesota Pollution Control Agency biological stressor identification reports, Minnesota Pollution Control Agency Watershed Restoration and Protection Strategies, and Minnesota Pollution Control Agency Phosphorus Effluent Limit Review (eutrophication) memos

(2) Existing total maximum daily loads and eutrophication memos

(3) Ammonia 304(a) ambient water quality criteria finalized in 2013 by the U.S. Environmental Protection Agency.

(4) Nitrate standards proposed in the Minnesota Pollution Control Agency draft Aquatic Life Water Quality Standards Support Document for Nitrate (reference (1)).

(5) Sulfate wild rice standards under development by the Minnesota Pollution Control Agency.

1.4.2 Estimating Effluent Limits

The first step in estimating effluent limits for a facility is identifying the existing limits in the facility's National Pollutant Discharge Elimination System permit. In some cases, due to recent changes, existing permit limits do not fully reflect current water quality standards. This can occur because of recently adopted standards, additional information becoming available, or recently completed studies. The second step is to evaluate, based on historic performance of the wastewater treatment facility, whether the discharge could reasonably be expected to cause exceedances of any identified current or future water quality standards. Where a reasonable potential to exceed was found, the third step was to estimate effluent limits based on the current standards. The estimated current effluent limits approximate the limits that would be enforced if the facility's permit were renewed today. The fourth step is estimating effluent limits based on future standards. The estimated future effluent limits approximate what could be expected for permit renewals over the next approximately 20 years. The effluent limits were estimated using calculations performed using methods published by the Minnesota Pollution Control Agency and the US Environmental Protection Agency. The calculations used only existing, publicly available data. More information about the methods and data used in these calculations is available in Section 4.0 of this report.

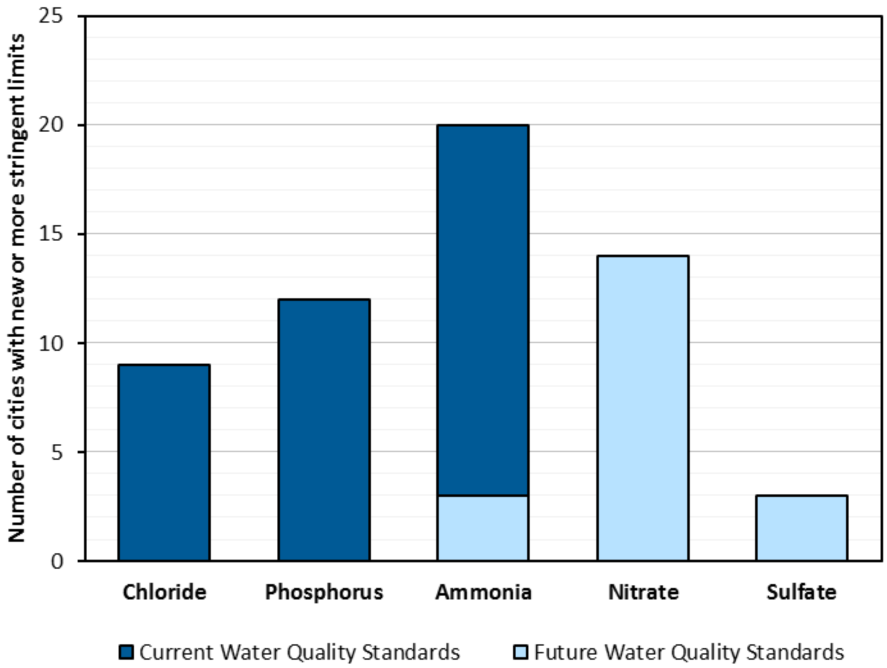
Of the 25 municipal wastewater treatment facilities reviewed, all but three would require effluent limit changes for comply with current and future water quality standards. Figure 1-2 shows how many cities would receive new or more stringent effluent limits for each of the pollutants included in this study. Many cities would receive new or more stringent effluent limits for several pollutants. New and more stringent effluent limits for ammonia and nitrate are most prevalent. Full details on the effluent limit changes for each city are described in Section 4.0.

1.5 Wastewater Treatment Facility Upgrades

1.5.1 Identifying Need for Upgrades

Engineering cost estimates for upgrades to meet estimated effluent limits were developed for 15 municipal wastewater treatment facilities in representative communities across Minnesota. The locations of those facilities are shown on Figure 1-1. These cities were selected from the group of 25 based on their willingness to participate in the study and to provide a representative range of geographical regions, existing treatment technologies, and level of upgrades required to meet estimated effluent limits. The existing configuration of each wastewater treatment facility was determined from site visits and construction plans. The existing performance of each wastewater treatment facility was compiled from monitoring data. Then, for each wastewater treatment facility, the existing performance was compared to the performance that would be required under the current and future effluent limits estimated for that facility.

All but 2 of the 15 wastewater treatment facilities would need to make some type of upgrade to meet estimated effluent limits based upon current and future water quality standards. No upgrades would be necessary for the Cook or Grand Rapids wastewater treatment facilities.



Note: Many cities will have new or more stringent effluent limits for more than one pollutants. See Section 4.0 for details.

Figure 1-2 Number of cities with new or more stringent effluent limits to meet current and future water quality standards

1.5.2 Selecting Technology for Upgrades

For the 13 wastewater treatment facilities that were identified as requiring upgrades, the study recommends appropriate wastewater technology upgrades to meet the estimated effluent limits based on current and future water quality standards. Three general types of systems are recommended: pond systems, secondary treatment, and membrane filtration (a form of tertiary treatment).

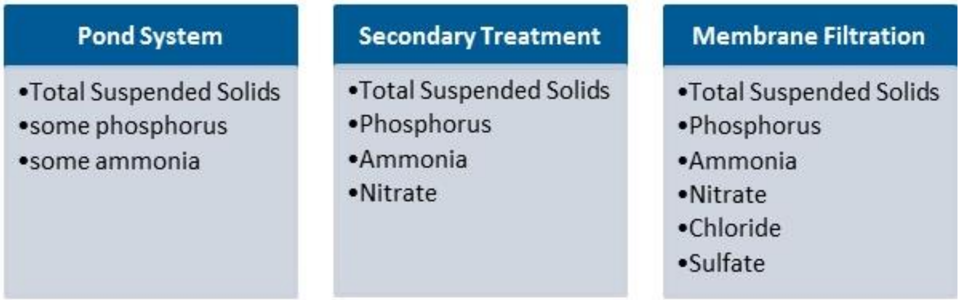


Figure 1-3 General types of treatment systems and the pollutants they remove

The treatment technology currently in use at many of the wastewater treatment facilities has been selected primarily to remove organic material and to disinfect the treated water. Existing treatment technology also removes total suspended solids, and can remove some ammonia, nitrate, and phosphorus, but technology upgrades would be needed to remove sulfate and/or chloride or to meet lower limits for ammonia, nitrate, and phosphorus. Ammonia, nitrate, and phosphorus removal can generally be enhanced by modifying the existing wastewater treatment facility processes. Secondary biological treatment is suitable to remove ammonia and nitrate (nitrogen), with the specific secondary treatment process selected dependent on the form of nitrogen to be removed. In some cases, additional nitrogen and phosphorus can be removed at a relatively low cost by modifying the existing wastewater treatment facility process. In other cases, the required modifications are more expensive.

Chloride and sulfate would be the most costly of the studied parameters to treat, because they would require installation of membrane filtration technology. Membranes have high capital costs, but the overwhelming challenge for their application is brine disposal, which adds high capital costs as well as high operation and maintenance costs. While not evaluated as part of this study, municipalities facing chloride effluent limits would pursue options that are potentially less costly—options such as source control and centralized water supply treatment that could reduce chloride in the wastewater sufficiently to meet effluent limits without wastewater treatment. However, source control is likely not a viable option to meet effluent limits for sulfate due to the high sulfate concentration in domestic wastewater.

1.5.3 Wastewater Treatment Facility Upgrade Costs

Cost estimates for the recommended upgrades for each wastewater treatment facility were compiled using CapDetWorks™ software, cost data available in published literature, and professional engineering judgement. To evaluate the impact of upgrade costs on users, Barr estimated the increase in sewer costs per equivalent residential unit in dollars, added this cost to the existing sewer costs and compared the total sewer costs with the local median household income. Estimated user costs for proposed upgrades range from approximately $200 to $1,600, as summarized in Figure 1-4.

Estimated costs are lowest for facilities where effluent limits can be met using pond systems, and highest where membrane treatment is needed to meet a chloride or sulfate effluent limit. Table 5-13 summarizes, for each city, the pollutants likely to require new or more stringent effluent limits, the recommended treatment technology to meet the estimated effluent limits, and the cost of the recommended upgrades.

Cost per equivalent residential unit does not tell the whole story, however, because the affordability of upgrades to meet current and future water quality standards depends on the median household income of a city’s residents. The Minnesota Public Facilities Authority offers grants for wastewater projects where the annual sewer cost exceeds 1.4% of median household income. Minnesota Pollution Control Agency has referred to this value, 1.4% of median household income, as the “affordability index”.

Existing sewer rates range from 0.6% to 2.5% of median household income in the 15 cities studied, as shown in Figure 1-5, with eight cities below 1.4%. As shown in Figure 1-6 and Figure 1-7, upgrades to meet the respective current and future water quality standards would cause sewer rates to range from 1.1% to 4.9% for current water quality standards (with four cities below 1.4%) and range from 1.1% to 5.2% for future water quality standards (with three cities below 1.4%).

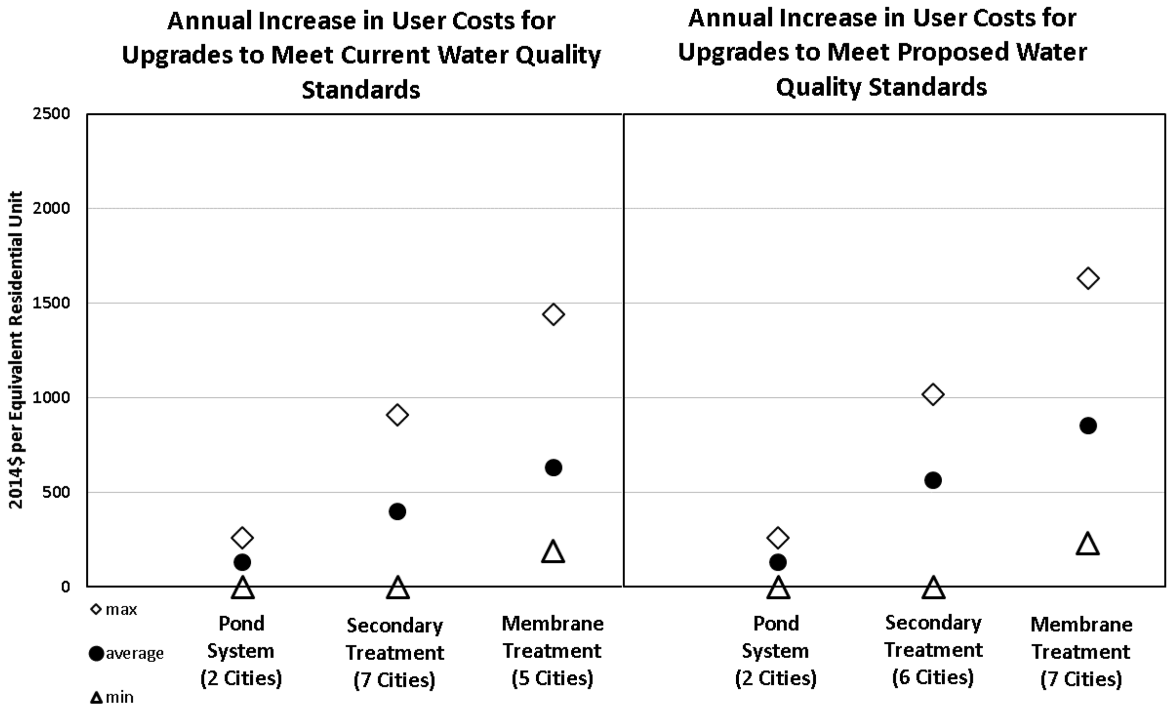


Figure 1-4 Annual increase in user costs to meet current and future water quality standards by proposed treatment type

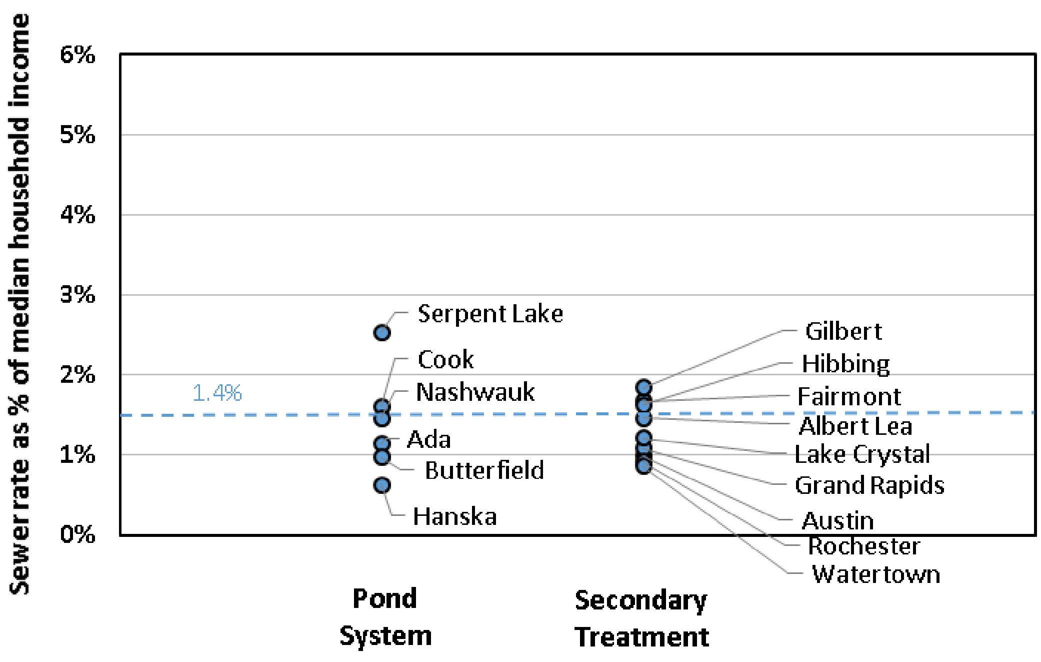


Figure 1-5 Existing sewer rate as a percent of median household income

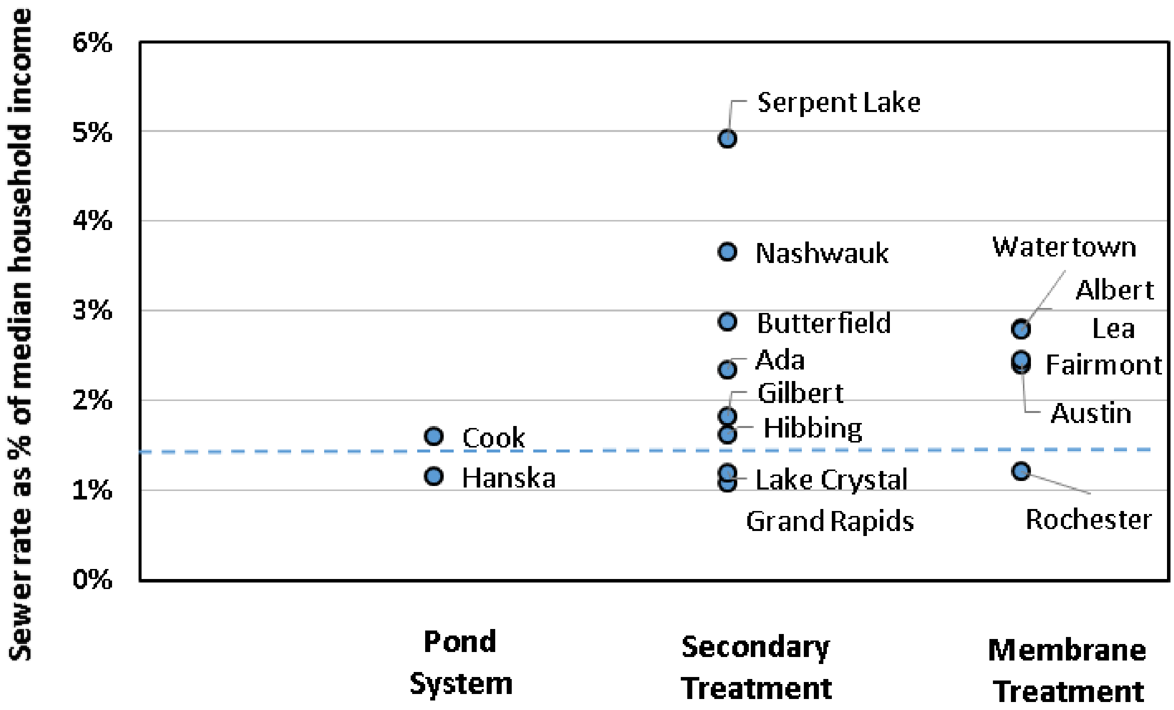


Figure 1-6 **Estimated sewer rate with upgrades to meet current water quality standards as a percent of median household income**

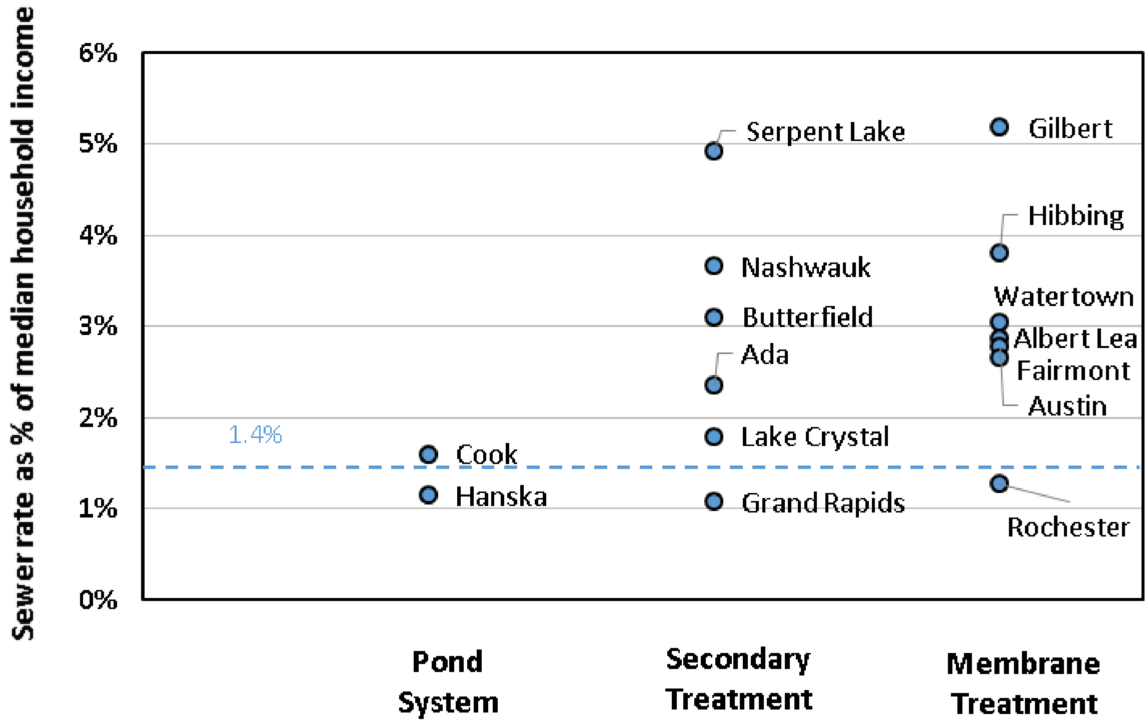


Figure 1-7 **Estimated sewer rate with upgrades to meet future water quality standards as a percent of median household income**

1.5.4 Impact of Technology Upgrades on Water Quality

Incremental water quality changes resulting from wastewater treatment facility upgrades will primarily be realized immediately downstream of the discharge point under lower flow conditions (when less stream flow is available to dilute the flow). Reduced pollutant levels in the treated water provides the greatest benefits to aquatic life and recreational users in the segment of the receiving water immediately downstream of the discharge location. The reduction of each pollutant in the wastewater treatment facility discharge, at the point that the treated water enters the receiving water at the critical flow, is shown in Figure 1-8 and Figure 1-9.

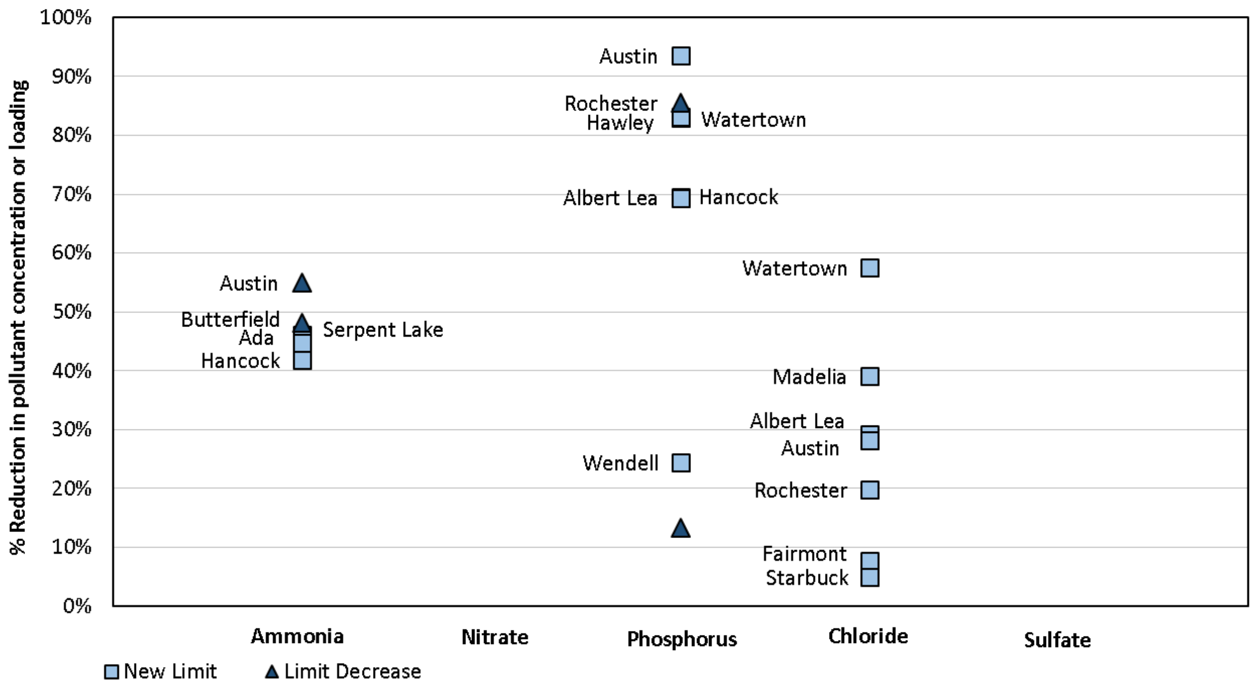


Figure 1-8 Pollutant reduction in wastewater treatment facility discharge from upgrades to meet current effluent limits

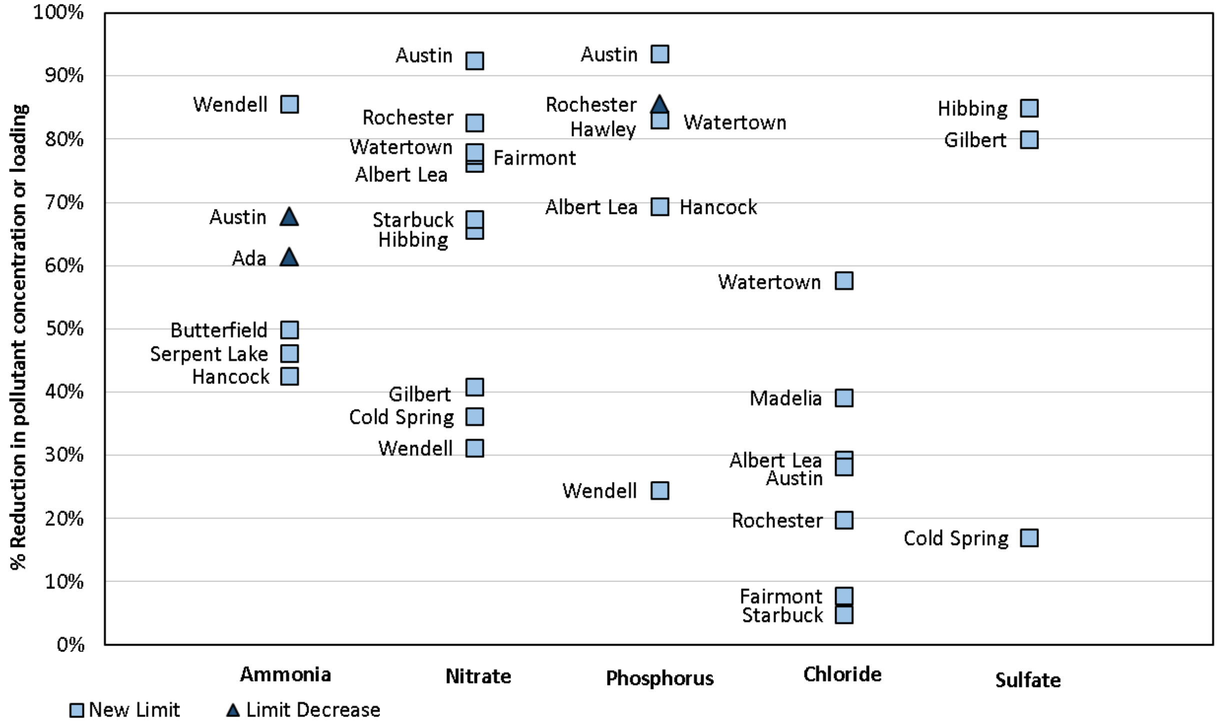
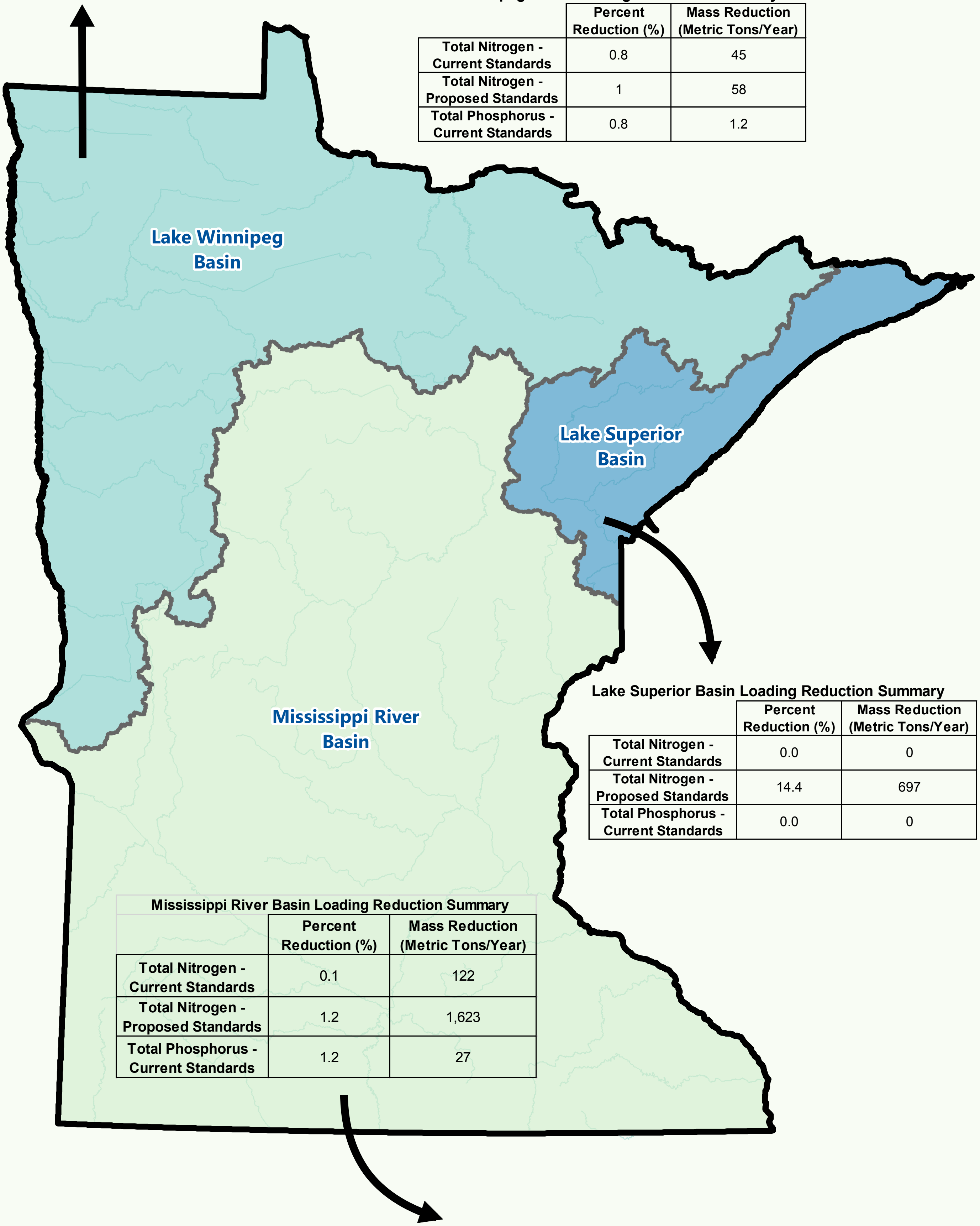


Figure 1-9 **Pollutant reduction in wastewater treatment facility discharge from upgrades to meet future effluent limits**

For some pollutants, namely nutrients (phosphorus and nitrogen (organic nitrogen, nitrate, and ammonia), wastewater treatment facility upgrades would also improve water quality further downstream in the watershed and the basin. Nutrient load reductions to Minnesota's major river basins due to wastewater treatment facility upgrades were estimated by calculating the pollutant load reductions in receiving waters downstream of the 25 municipal wastewater treatment facilities shown in Figure 1-1. The existing pollutant loading from municipal wastewater treatment facilities was calculated based on monitoring data, and loading under current and future water quality standards was calculated based on the relative differences with current and future effluent limits estimated for this study. Nutrient load reductions to Minnesota's major river basins due to wastewater treatment facility upgrades are shown on Figure 1-10.



Lake Winnipeg Basin Loading Reduction Summary

	Percent Reduction (%)	Mass Reduction (Metric Tons/Year)
Total Nitrogen - Current Standards	0.8	45
Total Nitrogen - Proposed Standards	1	58
Total Phosphorus - Current Standards	0.8	1.2

Lake Superior Basin Loading Reduction Summary

	Percent Reduction (%)	Mass Reduction (Metric Tons/Year)
Total Nitrogen - Current Standards	0.0	0
Total Nitrogen - Proposed Standards	14.4	697
Total Phosphorus - Current Standards	0.0	0

Mississippi River Basin Loading Reduction Summary

	Percent Reduction (%)	Mass Reduction (Metric Tons/Year)
Total Nitrogen - Current Standards	0.1	122
Total Nitrogen - Proposed Standards	1.2	1,623
Total Phosphorus - Current Standards	1.2	27

Minnesota State

Major Basin Divide

Mississippi River

Lake Superior

Lake Winnipeg

The three major basin divides are from the 2014 MPCA Nutrient Reduction Strategy Report.

0 25 50 75

Miles

BARR

TOTAL NITROGEN AND PHOSPHORUS LOADING REDUCTIONS TO MAJOR BASINS DUE TO CURRENT AND FUTURE WWTF EFFLUENT LIMITS

Water Quality Standards Cost Analysis

Minnesota Management & Budget

FIGURE 1-10

1.6 Municipal Stormwater System Upgrades

Stormwater treatment by municipal separate storm sewer systems would need to be upgraded to meet Minnesota's water quality standards which are applied through total maximum daily load studies and their resulting wasteload allocation. To estimate the potential total capital and operating costs to upgrade existing stormwater treatment systems throughout the state to meet current and future total maximum daily load wasteload allocations and National Pollutant Discharge Elimination System permit requirements, an in-depth cost analysis was performed on the six municipal separate storm sewer systems required to have permits under the Clean Water Act:, which under Minnesota Pollution Control Agency guidance could be assigned wasteload allocations: Albert Lea, Austin, Fairmont, Grand Rapids, Hibbing, and Rochester (Figure 1-1).

Details on the costs and load reductions associated with upgrades to stormwater treatment systems for the six municipal separate storm sewer system case studies are provided in Section 7.0.

1.6.1 Identifying Need for Upgrades

Current and future total maximum daily loads were considered to determine which total maximum daily loads would achieve the desired level of stormwater treatment for each municipal separate storm sewer system (i.e., the "controlling" total maximum daily load). Existing pollutant load, current and future total maximum daily load loading requirements, and pollutant loading reductions provided by existing stormwater treatment systems were determined for each municipal separate storm sewer system. Existing pollutant load and load reduction was then compared to the controlling total maximum daily load requirements to estimate the cost to upgrade existing stormwater treatment systems to meet current and future wasteload allocations.

It was determined that widespread implementation of structural Best Management Practices would likely be required by all six municipal separate storm sewer systems to comply with existing total maximum daily load wasteload allocations, new water quality impairments, and/or the draft Lake Pepin watershed total maximum daily load, which would typically require phosphorus loading reductions of approximately 50% from developed areas. Because wet detention ponds can be expected to provide 50% total phosphorus reduction, the cost analysis assumed that wet detention ponds would be implemented city-wide by all six municipal separate storm sewer systems.

1.6.2 Stormwater Infrastructure Upgrade Costs and Incremental Water Quality Impact

Total annualized costs to meet all total maximum daily load requirements using wet detention ponds were estimated to range from $958,000 to $6,732,000 per year for the six municipal separate storm sewer systems that were studied, totaling $15.0 million. The total amount of pollutants that would be removed by the wet detention ponds for the six municipal separate storm sewer systems was also calculated, and is shown on Figure 1-11.

The costs developed for this analysis are conservative in that they assume the full cost of implementing the desired level of stormwater treatment would be borne by each municipality. Unless compliance schedules for wasteload allocations dictate more rapid implementation, it is anticipated that municipalities would implement additional stormwater treatment for developed areas as future development and redevelopment occur. As a result, much of the cost for stormwater treatment upgrades would likely be incorporated into future project costs for land development or redevelopment.

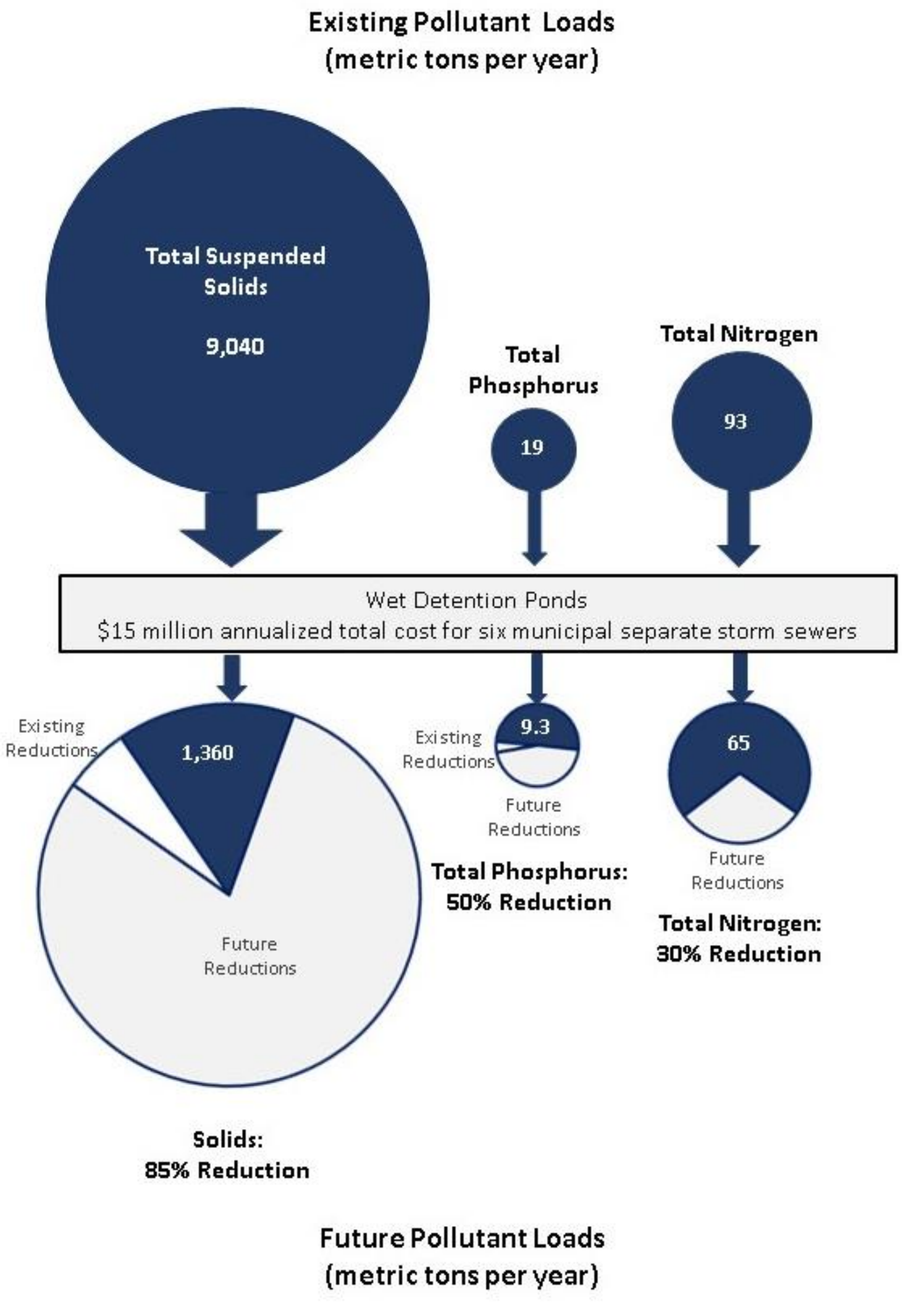


Figure 1-11 Pollutant load reductions by upgrades to six MS4 stormwater treatment systems to meet current and future total maximum daily loads

The results were used to develop cost-effectiveness analyses for total phosphorus, total suspended solids, and total nitrogen, calculated by comparing the annual expected pollutant reduction to the annualized cost estimate for infrastructure upgrades. Cost-effectiveness values estimated for total suspended solids, total phosphorus, and total nitrogen across each basin range from $0.90-1.20 per pound of total suspended solids, $760-$1,030 per pound of total phosphorus and $250-$340 per pound of total nitrogen removed annually, which are within a range considered typical for wet detention basins.

1.6.3 Extrapolation of Stormwater Costs to the Whole State

In-depth review of current and future total maximum daily load requirements could not be performed for all municipal separate storm sewer systems within the state. Therefore, basin-wide assumptions related to future total maximum daily load requirements were developed for the major basins in Minnesota. Based on basin-wide analysis of existing and expected total maximum daily loads, this study concluded that municipal separate storm sewer systems in the Lake Winnipeg and Lake Superior basins would not need to provide the same degree of stormwater treatment as other major basins. However, based on future potential loading requirements related to water quality in Lake Winnipeg, Hypoxia in the Gulf of Mexico, and other ongoing total maximum daily load efforts, it is possible that uniform stormwater treatment reduction goals may ultimately extend to all (164) municipal separate storm sewer systems within the state. Consistent with the basin-wide summary, it was assumed that any municipal separate storm sewer system included in an existing, approved total maximum daily load related primarily to stormwater pollutants would require widespread implementation of structural Best Management Practices, and the expected load reduction to meet future total maximum daily load requirements and the associated costs were then developed for all municipal separate storm sewer systems in the state.

Based on the approach used for this analysis, total annualized costs to meet all total maximum daily load requirements for municipal separate storm sewer systems across the state could approach $317 million per year. As noted above, the costs developed for this analysis are conservative in that they assume the full cost of implementing the desired level of stormwater treatment would be borne by each municipality. Unless compliance schedules for wasteload allocations dictate more rapid implementation, it is anticipated that municipalities would implement additional stormwater treatment for developed areas as future development and redevelopment occur. As a result, much of the cost for stormwater treatment upgrades would likely be incorporated into future project costs for land development or redevelopment. Section 7.0 presents details on the extrapolation of statewide costs for stormwater treatment system upgrades.

1.7 Statewide Effectiveness Summary

The combined pollutant load reductions from upgrades to wastewater and stormwater infrastructure described in this study are expected to yield significant water quality improvements to much of the state.

However, these improvements vary with distance from the city where upgrades occurred and with the flow level in the receiving water. While pollutant load reductions from wastewater treatment facility upgrades primarily benefit the receiving water immediately downstream of the discharge and while the benefit is greatest when stream flow is low, for nutrients (phosphorus, and nitrogen (nitrate and ammonia)), wastewater treatment facility upgrades would also improve water quality further downstream in the watershed and the basin on an annual basis. In contrast, benefits from stormwater treatment system upgrades extend further downstream, and are greatest during higher-flow conditions, because wet weather results in stormwater representing a greater share of streamflow. The overall cost-effectiveness of wastewater and stormwater upgrades is therefore difficult to estimate, because effects that differ by distance and flow-regime are difficult to meaningfully "add up" or "tease out." However, to provide context on overall statewide effects, Figure 1-12 summarizes the pollutant load reductions in Minnesota's major river basins as a result of upgrading wastewater and stormwater treatment systems to meet current and future effluent limits and total maximum daily loads.

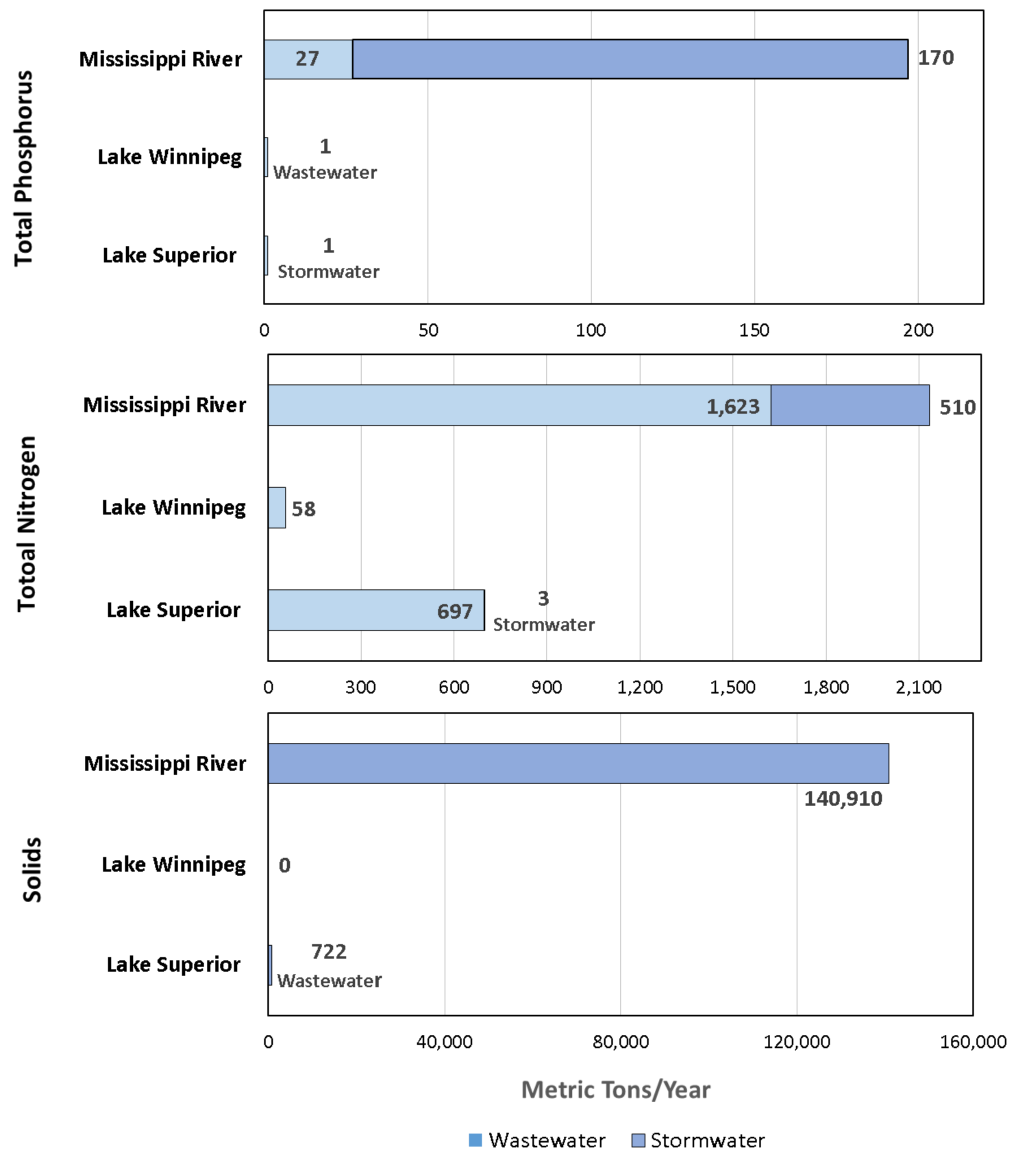


Figure 1-12 Total pollutant load reductions by major river basin

The overall cost for wastewater and stormwater treatment system upgrades are shown in Figure 1-13 for the six cities where both were estimated.

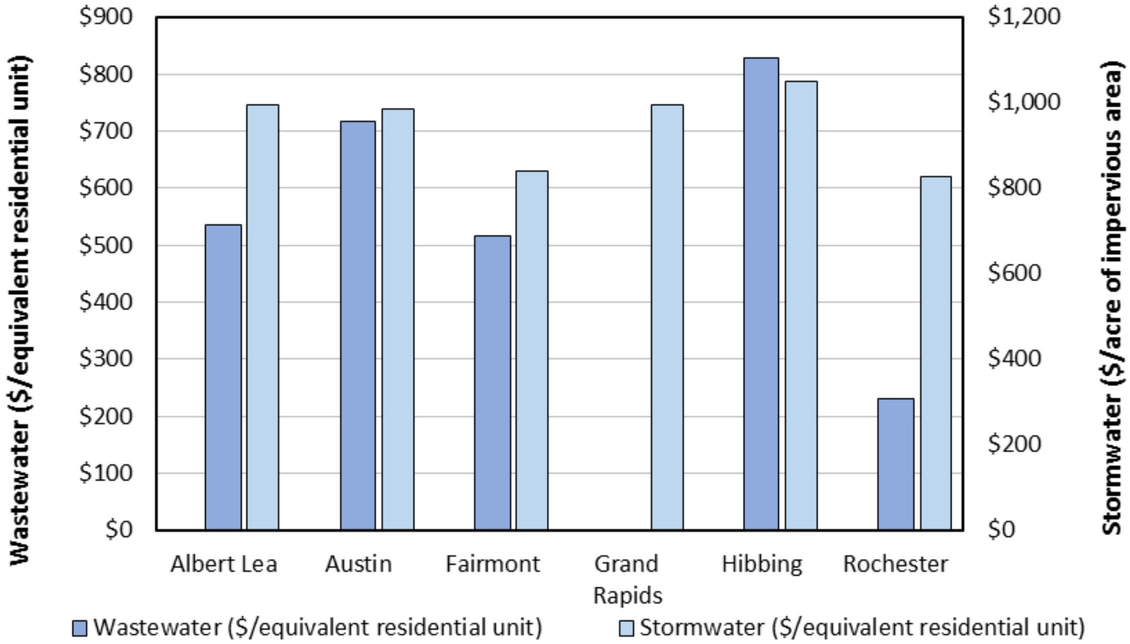


Figure 1-13 Cost of wastewater and stormwater treatment system upgrades to meet current and future water quality standards

1.8 Available Funding Programs

Wastewater and stormwater improvement projects in Minnesota can be financed by loans or grants from a variety of public funding programs, which are detailed in Section 9.0. Program loans typically provide more favorable repayment conditions than municipal bonds. Grants (when available) can be used to decrease the required loan amount, making repayment of capital costs more affordable.

In recent years, based upon the difference between the requested funding and the available funding, it could be inferred that current funding is limited. Existing wastewater infrastructure in many Minnesota cities is approaching the end of its useful design life, so many funding requests in recent years have been for rehabilitation projects of existing wastewater collection and treatment systems to maintain performance rather than meet new standards.

Existing sewer use fees are typically near recognized limits for affordability. For the fifteen municipalities in this study, the current sewer rates range from 0.6% to 2.5% of median household income. New water quality standards requiring upgrade of existing facilities would add to the operating city's financial burden. The wastewater treatment facility upgrade and operational costs for the fifteen municipalities in this study are expected to result in sewer fees ranging from 1.1% to 5.2% of household median income, which will increase the gap between funding requested and available wastewater treatment funding. This in turn will increase pressure on the affordability of wastewater infrastructure.

For the six regulated municipal separate storm sewer systems included in this study, future stormwater treatment requirements have the potential to add significant cost to the city's financial burden, approximately $15 million combined cost (capital and operating) per year. While a significant portion of the capital costs will likely be borne by future land development or redevelopment projects, the remaining capital and operational costs will borne by the respective cities, further adding costs to the new wastewater costs discussed above. Given the significant gap that currently exists between requested and available Clean Water Funding for stormwater projects and given that other non-municipal stormwater projects are also competing for funding, it is expected that future stormwater treatment requirements for all 164 cities with municipal separate storm sewer systems permits will significantly exceed current funding levels.

2.0 Introduction

2.1 Project Goal

The Minnesota State Legislature requested an engineering cost analysis of current and recently adopted, proposed, or anticipated changes to water quality standards (WQS) and rules (Laws of Minnesota 2015, chapter 4, article 3, section 135). Minnesota Management and Budget (MMB) contracted with Barr Engineering (Barr) to conduct this analysis. The goal of the project was to estimate the costs to upgrade, operate, and maintain wastewater and stormwater systems to meet existing and recently adopted WQS, and the costs likely to be incurred to upgrade wastewater and stormwater systems to meet proposed or anticipated changes to WQS. Engineering cost estimates were developed based on case studies of wastewater treatment systems and stormwater treatment systems in representative communities across Minnesota. The project also estimated the incremental effect to overall water quality in the receiving waters as a direct result of the recently adopted, proposed, or anticipated changes to WQS. The legislature specified five pollutants for this study: total suspended solids (TSS), chloride, nutrients (phosphorus and nitrogen), nitrate, and sulfate. The legislature also specified that the study address recently adopted antidegradation rules and potential, future, tiered aquatic life use (TALU) rules. In completing the study, Barr also evaluated current and future ammonia WQS and recently adopted variance rules. A 20-year-planning timeframe was used as a boundary for the study.

2.2 Project Approach

For the wastewater treatment systems, costs were estimated by first identifying current and recently adopted WQS (current WQS), as well as anticipated future WQS (future WQS) (Section 3.0). For twenty five geographically distributed facilities, Barr estimated current and future effluent limits for pollutants of concern based on effluent limits in the existing National Pollutant Discharge Elimination System (NPDES) permit, characteristics of the existing wastewater treatment facility (WWTF), and the classification and characteristics of the receiving water (Section 4.0). For the work described in Sections 3.0 and 4.0, the Barr team included Mark Tomasek, a recently retired Minnesota Pollution Control Agency (MPCA) water-quality-standards unit supervisor who reviewed effluent limits developed by the Barr team. Mr. Tomasek has direct knowledge of current and proposed water quality standards and detailed knowledge of MPCA's processes for developing effluent limits.

Fifteen wastewater treatment systems were selected for detailed engineering cost estimating, using criteria described in Section 5.6.1. The Barr team visited each of these communities to gather detailed information about the existing systems' configurations and operation. For each community, costs to upgrade, operate, and maintain the WWTF to meet current and future WQS were estimated based on the estimated current and future effluent limits, the existing WWTF configuration, and historic WWTF performance. For this work, the Barr team included another professional engineering firm, Bolton & Menk, which participated in the work and provided quality assurance reviews of our wastewater treatment plant concepts and cost estimates (Section 5.0).

Subsequently, the incremental water quality effects of the current and future WQS due to changes to the municipal wastewater treatment systems were estimated. For receiving waters associated with each of the 25 wastewater treatment systems, the study estimated water quality effects by comparing existing loading with the loading expected under the wasteload allocations (WLAs) and effluent limits required to meet current and future WQS. Information on existing loading was obtained from sources such as total maximum daily load (TMDL) WLAs, Stressor Identification (SID) analyses, and other MPCA monitoring data and memoranda supporting the applicable effluent limits (Section 6.0).

For the stormwater treatment systems, six stormwater treatment systems were selected for the study, using criteria described in Section 7.1. All of the systems selected are subject to municipal separate storm sewer system (MS4) permit requirements. Costs were estimated based on the assumption that they will be subject to antidegradation and current and future TMDL requirements. For each community, costs were estimated based on the additional stormwater detention pond storage volume that would be needed to reduce loadings of TSS and total phosphorus (TP), consistent and current and future TMDL requirements. The incremental water quality effects of the stormwater treatment systems were also estimated (Section 6.0).

For the six municipalities selected for both stormwater and wastewater analysis, the study compiled the costs of updating wastewater and stormwater treatment systems to meet current and future WQS and the corresponding changes in loading to major basins in the state. This compilation summarizes the relative costs and incremental water quality changes that can be expected at a basin scale from compliance with current and future WQS (Section 8.0).

Finally, funding programs available to finance the wastewater and stormwater upgrades needed to meet current and future WQS are summarized, and a brief description of the state's existing water infrastructure and funding programs is provided. The funding programs available to the municipalities for future upgrade needs are summarized and discussed in the context of user affordability (Section 8.0).

3.0 Current and Potential Future WQSs

As noted above in the introduction, this study estimated the impacts to certain cities within the state of complying with current and recently adopted WQS (current WQS) and anticipated future WQS (future WQS). Specifically, the legislature requested that this evaluation look at impacts from:

- Recently adopted or proposed changes to TSS, nutrient, chloride, nitrate, and sulfate standards.
- Proposed anti-degradation rulemaking provisions.
- Proposed changes to WQSs to incorporate a TALU framework.

This section presents the current WQS and the future WQS that were used as the basis for the effluent limits estimated in Section 4.0.

3.1 Current and Recently Adopted WQSs and Rules

Key current WQS that could result in effluent limits were identified, including both numeric and narrative standards.

3.1.1 Numeric Standards

Numeric WQSs describe the qualities or properties of the waters of the state that are necessary to protect aquatic life, human health, and/or recreation-designated public uses and benefits and represent the allowable concentrations of specific pollutants in a water body (reference (2)). Numeric standards exceedances indicate potential for a polluted condition considered potentially deleterious, harmful, detrimental, or injurious with respect to a water's designated use. Current numeric standards from Minnesota Rules Chapter 7050 and 7052, Waters of the State, applicable to this study are included in Appendix A.

Several of the key standards that were named in the MMB request for proposal have been recently revised:

- Total suspended solids (TSS) – In 2014, the MPCA proposed and adopted a series of standard changes which included changes to TSS standards by region.
- Nutrient – Nutrient standards primarily consist of nitrogen and phosphorus WQS.
    - Phosphorus – The MPCA has developed a series of memos evaluating phosphorus limits in specific watersheds and the limits for each discharger in those watersheds. Where those memos were available at 20 of the cities, they were used as a basis for the effluent limits. For the remaining five cities, the listed River Eutrophication Standards (RES) were applied similarly to the MPCA memos along with any applicable TMDL.
    - Nitrogen – There have been no recent changes to nitrogen WQS.

  - Ammonia – The current chronic ammonia standard is promulgated as a single numeric value for unionized ammonia as N. The current chronic standard is also accompanied with a formula to calculate the percent unionized ammonia at any given pH and temperature. The current WQS does not include an acute standard.

- Chloride – The Class 2 standard for chloride has not been changed recently, but newly available discharge and receiving stream data allow reasonable potential evaluations (RPEs) for some facilities that are currently only monitoring for chloride. The RPE analyses may result in new chloride effluent limits for some of these facilities.

- Antidegradation – The revised antidegradation rules became effective on November 21, 2016, so they are considered as current WQS for purposes of this evaluation. The impacts from anti-degradation triggers are noted in Section 4.8.

- Class 3 and 4 Standards – As directed by MMB and MPCA, the impact of implementing MPCA's salty discharger strategy will not be included in the scope. This means that current and potential, future Class 3 (industrial use) and Class 4 (agricultural and wildlife consumptive use) WQSs, due to their direct connection to the salty discharger strategy, will not be included in this scope either. Even though the Class 3 and 4 standards were not required to be addressed, our effluent limits evaluation does provide effluent limit estimates for informational purposes because of the potential impacts but are not used in the cost estimates for the facilities. Because sulfate is not addressed in the salty discharger strategy and because sulfate was directly named by the legislature for inclusion in this study, future limits on sulfate related to wild rice protection are addressed in Section 3.2 and Section 4.0.

3.1.2 Narrative Standards

Narrative standards also describe the qualities of waters of the state that protect designated uses and cover a broad range of requirements to protect waters of the state from developing impaired conditions. Narrative standards are statements of unacceptable conditions in and on the water (reference (2). Narrative standards apply to Class 2 waters to prevent material degradation. Narrative standards also apply to Class 2 waters to prevent polluted conditions associated with eutrophication. This study addressed the numeric components of eutrophication standards for phosphorus and TSS as discussed above. Additional narrative standards were not addressed.

3.2 Proposed or Anticipated WQSs and Rules

Key future WQSs that could result in effluent limits were identified, and the following rationale was used in anticipating future WQSs as part of this study. Future and proposed WQSs by associated use class are provided in Table 3-1.

- Nitrate - The MPCA has developed a draft *Aquatic Life Water Quality Standards Technical Support Document for Nitrate* dated November 12, 2010, (reference (1)) that includes the following:

- The draft acute value (maximum standard) calculated is 41 mg/L nitrate-N for a one-day duration, and the draft chronic value is 4.9 mg/L nitrate-N for a 4-day duration for Class 2B beneficial use classifications.
- The draft chronic value is 3.1 mg/L nitrate-N for a four-day duration for Class 2A beneficial use classifications.

The EPA has not developed ambient aquatic life WQS for nitrate. The MPCA has developed preliminary WQSs but has not started rulemaking. Although likely to be revised based on additional toxicity testing results, future nitrate WQSs were assumed to be the same as described in the draft *Aquatic Life Water Quality Standards Support Document for Nitrate*. In order to address the transformation of organic nitrogen and ammonia nitrogen into nitrate in the receiving water, effluent limits derived from the nitrate WQS are set as total nitrogen, not as nitrate-nitrogen. This was a conservative assumption that assumed that the nitrate equaled total nitrogen.

- Ammonia – In 2013, the US EPA finalized revised 304(a) ambient water quality criteria for ammonia as N that included revised criteria for the protection of sensitive mussel species and gill-bearing snails. The criteria includes acute and chronic criteria and is expressed as total ammonia as N. Similar to the existing standard, the acute and chronic ammonia criteria are presented as a single numeric value for unionized ammonia as N. These were adjusted using a formula to calculate the percent unionized ammonia at any given pH and temperature. The following 2013 final updated EPA criteria were used as the future potential limit.
  - EPA final updated 2013 criteria for acute conditions is 17 mg/L (unionized)
  - EPA final updated 2013 criteria for chronic conditions is 1.9 mg/L (unionized)
- Chloride – The EPA had begun development of a revised WQS for chloride but recently put that effort on hold. The MPCA has indicated that a revised WQS for chloride is under consideration for future rulemaking, but research has not started, a lead scientist has not been assigned, and no rulemaking has started according to the MPCA Rulemaking Docket (reference (3)). Currently, there is no schedule from the EPA for an updated WQS, and the MPCA has indicated that it is waiting for the EPA's update prior to rulemaking. As such, there is not a substantial basis for a WQS change. The current WQS for chloride was assumed to apply during the 20-year-planning timeframe of the study.
- Sulfate – The MPCA's current WQS for sulfate, 10 mg/L, applies to waters designated as being used for the production of wild rice during the periods when the rice may be susceptible to damage by high sulfate levels. The MPCA is considering revised WQSs for sulfate to address the protection of wild rice with the intended goal of publishing proposed rules in 2017 and completing the rule-making by January 15, 2018.

  The EPA has not developed an animal-based WQS for sulfate or provided a schedule for the update. The MPCA has indicated that it is following the EPA's research on the topic of sulfate, though it is unclear whether the MPCA will update the sulfate WQS within the assumed 20-year-planning timeframe of study. Receiving waters associated with the discharges from facilities included in this study were evaluated for proximity to MPCA-identified wild rice waters and those of the wild rice waters "watch" list (reference (4)). For the purposes of this study, it was assumed that the MPCA will not develop a sulfate animal-based aquatic-life WQS within the 20-year-planning timeframe, and that the existing sulfate standard for the protection of wild rice will remain the same within the planning timeframe. Thus, we applied the existing standard of 10 mg/L to receiving waters listed on the July 19, 2016, MPCA list of current and proposed wild rice waters

Table 3-1 Future and proposed water quality standards by associated use class

Parameter	Unit	MN SW 2A Chronic 7050 - 100 Hardness	MN SW 2A Maximum 7050 - 100 Hardness	MN SW 2A Final Acute Value 7050 - 100 Hardness	MN SW 2B Chronic 7050 - 100 Hardness	MN SW 2B Maximum 7050 - 100 Hardness	MN SW 2B Final Acute Value 7050 - 100 Hardness	MN SW 3A Industrial Consumption 7050	MN SW 3B State Waters 7050	MN SW 3C State Waters 7050	MN SW 4A State Waters 7050	MN SW 4B Livestock Wildlife 7050	MN SW 5 Aesthetic Navigation Non Wetlands 7050
Nitrogen, Ammonia as N	mg/l	1.9	17		1.9	17							
Nitrogen, Nitrate, as N	mg/l	3.1		41	4.9		41						
Sulfate, as SO4	mg/l										10[1]		

(1) Applied to Wild Rice waters listed on draft MPCA proposal, July 2016

3.1 Limitations of Analysis

The results of this study are based on assumptions in how recent WQS will be applied as well as assumptions about future WQS values. As such, the estimated effluent limits provided in Section 4.0 will be based on the assumptions above for applicable WQS and not actual changes. Some of the WQS assumptions have more uncertainty than others. A relative comparison of the uncertainty of these is presented in Table 3-2.

Table 3-2 Current and future water quality standards considered for this study

	Current standards(1)	Anticipated future standards included/considered in this study	Potential future standards not included in this study
Low Uncertainty	Ammonia Chloride Total Suspended Solids Variances		
Medium Uncertainty	Sulfate (wild rice) Antidegradation Phosphorus(2)	Ammonia(3) Nitrate(4) Sulfate (wild rice)(5)	
High Uncertainty		Tiered Aquatic Life Use (TALU)	Chloride

(1) Numeric surface water quality standards for Class 2, Class 3, and Class 4 waters, and antidegradation standards set forth in Minnesota Rules Chapter 7050. Also special protections that apply to specific waterbodies (or watersheds) such as total maximum daily load (TMDL) requirements, Minnesota Pollution Control (MPCA) biological stressor identification (SID) reports, MPCA Watershed Restoration and Protection Strategies, and MPCA Phosphorus Effluent Limit Review (eutrophication) memos

(2) Existing TMDLs and application of river and lake eutrophication memos

(3) Ammonia 304(a) ambient water quality criteria finalized in 2013 by the US EPA.

(4) Nitrate standards proposed in the MPCA draft *Aquatic Life Water Quality Standards Support Document for Nitrate* (reference (1)).

(5) Sulfate wild rice standards under development by the MPCA.

4.0 Estimated Current and Future Effluent Limits for Municipal WWTFs

4.1 Methods

To determine whether the current and future WQS could result in new effluent limits, Barr evaluated the existing performance of each municipal WWTF against the current and future WQS on a parameter-by-parameter basis. This analysis indicated each WWTF's potential to exceed the current or future WQS. For parameters identified as having the potential to exceed, Barr estimated the associated potential effluent limits. MPCA normally would develop effluent limits by: 1) determining applicable technology based effluent limits (TBELs); 2) determining applicable water quality based effluent limits (WQBELs); 3) selecting the most restrictive TBELs and WQBELs; and, 4) evaluating antidegradation issues. Because there were no revisions to the secondary treatment standards, it was assumed that those effluent limits did not change. Therefore, effluent limits were updated when a change to a WQBEL was lower than an existing limit or created a new limit only.

The first step in developing the WQBELs for each case study involved characterizing the effluent quality and the receiving water quality.

1. Characterize the effluent and receiving water quality
   - Identify the pollutants of concern
   - Identify critical conditions for effluent and receiving waterbody
   - Determine whether consideration of dilution or mixing is allowed by WQS
2. Determine the need for parameter-specific WQBEL
   - Determine if pollutants of concern are or may be discharged at a level that will cause or have the reasonable potential to exceed (RPE) the WQS
   - If yes, then a WQBEL will be required
3. Calculate parameter-specific WQBELs
   - Compare with WQBEL based upon TMDL or other watershed-based requirements
   - Antidegradation Impacts (where applicable)
   - Perform steady-state modeling under critical conditions:
   - Permit writers typically use steady-state modeling to model the effluent and receiving water

- Predicts the impact of the effluent on the receiving water for a single set of conditions—critical receiving water condition:
  - Receiving water flow (if applicable)
  - Background pollutant concentrations for pollutants of concern
  - Other receiving water characteristics (e.g., temperature, pH)
- Assumes critical conditions for flow, pollutant concentrations, and environmental effects—critical effluent conditions:
  - Effluent flow
  - Effluent pollutant concentrations
  - Apply appropriate dilution allowance or mixing zone
- Calculate the average monthly limit (AML) and maximum daily limit (MDL)

4.2 Facilities Studied and Key Pollutants of Concern

The 25 facilities included in the study are split into four WWTF classes as described in Table 4-1. Facility class size generally describes the size and level of treatment with Class A being the largest and Class D being the smallest. These facilities represent the 20 communities identified by MMB to be included in the analysis. These initial 20 facilities were selected primarily because MPCA had completed memoranda summarizing RES impacts in their watersheds. In order to provide more complete geographic and facility type coverage across the state and its watersheds, Barr worked with MMB to select five additional facilities (Cook, Gilbert, Grand Rapids, Hibbing, and Nashwauk) to include in the study, for a total of 25 facilities. Locations of these facilities are shown on Figure 4-1.

Table 4-1 Wastewater treatment facility (WWTF) types

Facility Class	Applicable Facilities
A	Albert Lea, Austin, Cold Spring, Fairmont, Gilbert, Grand Rapids, Hibbing, Madelia, Rochester
B	Lake Crystal, Starbuck, Watertown
C	Butterfield, Halstad
D	Ada, Campbell, Cook, Hancock, Hanska, Hawley, Lewisville, Nashwauk, Northrop, Serpent Lake, Wendell

- WWTF
- Minnesota State Boundary
- Major Basins
- Major Watersheds

0 25 50 75
Miles

BARR

WWTF LOCATIONS FOR EFFLUENT LIMIT ANALYSIS
Water Quality Standards Cost Analysis
Minnesota Management & Budget

FIGURE 4-1

4.2.1 Facility Permit Evaluation

The MPCA provided the most current National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permit (as of September 1, 2016) and the most recent permit application for each facility included in the study. Of the 25 facilities included in the study, 20 have expired permits that are under review by the MPCA. Permit expiration dates are shown in Table 4-2.

Each facility's permit was evaluated to assess the impact of current and future water quality standards on potential permit effluent limits. Table 4-2 presents key information obtained from existing permits on the receiving stream, designated use, permit dates, and existing effluent limits (existing permit limits). The designated use classifications were used to determine which current and future water quality standards are applicable to the facility.

The design average dry weather (ADW) flow used to calculate projected downstream concentrations and WLAs for each facility was collected from the Description of Permitted Facility section of each permit, if available. Additional information gathered from the permits was incorporated into the wastewater treatment costs evaluation, including five-day carbonaceous biochemical oxygen demand (CBOD) concentration, process flow description, process unit dimensions and detention times, and plans for expansion.

Pollutants of concern were summarized for each facility based on existing permit limits and current and future WQS as described in Section 3.0. Existing permit limits were extracted from the Limits and Monitoring Requirements table of each NPDES permit and compared to the current and future effluent limits calculated as part of this study.

Figure 4-1 and location details including section, township, and range were used to locate each facility's effluent discharge and confirm applicable receiving water data. The exact discharge location within the receiving stream guided receiving water data collection and identification of monitoring stations upstream and downstream of the discharge.

Table 4-2 Facility permit information

Facility	Permit Number	Receiving Water	River Nutrient Region	Beneficial Use Classification	Date Permit Issued	Date Permit Expires(ed)	Discharge Name
Ada	MN-580095	Unnamed Ditch to Marsh River	South	2B, 3C, 4A, 4B,5,6	Modified: October 20, 2010	August 31, 2015	SD 001: Main Facility Discharge
Albert Lea	MN0041092	Shell Rock River	South	2B, 3C, 4A, 4B, 5,6	Issued: December 16, 2009	November 30, 2014	SD-001: 001 Total Facility Discharge
Austin	MN0022683	Cedar River	South	2B, 3C, 4A, 4B, 5,6	Modified: February 07, 2013	June 30, 2015	SD-002: Combined Industrial & Domestic Discharge
Butterfield	MN-0022977	Butterfield Creek	South	2C, 3C, 4A, 5, 6	Modified: March 31, 2010	February 28, 2015	SD 001: Total Facility Discharge
Campbell	MN0020915	Rabbit River	South	2B, 3C, 4A, 4B, 5,6	Issued: February 23, 2010	January 31, 2015	SD 001: Surface Water Discharge
Cold Spring	MN0023094	Sauk River	Central	2B, 3C, 4A, 4B, 5,6	Modified: June 13, 2014	August 31, 2015	SD 001: Main Facility Discharge
Cook	MNG580179	Little Fork River	North	2C, 3C, 4A, 4B, 5, 6	Issued: November 19, 2010	August 31, 2015	SD 002: Total Facility Discharge (Applicable only during discharge)
Fairmont	MN-0030112	Center Creek	South	2B, 3C, 4A, 4B,5,6	Modified: October 10, 2011	April 30, 2015	SD001 Total Facility Discharge
Gilbert	MN0020125	Unnamed Ditch	North	2B, 3C, 4A, 4B, 5, 6, 7	Modified: March 3, 2010	June 30, 2014	SD 002: Main Facility Discharge
Grand Rapids	MN0022080	Mississippi River	North	2B, 3C, 4A, 5, 6	Modified: November 19, 2014	May 31, 2018	SD 004: Main Facility Discharge
Halstad	MN0020770	Red River of the North	South	1C, 2Bd, 3C, 4A, 4B, 5, 6	Issued: March 8, 2012	February 28, 2017	SD 002: Main Facility Discharge
Hancock	MN0023582	Unnamed Ditch	South	2B, 3C, 4A, 4B, 5, 6	Issued: March 4, 2011	February 29, 2016	SD 005: Surface Water Discharge
Hanska	MN0052663	County Ditch #63	South	3C, 4A, 4B, 5, 6, 7	Issued: March 1, 2016	February 28, 2021	SD 001 Total Facility Discharge
Hawley	MN0020338	Buffalo River	South	2B, 3C, 4A, 4B, 5, 6	Issued: April 21, 2011	March 31, 2016	SD 002
Hibbing	MN0030643	East Swan Creek	North	2B, 3C, 4A, 4B, 5, 6	Issued: August 20, 2012	July 31, 2017	SD 001: 001 Main Discharge
Lake Crystal	MN0055981	Minneopa Creek	South	3C, 4A, 4B, 5, 6, 7	Issued: December 22, 2010	November 30, 2015	SD 002: 001 Main Discharge
Lewisville	MN0065722	Unnamed Ditch	South	3C, 4A, 4B, 5, 6, 7	Issued: December 22, 2010	November 30, 2015	SD 001: Total Facility Discharge (Applicable only during discharge)
Madelia	MN0024040	Watonwan River	South	2B, 3A, 3C, 4A, 4B, 5, 6	Issued: April 20, 2016	March 31, 2021	SD 003: Main Facility Discharge
Nashwauk	MNG580184	Hanna Reservoir #2	North	2B, 3C, 4A, 4B, 5, 6	Issued: November 19, 2010	August 31, 2015	SD 002: Total Facility Discharge (Applicable only during discharge)
Northrop	MN0024384	Judicial Ditch No. 8	South	2B, 3C, 4A, 4B, 5, 6	Modified: September 10, 2013	February 29, 2016	SD-002: Combined Industrial & Domestic Discharge
Rochester	MN0024619	South Fork of Zumbro River	Central	2B, 3C, 4A, 4B, 5,6	Issued: May 26, 2010	April 30, 2015	SD 001: Main Facility Discharge
Serpent Lake	MNG580215	Rabbit River	North	2C, 3C, 4A, 4B, 5, 6	Issued: July 8, 2008	April 30, 2013	SD 002: Total Facility Discharge
Starbuck	MN-0021415	Outlet Creek	Central	2B, 3C, 4A, 4B, 5,6	Modified: June 15, 2011	May 31, 2016	SD 003: Effluent to Surface Water
Watertown	MN0020940	South Fork of Crow River	South	2B, 3B, 4A, 4B, 5, 6	Issued: October 30, 2009	September 30, 2014	SD 001: Total Facility Discharge
Wendell	MN0051501	Mustinka River	South	2B, 3C, 4A, 4B, 5,6	Modified: June 13, 2014	August 31, 2015	SD 001: Surface Water Discharge

4.2.2 Pollutants of Concern

Pollutants of concern are those pollutants that are expected to be in an effluent or that data indicates may be present in an effluent. Pollutants that have an effluent limitation assigned in the existing NPDES permit, have a high potential of a future effluent limitation, or have been identified as likely to be present in the discharge were considered pollutants of concern (POCs) for this analysis. Commonly reoccurring POCs identified include:

- nitrate as N
- ammonia as N
- carbonaceous biochemical oxygen demand (CBOD)
- chloride
- fecal coliform (FC)
- total nitrogen
- oil and grease
- pH
- sulfate
- total phosphorus
- total dissolved solids (TDS)
- total suspended solids (TSS)

Pollutants that each facility currently monitors under its discharge monitoring reporting (DMR) requirements were considered POCs. All DMR data summarized in the study and used to calculate current and future effluent limits was provided by the MPCA at Barr's request. The DMR data provided for each facility is from approximately the last five years and represents all reports received by the MPCA as of September 1, 2016. The DMR data evaluated for each facility is from the date ranges provided in Table 4-3. DMR data includes information not only on parameters with existing effluent limits, but also on monitoring only parameters. Data on monitoring only parameters was used in the RPE analysis (Section 4.5).

Table 4-3 Facility DMR data ranges

Location	Surface Discharge DMR Data	Influent Waste Stream DMR Data
Ada	06/01/2011 - 05/01/2016	11/01/2010 - 06/01/2016
Albert Lea	01/01/2010 - 07/01/2016	01/01/2010 - 07/01/2016
Austin	08/01/2010 - 06/01/2016	08/01/2010 - 06/01/2016
Butterfield	04/01/2010 - 05/01/2016	04/01/2010 - 06/01/2016
Campbell	NA	03/01/2010 - 06/01/2016
Cold Spring	09/01/2010 - 06/01/2016	09/01/2010 - 06/01/2016
Cook	11/01/2010 - 06/01/2016	11/01/2010 - 06/01/2016
Fairmont	08/01/2010 - 07/01/2016	06/01/2010 - 07/01/2016
Gilbert	11/01/2010 - 07/01/2016	11/01/2010 - 07/01/2016
Grand Rapids	11/01/2010 - 07/01/2016	11/01/2010 - 07/01/2016
Halstad	04/01/2012 - 06/01/2016	04/01/2012 - 06/01/2016
Hancock	04/01/2011 - 05/01/2016	04/01/2011 - 06/01/2016
Hanska	03/01/2011 - 06/01/2016	12/01/2010 - 06/01/2016
Hawley	05/01/2011 - 05/01/2016	05/01/2011 - 06/01/2016
Hibbing	11/01/2010 - 07/01/2016	11/01/2010 - 07/01/2016
Lake Crystal	01/01/2011 - 06/01/2016	01/01/2011 - 06/01/2016
Lewisville	04/01/2010 - 05/01/2016	01/01/2010 - 06/01/2016
Madelia	09/01/2010 - 06/01/2016	09/01/2010 - 06/01/2016
Nashwauk	05/01/2011 - 06/01/2016	11/01/2010 - 07/01/2016
Northrop	05/01/2014 - 05/01/2016	04/01/2011 - 05/01/2016
Rochester	06/01/2010 - 06/01/2016	06/01/2010 - 06/01/2016
Serpent Lake	04/01/2010 - 04/01/2016	01/01/2010 - 06/01/2016
Starbuck	08/01/2011 - 06/01/2016	08/01/2011 - 06/01/2016
Watertown	01/01/2010 - 06/01/2016	01/01/2010 - 06/01/2016
Wendell	04/01/2011 - 05/01/2016	02/01/2011 - 06/01/2016

A summary of all parameters included in the DMR reports across all 25 facilities is included in Table 4-4.

Table 4-4 DMR parameters

Parameters provided in DMR electronic data
Alkalinity, bicarbonate, as HCO3
Area of Disposal, used
Bacteria, coliform fecal
Cadmium
Calcium
Carbonaceous Biochemical Oxygen Demand (5-day)
Carbonaceous Biochemical Oxygen Demand (5-day), Percent Removal
Chloride
Chlorine, total residual
Chromium
Copper
Dilution Ratio, Receiving Water Flow: Effluent Flow
Dissolved oxygen
Flow
Flow, Instantaneous
Hardness, Calcium and Magnesium, as CaCO3
Hardness, Carbonate, as CaCO3
Lead
Magnesium
Mercury
Nickel
Nitrogen, ammonia, as N
Nitrogen, Nitrate + Nitrite, as N
Nitrogen, Nitrate, as N
Nitrogen, total
Nitrogen, total kjeldahl nitrogen (TKN)
Nitrogen, unionized ammonia, as N
pH
Phosphorus, total, as P

Parameters provided in DMR electronic data
Potassium
Precipitation
Salinity
Silver
Sodium
Solids, total suspended, percent removal
Solids, total dissolved
Solids, total suspended
Solids, total suspended, grab (Mercury)
Specific Conductance @ 25 °C
Sulfate, as SO4
Temperature
Toxicity, Whole Effluent (Chronic)
Water Elevation
Zinc

In addition to the DMR information, the most recent permit applications were reviewed for priority pollutant screens to identify additional potential pollutants of concern. Few of the permit applications included priority pollutant screens, so data is largely limited to DMR data.

4.3 Receiving Water Classifications and Criteria

4.3.1 Water Body Classification/Designated Beneficial Uses

Waters of the state are grouped into one or more of the classes described in Minnesota Administrative Rule 7050.0140 Subparts 2 to 8 and assigned beneficial uses. Table 4-5 provides a description of each of the waterbody segment classifications evaluated during the study. Table 4-2 includes the beneficial use classification assigned to each facility's receiving water.

Table 4-5 Receiving water beneficial use classifications

Beneficial Use Class	Description
1	Domestic consumption - all waters of the state that are/may be used as a source of supply for drinking, culinary or food processing use or other domestic uses. Quality control is or may be necessary to protect the public health, safety, or welfare of the water.
1A	Domestic consumption - without treatment of any kind the raw waters will meet in all respects both the primary (maximum contaminant levels-MCLs) and secondary drinking water standards issued by the US Environmental Protection Agency (USEPA). These standards will ordinarily be restricted to underground waters with a high degree of natural protection.
1B	The quality of these waters shall be such that with approved disinfection (simple chlorination or its equivalent), the treated water will meet both the primary (MCLs) and secondary drinking water standards issued by the USEPA. These standards will ordinarily be restricted to surface and underground waters with moderately high degree of natural protection and apply to these water in the untreated state.
1C	The quality of these waters shall be such that with treatment consisting of coagulation, sedimentation, filtration, storage, and chlorination, or other equivalent treatment processes, the treated water will meet both the primary (MCLs) and secondary drinking water standards issued by the USEPA. These standards will ordinarily be restricted to surface waters, and groundwaters in aquifers not considered to afford adequate protection against contamination from surface or other sources of pollution. Such aquifers normally would include fractured and channeled limestone, unprotected impervious hard rock where water is obtained from mechanical fractures or joints with surface connections, and coarse gravels subjected to surface water infiltration. These standards shall also apply to these waters in the untreated state.
2	Aquatic life and recreation - all waters of the state that support or may support fish, other aquatic life, bathing, boating, or other recreational purposes and for which quality control is or may be necessary to protect aquatic or terrestrial life or their habitats or the public health, safety, or welfare.
2A	The quality of these waters shall be able to permit the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing for which the waters may be usable. This class of surface waters is also protected as a source of drinking water.
2Bd	The quality of these surface waters shall be able to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water.
2B	The quality of these surface waters shall be able to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water.
2C	The quality of these surface waters shall be able to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.

Beneficial Use Class	Description
2D	A. The quality of Class 2D wetlands shall be able to permit the propagation and maintenance of a healthy community of aquatic and terrestrial species indigenous to wetlands, and their habitats. Wetlands also add to the biological diversity of the landscape. These waters shall be suitable for boating and other forms of aquatic recreation for which the wetland may be usable.
3	Industrial consumption - all waters of the state that are or may be used as a source of supply for industrial processes or cooling water, or any other industrial/commercial purposes. All waters for which quality control is or may be necessary to protect the public health, safety or welfare. Additional selective limits may be imposed for any specific waters of the state as needed. No sewage, industrial waste, or other wastes from point or nonpoint sources, treated or untreated, shall be discharged into or permitted by any person to gain access to any waters of the state classified for industrial purposes so as to cause any material impairment of their use as a source of industrial water supply.
3A	The quality of these waters of the state shall be able to permit their use without chemical treatment, except softening for groundwater, for most industrial purposes, except food processing and related uses, for which a high quality of water is required.
3B	The quality of these waters of the state shall be able to permit their use for general industrial purposes, except for food processing, with only a moderate degree of treatment.
3C	The quality of these waters of the state shall be able to permit their use for industrial cooling and materials transport without a high degree of treatment being necessary to avoid severe fouling, corrosion, scaling, or other unsatisfactory conditions.
3D	The quality of these wetlands shall be able to permit their use for general industrial purposes, except for food processing, with only a moderate degree of treatment.
4	Agriculture and wildlife - all waters of the state that are or may be used for any agricultural purposes (stock watering and irrigation, or by waterfowl or other wildlife). All waters for which quality control is or may be necessary to protect terrestrial life and its habitat or the public health, safety or welfare.
4A	The quality of these waters of the state shall be able to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area, including truck garden crops.
4B	The quality of these waters of the state shall be able to permit their use by livestock and wildlife without inhibition or injurious effects.
4C	The quality of these wetlands shall be able to permit their use for irrigation and by wildlife and livestock without inhibition or injurious effects and be suitable for erosion control, groundwater recharge, low flow augmentation, stormwater retention, and stream sedimentation.
5	Aesthetic enjoyment and navigation - all waters of the state that are or may be used for any form of water transportation or navigation or fire prevention. All waters for which quality control is or may be necessary to protect the public health, safety, or welfare. The quality of Class 5 waters of the state shall be such as to be suitable for aesthetic enjoyment of scenery, to avoid any interference with navigation or damaging effects on property.

Beneficial Use Class	Description
6	Other uses and protection of border waters - other uses: all waters of the state that serve or may serve the uses of class 1 - 5 or any other beneficial uses not already listed. This includes uses in any other state, province, or nation of any waters flowing through or originating in Minnesota. The uses to be protected in Class 6 waters may be under other jurisdictions and in other areas to which the waters of the state are tributary, and may include any or all of the uses listed in parts 7050.0221 to 7050.0225, plus any other possible beneficial uses.
7	Limited resource value - surface waters of the state that have been subject to a use attainability analysis and have been found to have limited value as a water source. Water quantities in these waters are intermittent or less than one cubic foot per second at the $7Q_{10}$ flow. The quality of these waters of the state shall be able to protect aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply.

4.3.2 Water Quality Standards and Special Protections

Minnesota's Water Quality Standards are numeric and narrative criteria used in determining when surface water has become unsafe for people and wildlife. For this project, each facility's receiving waterbody was identified along with the beneficial use classifications assigned to the receiving waterbody (Table 4-5) and the current and future water quality standards by beneficial use class listed in Appendix A and Table 3-1, respectively.

Where water quality standards are not met or there are other stressors on waterbodies, special protections may apply to the waterbody in addition to water quality standards. A water of the state that fails to meet one or more water quality standards, numeric or narrative, is considered to have one or more of its designated beneficial uses impaired. The MPCA is responsible for setting pollutant-reduction goals known as a TMDL to restore the designated beneficial use of impaired waters. Minnesota has developed a list of impaired waters that require TMDL studies, and many of these waters have been evaluated and assigned a TMDL (the maximum amount of a pollutant a body of water can receive without violating water quality standards). An allocation of that amount is typically assigned to dischargers of that pollutant in the form of a wasteload allocation which is ultimately incorporated into the facility's effluent limitations.

Additionally, stressor reports were available and were reviewed for some of the receiving waters and associated watersheds included in this study. These stressor reports were evaluated for additional parameters of concern to include in estimates of current or future effluent limits.

The TALU framework developed by the MPCA is another tool that has been used to develop special protections. The TALU framework has been used to assess and (where applicable) list water bodies for biological impairments. In some instances, the TALU framework may have also been used in developing Watershed Restoration and Protection Strategies (WRAPS) studies to identify high quality water bodies in need of protection from future increases in pollutant load. Barr reviewed the current and expected TMDL requirements to determine whether additional wastewater treatment that goes above and beyond that which is required to address TALU or other TMDL requirements of the municipal permits would be necessary.

Impairments, TMDLs, and stressors associated with the receiving waters and associated watersheds are summarized in Table 4-6. This study considered these special protections in development of current and future effluent limits, regardless of a facility's existing numerical limit, monitor only requirement, or if there was no previous limit imposed for the pollutant(s) contributing to impairment(s).

Table 4-6 Receiving waters applicable impairments, TMDLs, and stressor identifications

Receiving Water	Applicable Facilities	303(d) Listed Impairments	Total Maximum Daily Load (TMDL) Restrictions	Stressor Identification (SID)
Blue Earth River	Fairmont, Butterfield, Northrop, Madelia, Lewisville	Fecal coliform; fish Index of Biotic Integrity (IBI); mercury (fish); turbidity; nutrients	Mercury; fecal coliform; turbidity	
Center Creek	Fairmont	Fecal Coliform; ammonia (un-ionized); fish IBI; turbidity	Fecal coliform	
Minnesota River	Fairmont, Starbuck, Butterfield, Hanska, Northrop, Lake Crystal, Madelia, Lewisville		Dissolved oxygen	
Outlet River	Starbuck	E. coli; fish IBI; invertebrate IBI		
Chippewa River	Starbuck, Hancock	Fecal coliform; fish IBI; mercury (fish); turbidity	Fecal coliform; turbidity; ammonia; mercury	No numeric recommendations, but found elevated TP, low DO, and NO3 to be primary stressors.
Marsh River	Ada	Dissolved Oxygen; mercury (fish); turbidity	Mercury	
Wild Rice River	Ada	Turbidity		
Lower Wild Rice River	Ada		Turbidity	
Butterfield Creek	Butterfield	E. coli; fish IBI; invertebrate IBI; turbidity		
Watonwan River	Butterfield, Madelia	E. coli; fish IBI; invertebrate IBI; turbidity	Fecal coliform; mercury	
Rabbit River	Campbell	E. coli; fish IBI, invertebrate IBI; turbidity, dissolved oxygen	Turbidity	
Bois de Sioux River	Campbell	E. coli; fish IBI; mercury (fish); nutrients, turbidity, dissolved oxygen	Mercury	No numerical recommendations, but mentions Campbell WWTP may be contributing to excess nutrients (TP)

Receiving Water	Applicable Facilities	303(d) Listed Impairments	Total Maximum Daily Load (TMDL) Restrictions	Stressor Identification (SID)
Judicial Ditch 10	Hanska	Invertebrate IBI		
Morgan Creek	Hanska	E. coli; fish IBI; invertebrate IBI		
Mustinka River	Wendell	E. coli; fish IBI; turbidity; dissolved oxygen	Turbidity	No numerical recommendations, but suggests TP and low DO are primary stressors
Sauk River	Cold Spring	Fish IBI; invertebrate IBI; PCB; mercury (fish)	Bacteria; nutrients; mercury	Indicates Sauk may be impaired for TP and DO. No numerical recommendations.
Cedar River	Austin	Invertebrate IBI; fish IBI; turbidity; mercury (fish)	Mercury, fecal coliform	No numerical limits, but suggests that WWTP is contributing to excess TP and Nitrate
Judicial Ditch 3	Northrop	Dissolved oxygen; fecal coliform	Fecal coliform	
Elm Creek	Northrop	Fecal coliform; fish IBI; turbidity	Fecal coliform	
Zumbro River	Rochester	Fecal coliform; invertebrate IBI; nutrients; turbidity	Fecal coliform; turbidity	
Shell Rock River	Albert Lea	Fecal coliform; fish IBI; invertebrate IBI; nutrients; turbidity; dissolved oxygen; pH	Fecal coliform	No numerical recommendations, but suggests Albert Lea WWTPs are causing elevated total phosphorus, nitrate, and specific conductivity
Minneopa Creek	Lake Crystal	E. coli; fish IBI; invertebrate IBI; turbidity		
Crystal Lake	Lake Crystal	Fish IBI; nutrients	Nutrients	
Spring Branch Creek	Lewisville	E. coli; fish IBI		
Perch Creek	Lewisville	E. coli; fish IBI		
Red River of the North	Halstad	Mercury (fish); PCB (fish); turbidity		

Receiving Water	Applicable Facilities	303(d) Listed Impairments	Total Maximum Daily Load (TMDL) Restrictions	Stressor Identification (SID)
South Fork Crow River	Watertown	Chloride; fish IBI; invertebrate ibi; mercury (fish); nutrients; turbidity	Mercury (fish)	
South Fork Crow River Lakes	Watertown		Nutrients	
Buffalo River	Hawley	E. coli; turbidity	Total suspended solids (TSS); E. coli	No numerical recommendations, but indicates Low DO and Turbidity likely causes of IBI impairment
Downstream Mine Ponds	Serpent Lake	Mercury (fish)	Mercury (fish)	
Mississippi River	Serpent Lake, Grand Rapids	Mercury (fish); TSS	Mercury	
East Swan Lake	Hibbing	E. coli; invertebrate IBI		
East Swan River	Hibbing	Turbidity		
O'Brien Lake	Mercury (fish)	Mercury (fish)		
Swan Lake	Mercury (fish)	Mercury		
Swan River	Mercury (fish)	Mercury (fish)		
Little Fork River	Cook	Mercury (fish); turbidity	TSS; mercury	
Ely Creek	Gilbert	Fish IBI		
St. Louis River	Gilbert	Mercury (fish)		

4.4 Receiving Water Characteristics

4.4.1 Water Quality Data

Water quality data for the receiving waters associated with each facility was summarized and used to calculate current and proposed ammonia aquatic life criteria, based on pH and temperature in the receiving stream. Receiving stream water quality data was also used to establish background concentrations for specific parameters for facilities allowed to account for dilution.

The MPCA's Environmental Data Access (EDA) surface water search map and text-based tools were used to collect applicable receiving water data and watershed data. The data used in the study from the EDA surface water search tools represents data available as of September 1, 2016. The entire monitoring history for the stations in the receiving water nearest the discharge point was downloaded from the database. The datasets were evaluated as described in Figure 4-2. For some facilities, a combination of upstream, downstream, and/or watershed data was summarized to complete current and future effluent limit calculations. Table 4-7 summarizes what receiving stream background data was available and therefore applied for the RPE and WQBEL calculations.

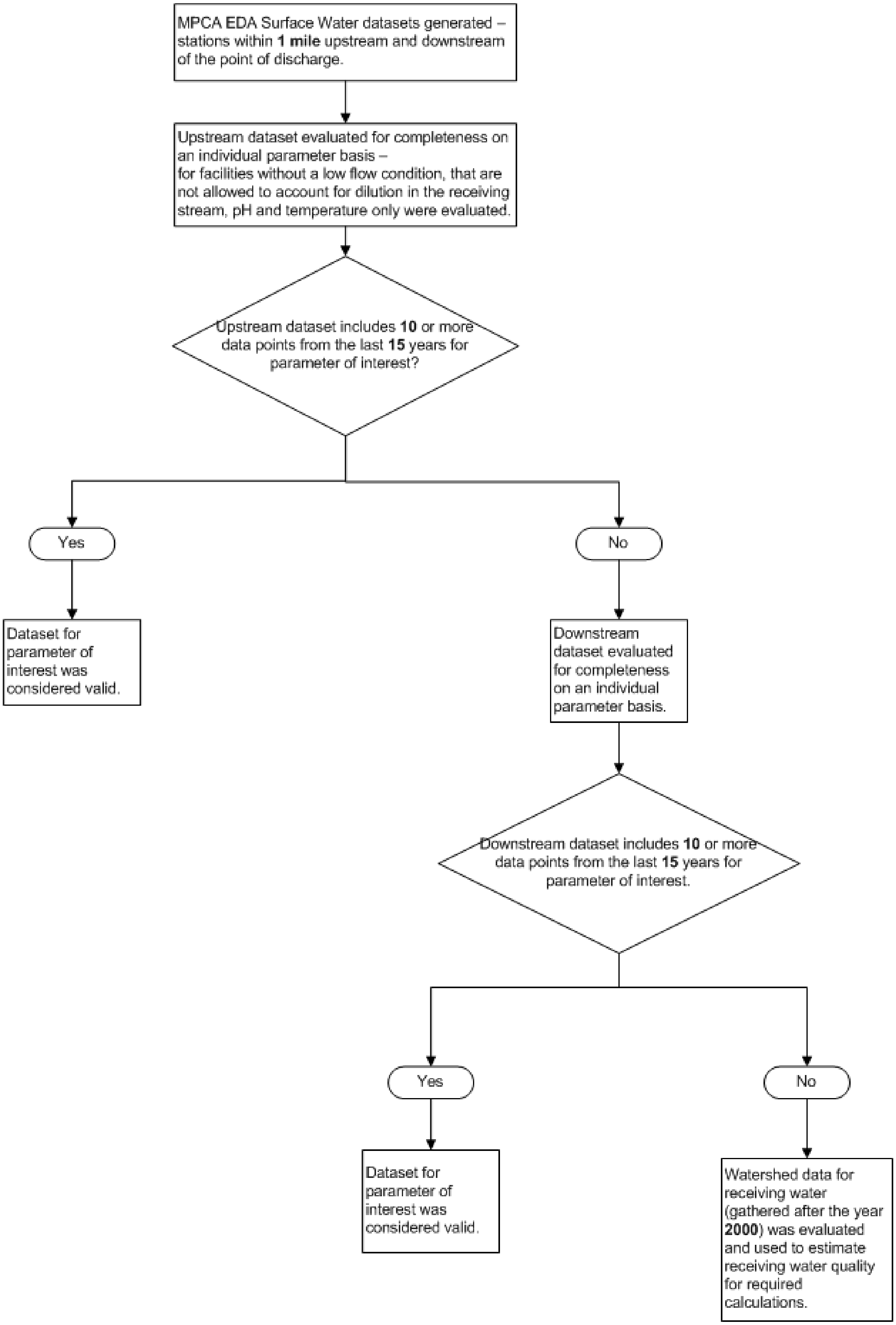


Figure 4-2 Receiving water data evaluation process

Table 4-7 Summary of Key Data Used for all RPE and WQBEL Calculations

Facilities	Receiving Stream Background Levels	DMR Dataset Number of Data Points
Ada	Watershed Stem	0-10
Albert Lea	Receiving Water	20+
Austin	Receiving Water	20+
Butterfield	Mixed	10-20
Campbell	Receiving Water	0-10
Cold Spring	Receiving Water	20+
Cook	Mixed	0-10
Fairmont	Watershed Stem	20+
Gilbert	Watershed Stem	10-20
Grand Rapids	Receiving Water	10-20
Halstad	Receiving Water	0-10
Hancock	Watershed Stem	10-20
Hanska	Not Applicable	10-20
Hawley	Mixed	10-20
Hibbing	Mixed	20+
Lake Crystal	Receiving Water	10-20
Lewisville	Mixed	10-20
Madelia	Mixed	20+
Nashwauk	Mixed	0-10
Northrop	Mixed	0-10
Rochester	Receiving Water	20+
Serpent Lake	Mixed	0-10
Starbuck	Mixed	20+
Watertown	Receiving Water	20+
Wendell	Receiving Water	0-10

(1) The background level category is "conservative" - i.e., if source is mixed, the least localized category was chosen

4.4.2 Critical Low Flow Evaluation

The critical low flow condition in receiving waters was used to calculate downstream concentrations and WLAs for facilities where the MPCA allows calculations to account for dilution in the receiving stream. The critical low flow is the flow of water in a stream during prolonged dry weather, according to the World Meteorological Organization (reference (5)). The 7Q10 is the lowest 7-day average flow that occurs on average one time every 10 years. The MPCA calculates and uses the 7Q10 flow statistic for the purpose of setting most permit discharge limits in Minnesota per Minnesota Rules, part 7053.0205, subpart 7, item A. The 30Q10 flow is used for determining ammonia discharge limits per Minnesota Rules, part 7053.0205, subpart 7, item B.

At Barr's request, the MPCA provided the critical low flow conditions for the receiving waters of interest to the study, summarized in Table 4-8 and Table 4-9 for the 7Q10 and 30Q10 flows respectively. "NA" (not available) indicates that MPCA has not yet calculated a critical low flow condition for a specific facility's receiving water for the designated season and has only calculated an annual low flow or that only seasonal low flows have been calculated and not an annual low flow. Zero indicates that a critical low flow condition was found to be zero, and no dilution can be accounted for in the facility's discharge to the specified receiving water. Facilities with no calculated low flow values were not included in Table 4-8. For these facilities, no dilution was accounted for when calculating projected downstream concentrations in this study. The facilities with no calculated low flow values discharge to smaller streams rather than large rivers, and therefore a low flow condition of zero is a reasonable assumption.

Table 4-8 Receiving waters low flow values provided by MPCA (7Q10 Flow in cubic feet per second)

	Annual	Summer	Fall	Winter	Spring
Albert Lea	1.3				
Austin	15.3				
Cold Spring	12.9	15.2	17.8	14.7	47.9
Fairmont	0.03	0.05	0.16	0.04	1.62
Halstad	72.621				
Hawley	8	8.65	12.65	10.33	27.94
Madelia	3.5	4.92	6.18	3.75	27.55
Rochester 2008	17.494	21.049	25.531	19.226	45.348
Rochester 2013	18	21.4	26.4	19.8	45.7
Starbuck	0.8	2.23	2.55	0.82	9.92
Watertown	0.0	0.3	0.69	0.0	10.3
Cook	0.36	0.52	1.21	0.46	2.36
Grand Rapids	115	138.7	375.3	289.5	161
Hibbing South	0.46	0.65	0.91	0.47	1.21

Note: Facilities with no calculated flow or with no dilution not included

Table 4-9 Receiving waters low flow values provided by MPCA (30Q10 Flow in cubic feet per second)

	Annual	Summer	Fall	Winter	Spring
Albert Lea		4.89	6.76	1.66	30.6
Austin		36.968	43.2	35.2	76.1
Cold Spring	16.6	22.9	23.3	17.8	81.8
Fairmont	0.05	0.1	0.28	0.07	3.45
Halstad	99.053				
Hawley					
Madelia	4.54	7.3	8.52	4.49	44.21
Rochester 2008		24.999	29.145	21.221	65.783
Rochester 2013		25.26	30.13	21.91	66.12
Starbuck					
Watertown		0.62	2.07	0.04	27.73
Cook	0.43	0.73	2.11	0.5	29.76
Grand Rapids	175.46	227.8	486.6	438.9	275.1
Hibbing South		0.79	1.1	0.51	2.89

Note: Facilities with no calculated flow or with no dilution not included

4.5 Reasonable Potential to Exceed Evaluation

Clean Water Act regulations require the state of Minnesota to evaluate discharges for pollutants to determine if RPE water quality standards exists. This is accomplished through a Reasonable Potential to Exceed (RPE) evaluation performed in accordance with 40 CFR 122.44(d)(1). The ultimate purpose of an RPE evaluation is to determine if the projected downstream concentration of a pollutant will exceed the applicable water quality standards. This also includes comparing the maximum recorded effluent concentration to the Final Acute Value (FAV). Discharge data available from the DMRs provided by MPCA sometimes included monthly average values. When the monthly average values were used, RPE may be underestimated. If reasonable potential exists, a WQBEL, must be developed and implemented.

For this study, Barr conducted an RPE for each parameter of concern for each facility. The following subsections outline the variables used for the RPE, describe the general methodology for the calculations, and identify any facility-specific deviations from the general methodology.

4.5.1 Calculation Variables

4.5.1.1 Mixing Zone

Minnesota Administrative Rules state that the allowable mixing zone for use in the RPE shall not exceed 25 percent of the cross-sectional area and/or volume of flow of the stream (Minnesota Rules, part

7050.0210, subpart 5, item B). For the RPE calculations, 25 percent of the low flow of the receiving stream was used for the chronic mixing zone, i.e. dilution ("Qs chronic"). All parameters, with the exception of ammonia, were analyzed with a mixing zone based on the 7Q10 low flow. The 30Q10 low flow, which is the lowest thirty-day average flow that occurs once every ten years, is used for ammonia per Minnesota Rules, part 7053.0205, subpart 7, item B.

The 7Q10 and 30Q10 values for receiving waters were obtained from existing permit fact sheets or were provided by MPCA. These values have been summarized in Table 4-8 and Table 4-9. They are assumed to be accurate but have not been verified or independently calculated as part of the effluent limit calculations.

4.5.1.2 Zone of Initial Dilution (ZID)

Minnesota addresses acute toxicity through use of an FAV, which is a concentration based on acute toxicity testing that is not to be exceeded at any point in the mixing zone. As such, the Minnesota Administrative Rules do not have allowances for use of a zone of initial dilution (ZID) within the mixing zone. For the purposes of the RPE calculation, the ZID ("Qs acute") was shown in the calculations, but was set equal to zero.

4.5.1.3 Receiving Stream Concentrations

Receiving stream concentrations used in the RPE calculations are based upon the best available data for the receiving stream or a comparable waterbody in the same watershed. More detail on the receiving stream water quality data can be found in Section 4.4.1. Average values for receiving streams were calculated from this data set and used as the receiving stream concentrations.

4.5.1.4 Facility-Specific Values

Facility-specific data used in the RPE calculations includes DMR data, which have been summarized in Table 4-2. In addition, facility effluent flow and the projected effluent quality (PEQ) multiplier are used in the RPE. The ADW flow was used for the facility effluent flow. In instances where the ADW flow was not available, the average wet weather (AWW) design flow was multiplied by the average ratio of average annual monthly flow and minimum monthly flow. This methodology was per MPCA's October 2011 guidance "Average Dry Weather Design Flow Determinations for Existing Permits" (reference (6). Where not enough data was available to perform the ADW calculation, the AWW flow was multiplied by 0.8 to estimate ADW flow. The permit ADW and AWW flows were obtained from the NPDES permits listed in Table 4-2.

The PEQ multiplier is used in calculating the projected effluent concentrations. It was calculated assuming a lognormal distribution of facility effluent data using the calculation method outlined in Appendix E of reference (7) (EPA Technical Support Document [TSD]). For parameters where fewer than 10 effluent data points were available, the dataset was evaluated, and in most cases, a default PEQ multiplier was assigned using Table 3-2 – Reasonable Potential Multiplying Factors 95% Confidence Level of reference (7) (TSD) and a default coefficient of variation of 0.6.

4.5.2 RPE Evaluation Methodology

The RPE evaluation can be divided into two basic tasks: calculating the projected downstream concentration and comparing the calculated concentration to applicable water quality standard for the receiving water. This methodology is mathematically equivalent to the MPCA methodology where a projected effluent limit is calculated and compared to the effluent. To calculate the projected downstream concentration, a projected effluent concentration is determined by multiplying the maximum recorded effluent concentration from the DMRs by the PEQ multiplier, which provides for a factor of safety. The projected effluent concentration is then used in a mass balance equation.

$$Projected\ Downstream\ Concentration\ (C_d) = \frac{(C_s * Q_s) + (C_e * Q_e)}{Q_s + Q_e}$$

Where C_s is the pollutant concentration in the receiving stream (Section 4.4), C_e is the projected effluent concentration, Q_s is the mixing zone (low flow stream flow), as described in Section 4.5.1.1, or the ZID, as described in Section 4.5.1.2, and Q_e is the effluent flow. The calculation is performed for both chronic (at the edge of the mixing zone) and acute (at the point of discharge) conditions. For the chronic calculation, the mixing zone is stated as Q_s, while the ZID is stated as Q_s in the acute calculation.

The acute and chronic projected downstream concentrations are then compared to the applicable water quality standard. It was determined that reasonable potential existed (effluent limit needed) if one of the following conditions were met:

- The chronic downstream concentration (Cd_c) exceeds the chronic water quality standard (Cwq_c). It is noted that for ammonia, seasonal pH and temperature data were used to calculate the appropriate standard.
- The chronic downstream concentration (Cd_c) exceeds applicable Class 3/4 standard (Cwq_3).
- The acute downstream concentration (Cd_a) exceeds the acute aquatic life standard (Cwq_a).
- The maximum recorded DMR concentration exceeds the FAV.

4.5.3 Results/Facility-Specific Notes

For a limited number of facilities, insufficient data was available to perform an RPE calculation for some parameters of concern; those facilities and parameters are summarized in Table 4-10. Additionally, Halstad and Northrop had DMR data sets that spanned less than five years, which is the typical data set that MPCA reviews in determining effluent limits. In those instances, no RPE analysis was completed, and no numeric effluent limitation was calculated.

Table 4-10 Summary of facilities with insufficient data to perform an RPE

Facility	Parameter
Austin	Ammonia
Campbell	Ammonia, Nitrate
Northrup	All parameters
Wendell	Ammonia, Nitrate

4.6 Water Quality Based Effluent Limit (WQBEL) Development

Pollutants found to have reasonable potential to cause or contribute to an exceedance of a water quality standard must have effluent limits (Water Quality-based Effluent Limit, WQBEL) included in their permits in accordance with 40 CFR 122.44(d)(1)(iii). This section outlines the methods used to calculate WQBELs for pollutants found to have reasonable potential and also outlines any facility-specific notes or exceptions to the methodology.

Effluent limits for pollutants where no tabulated DMR data was available were not calculated in this study.

4.6.1 WQBEL Methodology

The first step of the calculation of a WQBEL is determining the chronic and acute WLAs for Class 2 standards. For sulfate, which is a Class 4 criterion, a WLA calculation was also performed for those standards. Note that for Class 3 or 4 WLA calculations, chronic conditions only were assumed since the protected uses associated with Class 3 and 4 are not based on acute aquatic toxicity. The WLA is the available portion of the receiving water's load proportioned to point sources to meet WQS. The following equation was used to calculate the WLAs for specific facilities:

$$Waste\ Load\ Allocation\ (WLA) = \frac{\left((Q_e + Q_s) * Cwq\right) - (Q_s * C_s)}{Q_e}$$

Where Q_e is the effluent flow, Q_s is the mixing zone or the ZID (not included in Minnesota's water quality standards), *Cwq* is the applicable standard (acute aquatic life standard, chronic aquatic life standard, or Class 3/4 standard), and C_s is the pollutant concentration in the receiving stream (Section 4.4.1). For the chronic WLA and the Class 3/4 WLA, the mixing zone is used for Q_s. The ZID is used for Q_s in the acute WLA calculation. For parameters with an applicable FAV, the acute WLA was set equal to the FAV. It should also be noted that in instances where the receiving stream concentration upstream from the facility already exceeds the water quality standard, the WLA is equal to the WQS.

The long term average (LTA) concentration refers to the average performance level the facility is capable of achieving, accounting for expected variability in the discharge. Using the calculated WLAs, the LTA is calculated by multiplying the WLA by the corresponding LTA multiplier. The LTA multiplier for acute, chronic, and Class 3/4 is calculated as follows:

$$LTA\ Multiplier = e^{0.5\sigma^2 - z\sigma}, where$$

$$\sigma = \ln(CV^2 + 1)$$

In the above equation, CV is the coefficient of variation of the natural log of facility effluent data. For parameters where fewer than 10 effluent data points were available, the dataset was evaluated, and in most cases, a default CV of 0.6 was assigned as described in Section 3.3.2 of reference (6) (TSD). The variable z represents the Z-score for the appropriate percentile, which is a statistical representation of the number of standard deviations between the mean and the specified upper percentile.

Finally, the maximum daily limit (MDL) and AML can be calculated by multiplying the LTA by the MDL or AML multiplier. MDL and AML calculations were performed separately for "Class 2," which are the standards for protection of aquatic life and recreation (acute and chronic) and Class 3/4 standards. The Class 2 MDL and AML is calculated by multiplying the lowest of the acute or chronic LTA by the MDL or AML multiplier. The Class 3/4 MDL and AML is calculated by multiplying the Class 3/4 LTA by the MDL or AML multiplier.

Note, the scope of this project was focused on Class 2 standards; however, for permit calculations performed by MPCA, the AML and MDL would be calculated using the lowest of the LTAs for any of the applicable standards, rather than just Class 2.

4.6.2 Facility-Specific Notes

WQBEL calculations were not performed for any technology-based effluent limits (TBELs), which include CBOD, fecal coliform (FC), pH, and TSS. TBELs are developed independently of the potential impact of a discharge on a receiving water and are derived from secondary treatment regulations. Because there were no revisions to the secondary treatment standards, it was assumed that TBELs did not change.

A WQBEL was calculated for phosphorus at Rochester. The goal of this calculation was to get a picture of what a phosphorus limit may look like for the facility, although there is currently no phosphorus memo available for the watershed. The calculation was performed assuming a RES of 0.1 mg/L. Phosphorus effluent limits were also estimated for the other facilities that did not have MPCA watershed phosphorus memos including: Cook, Gilbert, Grand Rapids, Hibbing, and Nashwauk

In addition to facilities with existing effluent limits or monitoring requirements, sulfate WQBELs were also calculated for facilities that discharge to a wild rice waters or to waters that are upstream of wild rice waters.

4.6.3 Sulfate WQBEL Methodology

For sulfate, a similar WQBEL calculation method was followed as described in Section 4.6.1. However, the sulfate standard only applies for wild rice waters. MPCA's draft list of wild rice waters updated on July 17, 2016, was used to assess the potential for the facilities' discharges to impact these identified waters (reference (8)). The wild rice sulfate standard was applied to discharges within 50 miles upstream of these waters. The RPE and WQBEL was calculated using the downstream water concentration for sulfate. If an

RPE was found for sulfate, then it was confirmed that the receiving water at or near the wild rice location would likely exceed the sulfate standard as well.

4.6.4 Total Suspended Solids (TSS) Methodology

WQSs for TSS were updated in 2014 to replace the existing turbidity standards but did not make a significant impact in this study. TSS standards were promulgated by river nutrient region and by specific sites. All facilities in this study have existing TSS permit limits based on the secondary treatment standards. Most of the facilities have TSS permit limits that are at least as restrictive as the newly promulgated TSS WQS. The newly promulgated TSS WQS would be more restrictive for six facilities in this study, which fall within the North River Nutrient Region which has a TSS water quality standard of 15 mg/L. However, Minnesota Rule, part 7053.0205, subpart 9a establishes that a WQBEL be established considering the nonvolatile suspended solids (NVSS) in the effluent. MPCA's internal memorandum on compatibility of existing TBELs with new TSS water quality standards provides guidance that was used to calculate the RPE when considering the NVSS content of the effluent (reference (9)). MPCA's memorandum uses existing data to provide estimates for the fraction of TSS that is NVSS for different water treatment technologies. As shown in the next section, the recently adopted WQS for TSS did not result in more stringent effluent limits, even in the north river region where the WQS for TSS is the lowest, due in part to the accounting for the portion of the TSS that is NVSS.

4.6.5 Estimated Effluent Limits

Barr followed the RPE and WQBEL methods described in the TSD to estimate RPE and calculate WQBELs for each facility, which are essentially the same procedures that are followed by the MPCA. Even though Barr's best efforts were made to accurately estimate effluent limits for each facility, the scope of this study, however, did not allow the detailed site-specific considerations that MPCA may consider in setting limits. Limited time and budget required estimates of effluent limits for a large number of facilities to be completed from available and accessible data. Effluent limits estimated for this study are meant to be used to assess typical impacts of water quality regulations to cities across the state. Therefore, while an effluent limit in a future permit for a specific facility determined by MPCA may differ from the value estimated in this study, the general outcome is applicable for assessing statewide impacts.

Tables summarizing the existing, estimated current and estimated future effluent limits for each City can be found in Appendix B. These estimated effluent limits were used below as a basis for assessing the cost impacts to the Cities. Figure 1-2 shows how many cities would get new or more stringent effluent limits for each of the pollutants in this study. Many cities would get new or more stringent effluent limits for several pollutants. New and more stringent effluent limits for ammonia and nitrate are most prevalent, as shown in Figure 1-2. Finally, Table 4-11 presents a full summary of the effluent limit changes to each City by key WQS. Of note are the number of facilities that show new effluent limits where the water quality standard has not changed (i.e. chloride). Monitoring requirements in recent permits resulted in more data available to estimate those limits for this study. Figure 4-4 to Figure 4-8 present maps showing which Cities had new effluent limits as part of this study for chloride, phosphorus, nitrate, ammonia, and sulfate.

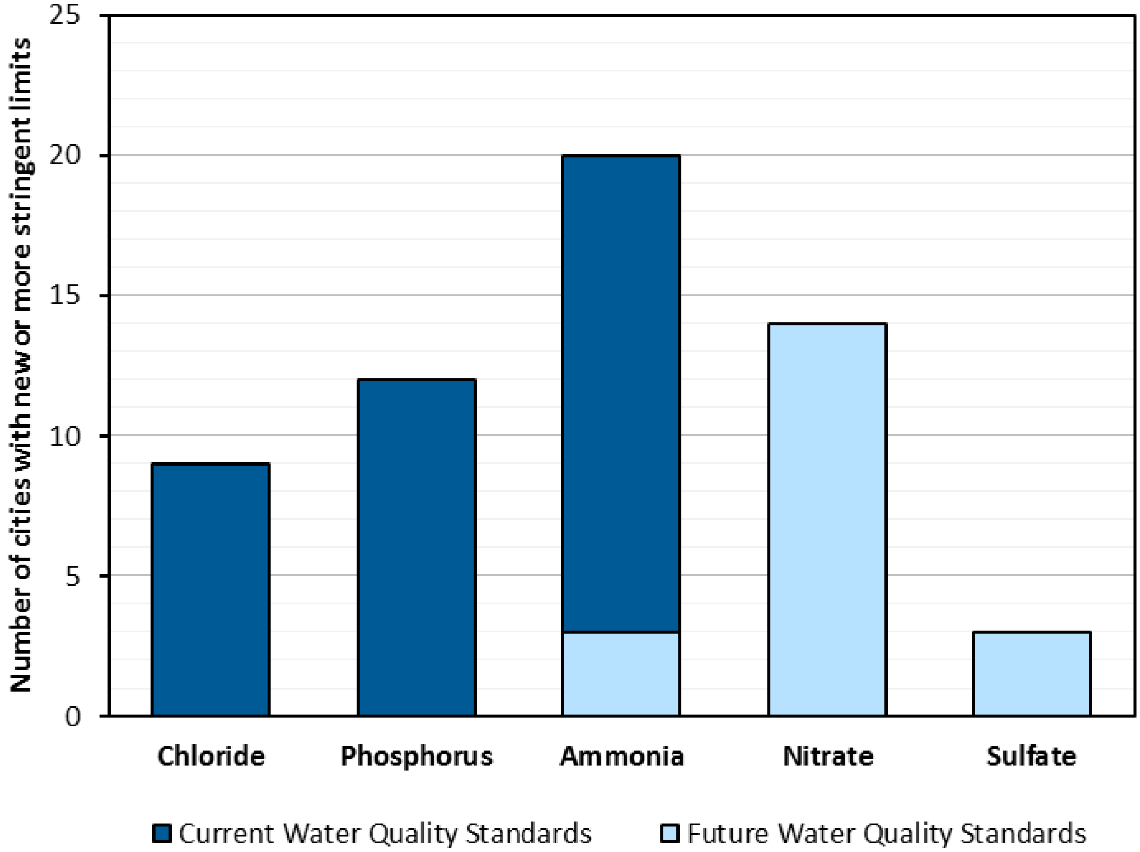


Figure 4-3 Number of cities with new or more stringent effluent limits to meet current and future water quality standards

Table 4-11 Summary of effluent limit changes

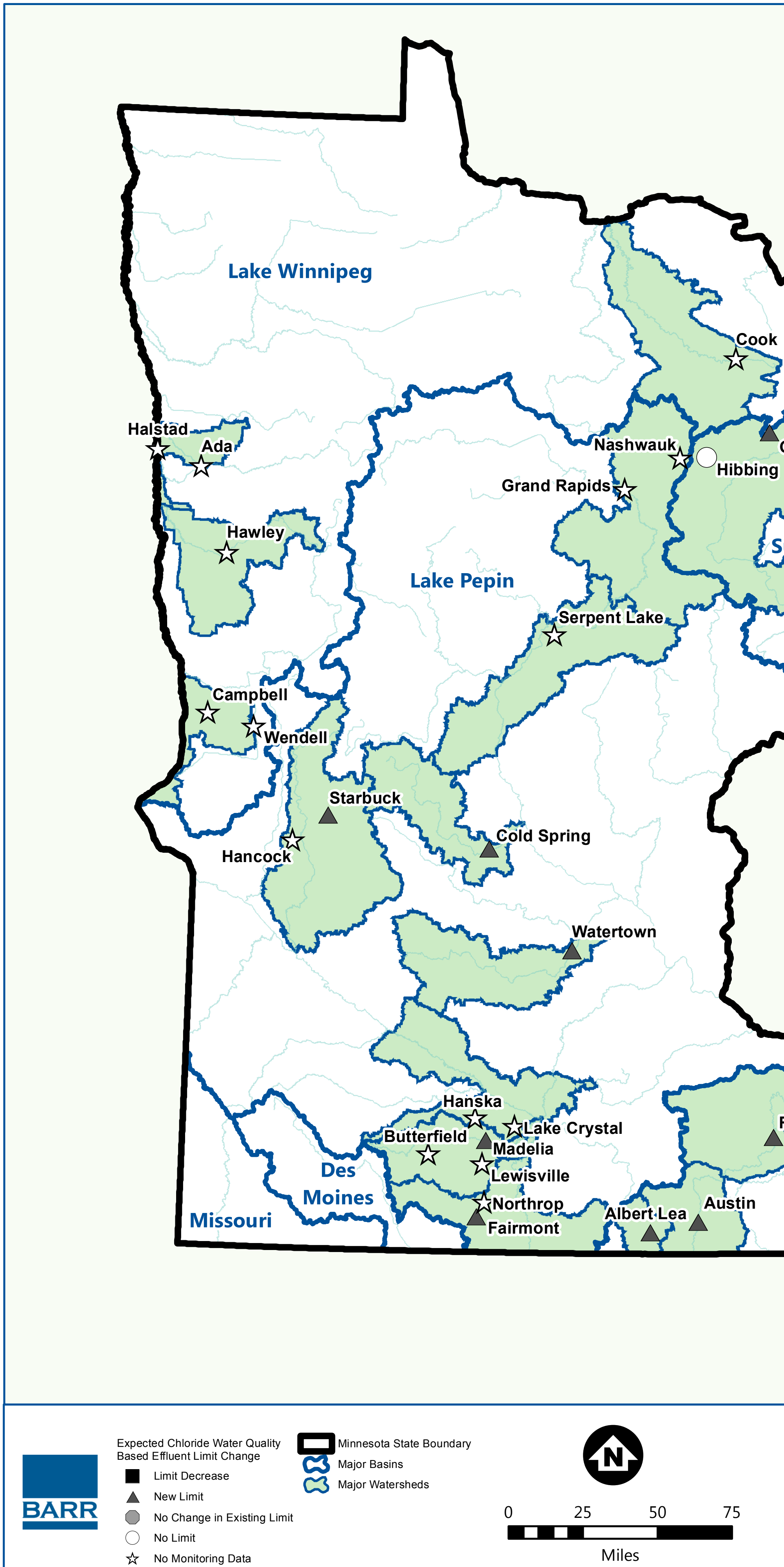
Facilities	Ammonia[1]	Chloride[2]	Nitrate[3]	Phosphorus[2]	Sulfate[3]
Ada	New Limit	No Monitoring Data	No Limit	No Limit	No Limit
Albert Lea	Limit Decrease	New Limit	New Limit	New Limit	No Limit
Austin	Limit Decrease	New Limit	New Limit	New Limit	No Limit
Butterfield	New Limit	No Monitoring Data	New Limit	New Limit	No Limit
Campbell	New Limit	No Monitoring Data	New Limit	New Limit	No Limit
Cold Spring	Limit Decrease	New Limit	New Limit	Limit Decrease	New Limit
Cook	No Limit	No Monitoring Data	No Limit	No Limit	No Limit
Fairmont	Limit Decrease	New Limit	New Limit	Limit Decrease	No Limit
Gilbert	New Limit	New Limit	New Limit	No Change in Limit	New Limit
Grand Rapids	Limit Decrease	No Monitoring Data	No Limit	No Limit	No Limit
Halstad	No Limit	No Monitoring Data	No Limit	No Limit	No Limit
Hancock	New Limit	No Monitoring Data	New Limit	New Limit	No Limit
Hanska	No Monitoring Data	No Monitoring Data	No Monitoring Data	No Change in Limit	No Limit
Hawley	New Limit	No Monitoring Data	No Limit	New Limit	No Limit
Hibbing	Limit Decrease	No Limit	New Limit	No Change in Limit	New Limit
Lake Crystal	New Limit	No Monitoring Data	No Limit	No Change in Limit	No Limit
Lewisville	No Monitoring Data	No Monitoring Data	No Monitoring Data	No Change in Limit	No Limit
Madelia	Limit Decrease	New Limit	New Limit	New Limit	No Limit
Nashwauk	New Limit	No Monitoring Data	No Monitoring Data	No Change in Limit	No Limit
Northrop	No Monitoring Data	No Monitoring Data	No Monitoring Data	No Change in Limit	No Limit
Rochester	Limit Decrease	New Limit	New Limit	Limit Decrease	No Limit
Serpent Lake	New Limit	No Monitoring Data	No Limit	No Change in Limit	No Limit
Starbuck	New Limit	New Limit	New Limit	Limit Decrease	No Limit
Watertown	Limit Decrease	New Limit	New Limit	New Limit	No Limit
Wendell	New Limit	No Monitoring Data	New Limit	No Change in Limit	No Limit

Note: Color coding in this table is a visual representation of the information contained in the table. The colors do not represent any new or additional analysis

[1] Comparison of existing limits to limits calculated based on current and future standards

[2] Comparison of existing limits to limits calculated based on current standards

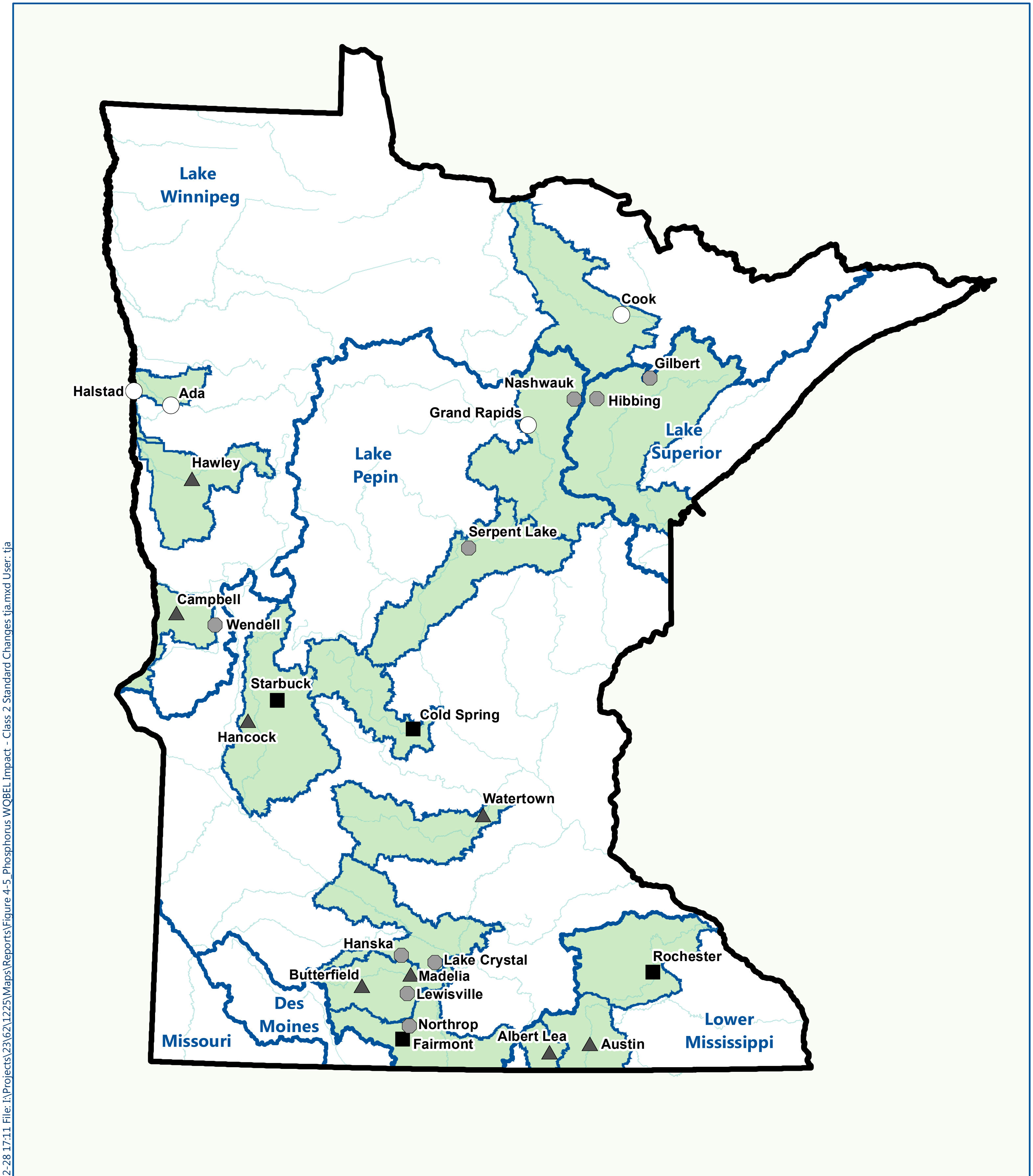
[3] Comparison of existing limits to limits calculated based on future standards



BARR

CHLORIDE EFFLUENT LIMITS TO MEET CURRENT AND FUTURE WATER QUALITY STANDARDS
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 4-4



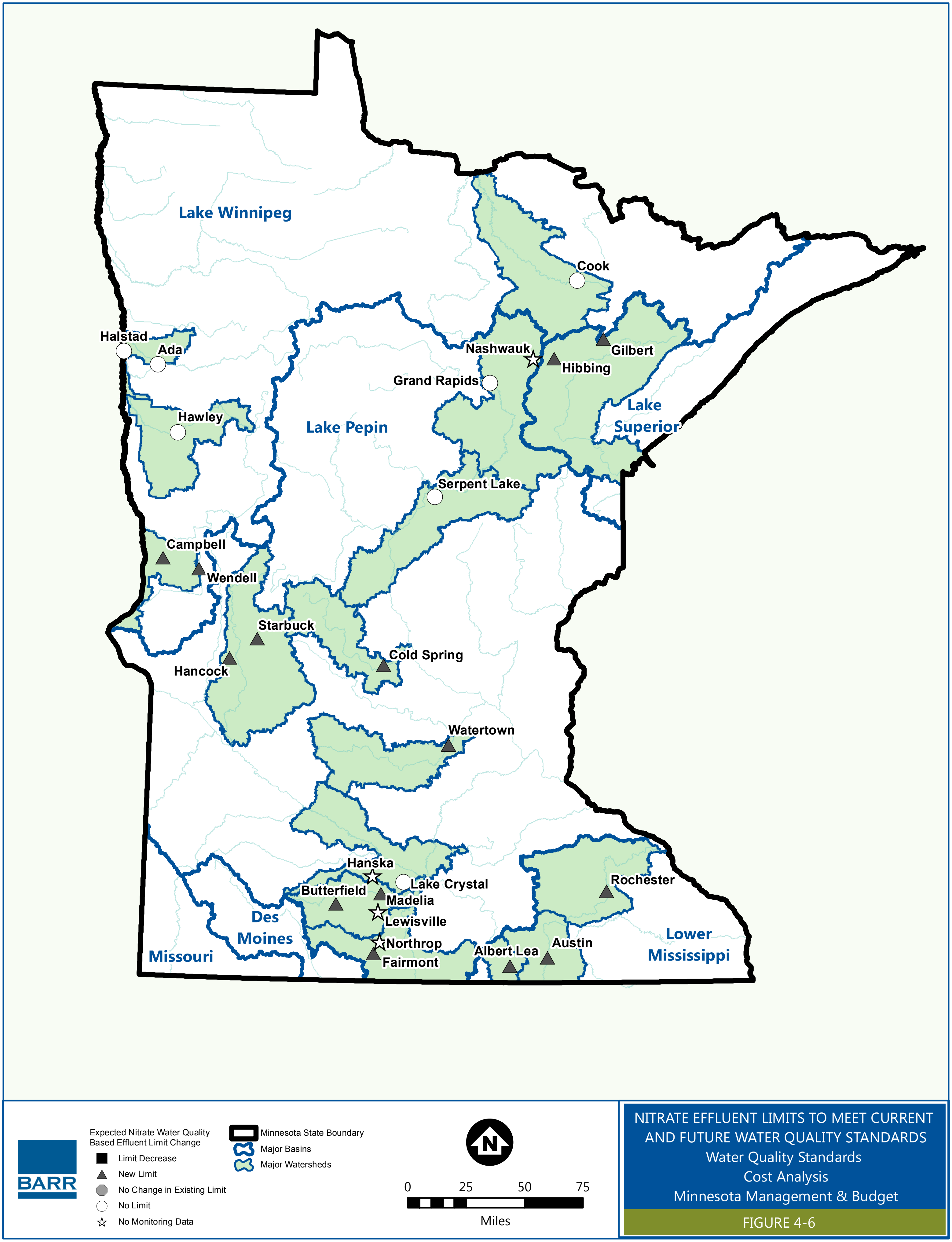
Expected Phosphorus Water Quality Based Effluent Limit Change
- Limit Decrease
- New Limit
- No Change in Existing Limit
- No Limit
- No Monitoring Data

- Minnesota State Boundary
- Major Basins
- Major Watersheds

BARR

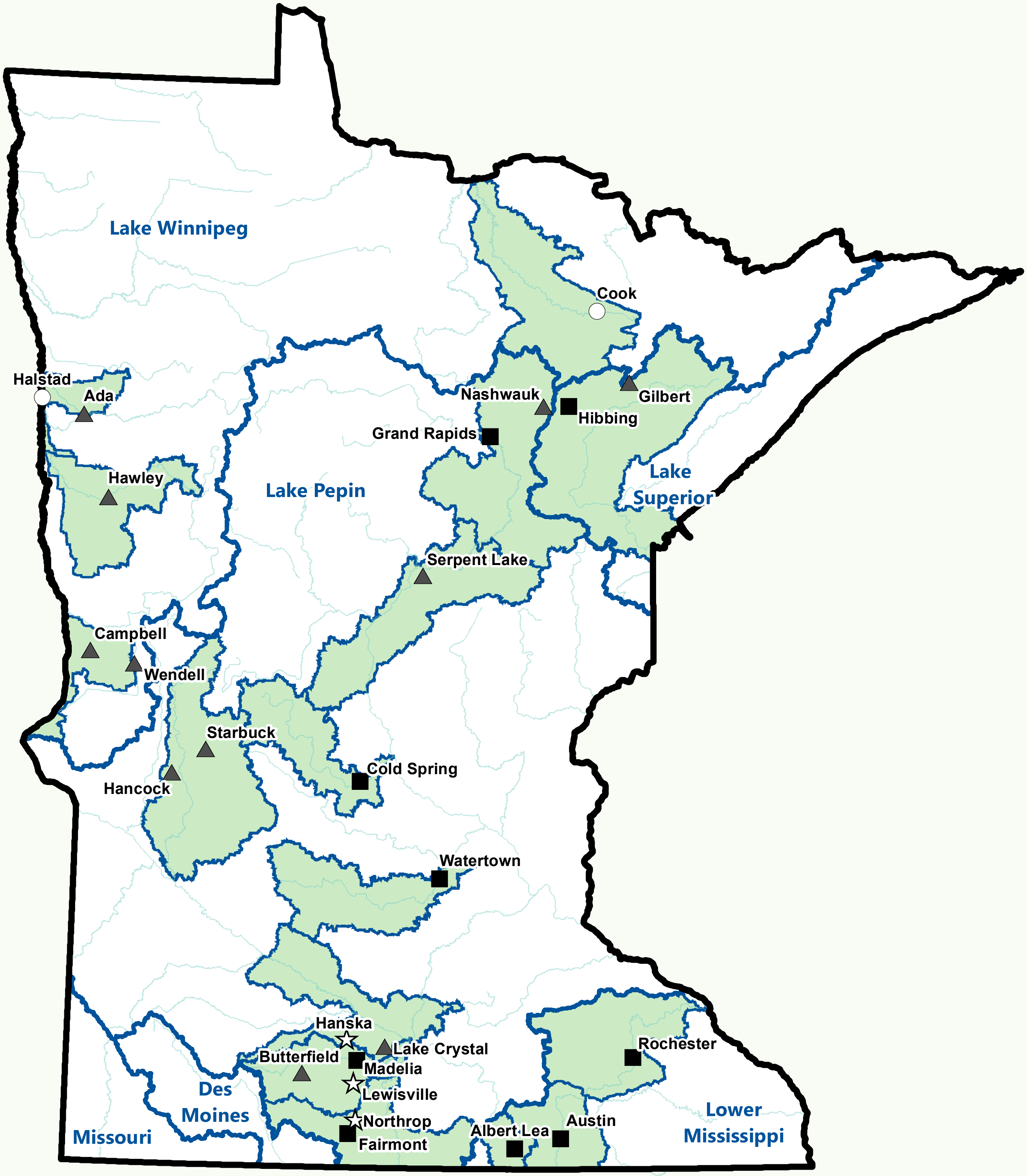
PHOSPHORUS EFFLUENT LIMITS TO MEET CURRENT AND FUTURE WATER QUALITY STANDARDS
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 4-5



NITRATE EFFLUENT LIMITS TO MEET CURRENT AND FUTURE WATER QUALITY STANDARDS
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 4-6



Expected Ammonia Water Quality Based Effluent Limit Change
- Limit Decrease
- New Limit
- No Change in Existing Limit
- No Limit
- No Monitoring Data

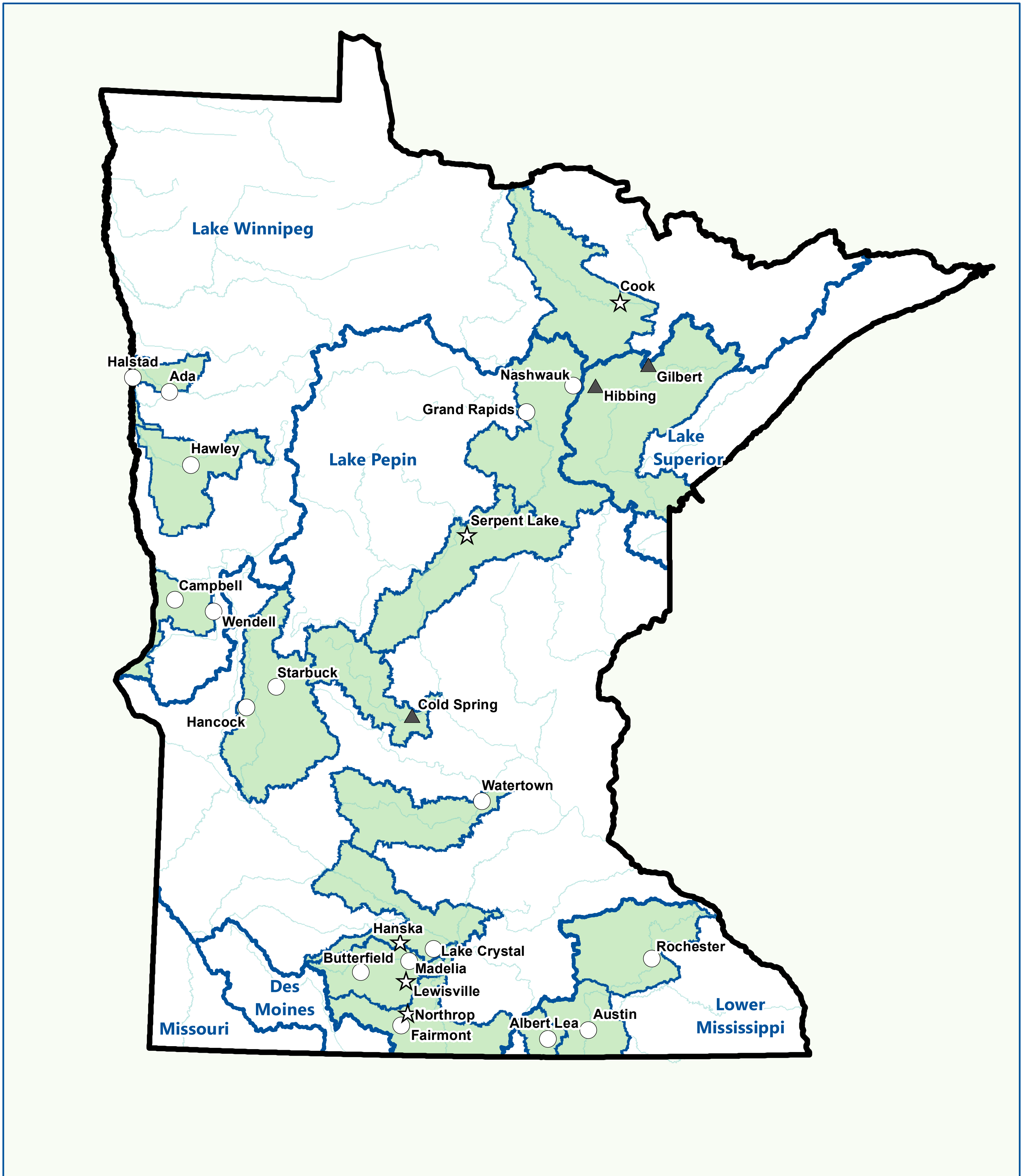
Minnesota State Boundary
Major Basins
Major Watersheds

0 25 50 75
Miles

BARR

AMMONIA EFFLUENT LIMITS TO MEET CURRENT AND FUTURE WATER QUALITY STANDARDS
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 4-7



Expected Sulfate Water Quality Based Effluent Limit Change

- ■ Limit Decrease
- ▲ New Limit
- ⬢ No Change in Existing Limit
- ○ No Limit
- ☆ No Monitoring Data

Minnesota State Boundary

Major Basins

Major Watersheds

N

0 25 50 75

Miles

BARR

SULFATE EFFLUENT LIMITS TO MEET CURRENT AND FUTURE WATER QUALITY STANDARDS

Water Quality Standards

Cost Analysis

Minnesota Management & Budget

FIGURE 4-8

4.7 Antidegradation Impact

Minnesota's revised antidegradation rule became effective on November 21, 2016. The new rule triggers an antidegradation evaluation to assess whether a proposed project will minimize impacts to water quality even if the project would not exceed WQS. The antidegradation evaluation is triggered by a "net increase in loading or other causes of degradation" to surface waters. For the 25 municipal wastewater treatment plants evaluated in this study, antidegradation evaluation would be triggered if its next or subsequent permits would require an increase in the maximum mass of pollutants allowed by the prior permit. A net increase in loading means an increase in the permitted loading and not an increase in actual loading currently discharged. If triggered, an antidegradation evaluation and the other rule requirements could result in a city implementing a project to reduce the loading beyond merely meeting the WQBEL derived from WQSs.

As part of this study, the impact of the new antidegradation rule was assessed for each City. First, the applicability of the antidegradation rule had to be determined. Then, if the rule applied, the possible impact was assessed. In order to assess whether a net increase in loading was likely, the recent population growth of the city was compared between 2000 and 2015 using the Minnesota State Demographer Office's 2015 report. Of the Cities evaluated, only Austin, Grand Rapids, Rochester, and Watertown had growth of more than 6% between 2000 and 2015 indicating that the majority of the Cities were experiencing flat or decreasing growth.

Each of the Cities that had recent population growth between 2000 and 2015 above 6% were assessed for the potential to have a net increase in permitted loading over the study period. Austin has a relatively low population growth of 8%. Its actual monthly average discharge flow rates exceeded the AWW design flow of 8.64 mgd several times in the past 5 years. However, a significant percentage of the flow during the peak events appears to be from inflow and infiltration. The capacity of the plant due to population is not expected to reach the 30,000 person capacity in the current facility plan, and therefore would not have a net increase in loading. In assessing Grand Rapids' potential to have a net increase in loading, recent flow data in the past five years was compared to the AWW design flow of 15.2 mgd. The maximum flow was 6.7 mgd. The projected population increase at the current growth of 3% per year does not appear to cause an increase in load unless significant industrial development occurs, and therefore, would not have a net increase in loading. Similarly, for Watertown, the current facility plan includes the capacity for the next plant upgrade which accounts for projected population growth. The AWW design flow is proposed to remain the same for that upgrade and without significant industrial growth would not have a net increase in loading.

Rochester is the only City that has growth rates that could potentially trigger a net increase in loading based on population. However, the most recent permit planned for a WWTP expansion that resulted in an AWW design flow of 23.85 mgd and that NPDES permit addressed antidegradation for the increase in AWW design flow from 19.1 mgd to 23.85 mgd. Because the current AWW design flow of 23.85 mgd and its associated loading is the trigger for future antidegradation evaluations, it was assumed that the anticipated population growth would not have a net increase in loading.

While significant industrial growth in any city might cause unpredictable increases in loading, the recently revised antidegradation rule does not appear to have a direct impact on the effluent limits estimated for any City in this study.

4.8 Limitations of Analysis

For the estimated effluent limit development in both the current and future scenarios, the following limitations of the analysis are summarized below:

- Effluent limit estimates did not include evaluation of TBELs as they were assumed to have not changed.
- MPCA phosphorus allocations in memoranda summarizing RES impacts in their watersheds were used for phosphorus limits where available.
- POCs evaluated only when data was available in DMR database provided by MPCA.
- MPCA's EDA surface water search map and text-based tools were used to obtain surface water quality data available as of September 1, 2016.
- Critical low flow values were obtained in the permit, fact sheet, or provided by MPCA.
- An effluent limit was applied if the FAV value was exceeded in the mixing zone.
- Receiving stream concentrations were estimated with upstream data where available, but often required the use of downstream data as well. Use of this data allowed a more complete evaluation but MPCA would most likely request or gather additional information prior to setting an effluent limit.
- RPE and WQBEL calculations could only be completed when some DMR data was available, therefore future data could result in a new limit not shown in this study.
- The average value of receiving stream concentrations available was used in completing the RPE and calculating the WQBEL.
- Calculations for the RPE and WQBEL evaluations followed EPA's TSD which is the reference MPCA has indicated that is followed.
- The sulfate WQS of 10 mg/L was applied to all wild rice waters from the July 2016 proposed list that were within 50 miles of a facility discharge.
- Estimated effluent limits were based on best available information at the time and in no way represent actual future effluent limits that will be issued by MPCA.

The limitations of analysis discussed above provide information on areas of uncertainty in specific assumptions. They do not change the overall conclusions of the report, or application for its intended purpose.

5.0 Wastewater Treatment Costs

Municipal wastewater treatment facilities' foremost objective is to remove organics from sanitary wastewater. The treatment technology currently in use at municipal WWTFs has been selected primarily to meet this objective. Existing treatment technology also removes TSS and can remove some nitrogen and phosphorus, but technology updates would be needed to remove the other parameters of interest for this study (sulfate and chloride) or to meet lower limits for nitrogen and phosphorus. This section outlines wastewater treatment technologies for removal of organics, TSS, nitrogen, phosphorus, sulfate, and chloride to provide context for treatment upgrades and Barr's analysis of required treatment upgrades and associated costs to meet current and future WQS. Barr's team performed a literature review of academic articles, white papers, and government documents to identify practical technologies to remove these parameters from wastewater.

Sections 5.1 through 5.5 describe the technologies used to meet effluent targets for organics and for the parameters of concern for this project: TSS, nutrients (total phosphorus, ammonia, and nitrate), sulfate, and chloride. These sections include descriptions of existing processes, descriptions of potential upgrades, and the rationale for selecting the upgrades deemed most practical for a specific WWTF. For each parameter, a detailed decision flow chart was developed to determine which technology or combination of technologies is most appropriate for a given facility. The following sections are ordered to reflect increasing treatment cost, complexity, and contaminant removal. For example, technologies to remove sulfate cost more than technologies to remove nutrients, and the technologies that remove sulfate can also remove organics, TSS, and nutrients. Table 5-1 is an overview of treatment technologies and the parameters each can remove.

Table 5-1 Summary of treatment technologies and parameters removed

Level of Treatment	Technology	Organics and Pathogens	TSS	Nutrients	Sulfate	Chloride
Primary	Primary Clarification	X	X			
Secondary	Pond Treatment	X	X			
Secondary	Conventional Activated Sludge	X	X			
Secondary	Biological Nutrient Removal (BNR) Activated Sludge	X	X	X		
Secondary	Chemical Phosphorus Removal	X	X	X (P only)		
Tertiary	Tertiary Filtration	X	X			
Tertiary	Nanofiltration	X	X	X	X	
Tertiary	Ion Exchange	X	X	X	X	
Tertiary	Reverse Osmosis/EDR	X	X	X	X	X

5.1 Organic Material and Pathogens

This section describes treatment technologies to remove organic material and pathogens that are currently in use at the WWTFs evaluated for this study.

5.1.1 Background

The primary purpose of wastewater treatment is to reduce the amount of organic material and pathogens discharged to surface waters. While these constituents are not the primary focus of this report, an understanding of basic wastewater treatment processes will provide the reader with a knowledge base for evaluating treatment technologies that may be used to meet effluent limits for TSS, nutrients, sulfate, and chloride.

Wastewater treatment plants consist of primary treatment, secondary treatment, disinfection, and sludge handling. Some plants also include tertiary treatment processes to provided additional treatment prior to discharge.

5.1.2 Primary Treatment

Primary treatment consists of physical methods to remove large objects, sand, grit, oils, and particles from the water prior to biological treatment. These methods include screening, settling, and flotation. The most common primary treatment process is primary clarification, in which water is held in a large tank to allow solids to settle out. Any organic material present as large particles and any pathogens attached to them will be removed in primary treatment.

5.1.3 Secondary Treatment Processes

Secondary treatment processes remove dissolved organic material from wastewater using biological degradation. Secondary treatment can use bacteria that grow suspended in liquid (activated sludge) or bacteria attached to a surface (fixed-film methods). The effectiveness of secondary treatment is assessed using the parameter biological oxygen demand (BOD), a measurement that reflects the amount of biodegradable organic material present in a water.

5.1.3.1 Activated Sludge and Clarification

Activated sludge treatment systems use suspended biomass to remove organic material from water. The primary distinguishing characteristics of these processes are aeration to provide the biomass something to respire, sedimentation to remove solids from the treated flow stream, and recycling of settled sludge to maintain sufficient biomass to consume organics in the reaction tank. Albert Lea, Fairmont, Gilbert, and Grand Rapids operate conventional activated sludge systems in which air is mechanically added to water in aeration tanks and clarifiers collect accumulated solids and biomass.

Extended Aeration

Extended aeration plants do not have a primary clarifier upstream of the activated sludge system. Screened wastewater is sent directly to an activated sludge tank, and biomass and other solids in the clarifier are sent back to the reaction tank to maintain biomass. The downside of this process is that longer retention times and tank volumes are needed, and the sludge contains more inorganic material. Extended aeration is typically applied in "package plants" or small permanent facilities designed to be easily installed and operated. In addition, the relatively large amount of biomass retained in the system offers improved resistance to shock loads. Extended aeration systems can remove BOD to less than 30 mg/L (reference (10)) and easily meet the 25 mg/L BOD limit found in most Minnesota NPDES permits. Of the evaluated WWTFs, Watertown operates an extended aeration system.

Oxidation Ditch

In oxidation ditch systems, a large round or ovular pond provides a long flow path for incoming wastewater. Mechanical aerators in the pond add oxygen and keep solids suspended. Sludge is collected in a clarifier and returned to the front of the ditch. Some oxidation ditches operate as extended aeration systems in that they do not have an upstream primary clarifier and operate with a high solids residence time. Oxidation ditch systems can remove BOD to less than 10 mg/L (reference (10)).

Contact Stabilization

In contact stabilization, biomass to be returned to the activated sludge tank is first sent to an aerated stabilization tank, where some of the waste solids are consumed. This allows the system to accommodate more variable wastewater quality but not variable wastewater flows (reference (11)).

High-Purity Oxygen Activated Sludge

In high-purity oxygen (HPO) activated sludge systems, the activated sludge tanks are aerated with oxygen instead of air. The tanks are covered and surface aerators are used to help dissolve oxygen from the headspace into the water. Air contains about 23% oxygen by weight, so using pure oxygen decreases the volume of gas required to provide a set amount of oxygen. However, oxygen must either be generated onsite or supplied externally, which increases costs. These systems were developed in the 1970s, and about 300 have been installed worldwide. They are not commonly installed anymore. HPO systems can remove BOD to less than 10 mg/L and can be adapted to remove nitrogen and phosphorus (reference (12)). Of the evaluated WWTFs, Rochester operates a HPO system.

Pond Systems

In areas with large amounts of land available, pond systems can be used to remove suspended solids and organic matter from wastewater. Stabilization ponds without aeration must retain the water for 180 days in the southern part of the state and 210 days in the northern part of the state. Ponds are broken up into separate sections called cells. MPCA guidelines state that pond systems should contain at least three cells, but some existing systems operate with only two (reference (13)). Treated water is typically discharged from the ponds in the spring and fall of each year, depending on the location and the size and load of the system. Because ponds must hold water for extended periods between discharge, they require approximately 250 acres per MGD of capacity, including area for dikes and buffers. For this reason, they are generally not applicable for larger facilities. Hanska operates a two-cell stabilization pond system. Ada, Cook, Nashwauk, and Serpent Lake operate three-cell stabilization pond systems.

Aerated ponds can provide additional treatment and can discharge continuously as they are not subject to the holding period requirement. Aerated ponds can be used in place of stabilization ponds or as a pre-treatment prior to stabilization ponds. Butterfield operates an aerated pond upstream of a three-cell stabilization pond system.

Clarifiers

Clarifiers are large settling tanks where the water velocity slows enough for solids to settle out of the water. Secondary clarifiers are placed downstream of activated sludge tanks and are used to collect the biomass grown in the tanks. Clarified water is sent to tertiary treatment or discharge while settled solids are split between recycle back to the activated sludge tank and waste (reference (14)).

5.1.3.2 Fixed Film

In contrast to activated sludge systems, fixed film secondary treatment uses biomass that is attached to surfaces to remove organic material from wastewater. Similar to activated sludge systems, fixed film systems require contact with biomass and oxygen.

Trickling Filters

Trickling filters use biomass attached to media within a large tank to treat wastewater. Water is sprayed over the media and trickles through the filter, where it is constantly exposed to both biomass and air. Air can be vented to the system naturally or using mechanical ventilation. Historically, trickling filters were constructed using rock media. However, new trickling filters use plastic media. These systems use less power than activated sludge, because they do not require aeration of the water phase. Trickling filters also require a settling tank downstream, but these can be smaller because less biomass leaves fixed film systems. Trickling filters can remove BOD to below 30 mg/L, and some can also remove ammonia (reference (14)), but typically, they cannot achieve effluent ammonia concentrations as low as activated sludge. Austin and Hibbing operate trickling filter systems.

Rotating Biological Contactors

Rotating biological contactors (RBCs) consist of partially submerged plastic discs that rotate. The discs are designed to have a high surface area that can support the growth of biomass, and the rotation exposes the biomass to both oxygen and wastewater, which enables degradation of organics. RBCs can be staged in several different ways and can be operated to remove only BOD or to remove both BOD and ammonia. Effluent BOD concentrations range from 7 mg/L to 30 mg/L (reference (14)). Like trickling filters, RBCs cannot achieve ammonia limits as low as activated sludge. Of the WWTFs evaluated, Lake Crystal operates an RBC system.

5.1.4 Tertiary Treatment Processes

Tertiary treatment processes can be added to meet more stringent effluent limits. Tertiary treatment refers to any additional treatment needed to improve effluent water quality and may include filtration, membrane treatment, or adsorption. Gilbert operates a system with tertiary filtration.

5.1.5 Disinfection

Treated wastewater must be disinfected before it is discharged to surface water in order to reduce the spread of human diseases.

5.1.5.1 Chlorination/Dechlorination

Chlorine disinfection uses either gaseous or liquid chlorine compounds to kill pathogens and requires the constant addition of chemical. A small amount of chlorine forms chloride during disinfection. Residual chlorine needs to be removed before the water is discharged, because it can be toxic to downstream organisms. This process is called dechlorination and requires additional chemicals ((reference (14)). Grand Rapids operates a chlorine disinfection system.

5.1.5.2 UV Disinfection

Disinfection using ultraviolet (UV) light is gaining in popularity because it eliminates the need for a chemical disinfectant and a dechlorination step. In addition, it does not contribute chloride to the effluent (reference (14)). Fairmont operates a UV disinfection system.

5.1.6 Biosolids Treatment and Disposal

Solids produced in primary and secondary treatment processes need to be treated further to remove water, reduce volume, and kill pathogens prior to disposal.

5.1.6.1 Stabilization

Biosolids stabilization destroys pathogens, further reduces the volume of solids requiring disposal, and prepares the solids for disposal to landfill or land application.

5.1.6.2 Anaerobic Digestion

Anaerobic digestion is the consumption of organic material by microbes in the absence of oxygen. This process requires high temperatures but produces methane-containing biogas that can be burned onsite for energy production. Phosphorus removed in secondary treatment is released during digestion and must be treated if a phosphorus limit exists (reference (14)).

5.1.6.3 Aerobic Digestion

Aerobic digestion is similar to anaerobic digestion but occurs in the presence of oxygen. It can have a lower capital cost than anaerobic digestion and produces solids more suitable to land application. In addition, less phosphorus is released from the solids. However, the need to aerate the system increases operations costs. Aerobic digestion is not typically used at plants treating more than 5 MGD (reference (14)).

5.1.6.4 Thickening and Dewatering

Sludge collected from the primary and secondary clarifiers typically contains about one to three percent solids. Additional water can be removed via thickening and dewatering in order to reduce the volume of solids requiring additional treatment and disposal. Excess water removed from the sludge in both processes is routed back to the front of the plant and may contain large concentrations of nitrogen and phosphorus. If nutrient removal is required at the WWTF, dewatering processes may need to be optimized to retain nutrients or excess water may need to be treated before it is routed to the front of the plant (reference (14)).

Gravity Thickening

A gravity thickener is a large conical tank similar to a clarifier where collected sludge is stored and allowed to thicken using gravity to three to 10 percent solids. Thickened sludge is sent to a stabilization process, such as anaerobic or aerobic digestion (reference (14)).

Dewatering and Drying

Additional water can be removed from stabilized sludge by physically pressing the sludge or by using centrifuges which spin the sludge to remove water via centrifugal force to achieve solids contents of 15 percent to 30 percent solids. Additional water can be removed by piling solids to dry or through additional heating (reference (14)).

5.1.6.5 Ultimate Disposal

Dewatered biosolids can be applied to farm land if they meet certain safety specifications. Because biosolids can only be land applied at certain times of the year, facilities using this disposal option need a large volume of storage capacity for stabilized biosolids. Solids not meeting requirements for land disposal are typically landfilled.

5.2 Total Suspended Solids (TSS)

This section describes treatment technologies to remove TSS that are currently in use at the WWTFs evaluated for this study and potential technologies to improve TSS removal. It also summarizes the logic used to determine the appropriate TSS treatment technology upgrades to achieve estimated current and future effluent limits at the WWTFs in this study.

5.2.1 Background

Solids are present in sanitary wastewater and many types of industrial wastewater. TSS include the portion of the total solids that is retained on a 0.45 micron filter. TSS is an effluent standard used for regulatory control of treatment plant performance.

As levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen (warmer water holds less oxygen than cooler water). Some cold water species, such as trout and stoneflies, are especially sensitive to changes in dissolved oxygen. Photosynthesis also decreases since less light penetrates the water.

For wastewater treatment plants, adequate treatment of TSS is necessary to protect the water quality of the receiving waters. Within a wastewater treatment plant, TSS removal is typically implemented upstream of biological processes, as suspended solids can foul downstream surfaces and damage pumps and pipes.

5.2.2 Existing TSS Removal Technologies at Evaluated WWTFs

Two types of physical processes are used to remove TSS from wastewater: sedimentation and filtration.

5.2.2.1 Sedimentation

Stabilization Ponds

Stabilization ponds are lined ponds that typically have a depth of six feet with two feet reserved for sludge accumulation. This results in an operating depth of approximately four feet. Pond systems usually consist of two primary ponds and one secondary pond. Water is typically discharged from the ponds during MPCA-permitted discharge windows in the spring and fall of each year. The ponds can be used in parallel or in a series for improved water treatment during cold weather. Water is typically retained for three to seven months in the ponds to allow solids to settle to the bottom of the pond and to store water between approved discharge windows (reference (15)). In some instances, chemicals can be added to the system to enhance settling or inhibit algae growth. Prior to discharge, ponds should be in compliance with the discharge limits established in their NPDES permit. Stabilization ponds commonly meet an average monthly TSS discharge limit of 45 mg/L and a daily maximum TSS discharge limit of 65 mg/L (reference (15)).

Ponds can achieve high TSS reduction at a low operating cost and can typically operate for many years without dredging solids. However, ponds require a large amount of land and offer limited operational flexibility. They are also subject to algal blooms, which can increase TSS above discharge limits.

Primary and Secondary Clarification

Many wastewater treatment plants use a primary clarifier to remove TSS from raw wastewater and a secondary clarifier to remove TSS from biological treatment basins. Solids are settled to the bottom of the clarifiers, sometimes with the assistance of chemicals. These solids then require disposal, while the overflow is discharged or sent to additional treatment processes. Mechanical treatment with primary and secondary clarification commonly produces effluent with TSS levels of 15 mg/L monthly average (reference (15)). Additional TSS removal can be achieved by adding chemicals to promote formation of larger particles that remove other particles during settling.

Clarifiers can be used following stabilization ponds for algae removal. They achieve high TSS removal with a much smaller footprint than ponds and are relatively low maintenance. However, the produced sludge requires disposal, and clarifiers have a higher capital cost than pond systems.

5.2.2.2 Filtration

Tertiary filtration is used to remove remaining solids from treated wastewater using mechanical filtration methods downstream of sedimentation or clarification. TSS is retained on filter media, while filtered water passes through. The filters need to be periodically backwashed to remove suspended solids from the filter, and backwash must be routed to the front of the plant or disposed of through an alternate method.

Media Depth Filtration

Media depth filtration uses granular media to remove TSS from water. Some examples of filtration media include sand, anthracite, magnetite, or a combination (reference (16)). As the water passes through the media bed, suspended solids will attach to the media and be removed from the stream. This process is diagrammed in Figure 5-1 and is also called deep-bed media filtration.

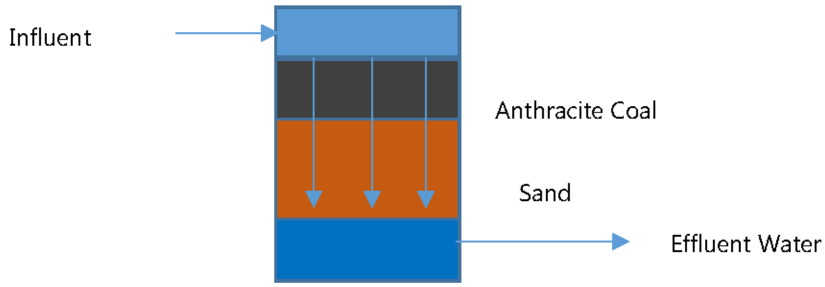


Figure 5-1 Tertiary media depth filtration process flow

Media filtration has a higher operating cost than clarification but has a smaller footprint and can remove smaller particles. Filters also require regular backwashing and maintenance, and backwash water requires disposal.

Traveling Bridge Filter

Additional treatment can be accomplished using media filters. Traveling bridge filters are divided into several sections that can be individually backwashed to remove filtered material. This allows continuous filtration so the unit does not have to be taken offline for full backwash. Traveling bridge filters can only achieve TSS removal to about 5 mg/L, and cannot enhance phosphorus removal to below 0.5 mg/L (reference (17)). Watertown operates a traveling bridge filter.

5.2.3 Potential Technologies to Improve TSS Removal

Treatment technologies discussed in this section can improve TSS removal at facilities where they are not currently in use.

5.2.3.1 Filtration

Recirculating Bed Filters

Recirculating bed filters are commonly applied at stabilization ponds for algae control. They can be installed without a separate source for backwash water and can reduce TSS below the 45 mg/L typically achieved in pond systems.

Cloth Filtration

Another type of tertiary treatment is a cloth disc filter – a rotating filter where TSS is retained on the cloth. Cloth filters have similar advantages and disadvantages to media filtration but can remove smaller particles (reference (18)). However, they produce more backwash water requiring disposal.

5.2.4 Summary of TSS Removal Methods

Table 5-2 summarizes technologies commonly used for TSS removal at WWTF.

Table 5-2 TSS removal technology summary

TSS Removal Method	Advantages	Limitations	Achievable Effluent Concentrations
Settling Ponds	Inexpensive and easy to operate Existing at some plants	Requires large land area	45 mg/L TSS
Secondary Clarification	Smaller than ponds Existing at some plants Additional TSS removal can be achieved with by adding chemicals	Requires sludge disposal	15 mg/L TSS
Recirculating Bed Filter	Improves solids removal in pond systems without needing to upgrade to activated sludge	Requires additional land area Requires additional pumping	10 mg/L
Media Depth Filtration	Removes smaller particles than settling (as low as 1 μm with chemical addition)	Requires upstream sedimentation Requires disposal of backwash water Operationally intensive	2 mg/L
Traveling Bridge Filter	Does not need to be taken offline for backwash	Operationally more complex than traditional media filters	5 mg/L
Cloth Filtration	Less expensive than media depth filtration Requires smaller footprint that media depth filter	Requires upstream sedimentation Requires disposal of additional backwash water Operationally intensive	5 mg/L

5.2.5 Process Evaluation

The primary factors that affect selection of technology to achieve effluent limits for TSS are:

- TSS effluent limits
- land availability
- existing TSS removal methods

5.2.5.1 TSS effluent limits

Stabilization ponds can be an appropriate technology if the land is available and the effluent TSS limit is not less than 45 mg/L. If the TSS limit is lower than 45 mg/L, alternative technologies would need to be used or filtration would be needed following the stabilization ponds.

5.2.5.2 Land availability

Stabilization ponds are easy to maintain with low labor and operating costs. However, they require large areas of available land as typical stabilization pond system will require approximately 250 acres per MGD of capacity. As a result, ponds are typically only cost effective for smaller towns. If sufficient land is available, stabilization pond technology should be considered for further evaluation. If land is not available, then other technologies with a smaller footprint need to be used.

5.2.5.3 Process Evaluation Summary

A flow chart outlining decision making for TSS removal is diagrammed in Figure 5-2. For the purpose of this study, media depth filtration was selected for WWTFs requiring tertiary filtration for TSS removal.

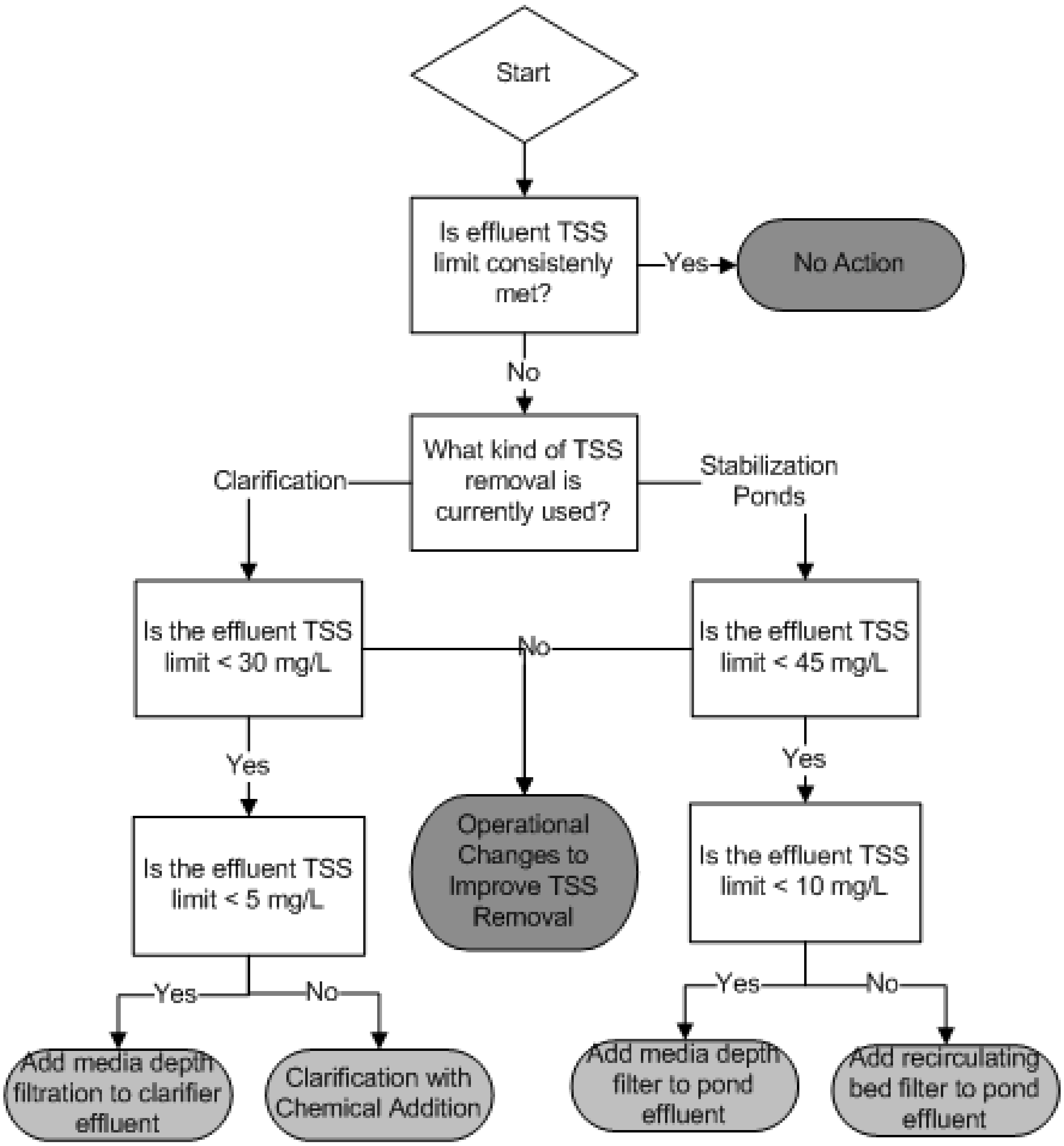


Figure 5-2 TSS removal decision flow chart

5.3 Nutrients (Total Phosphorus, Ammonia, and Nitrate)

This section describes treatment technologies to remove nutrients that are currently in use at the WWTFs evaluated for this study and potential technologies to improve nutrient removal. It also presents the logic used to determine the appropriate nutrient removal technology upgrades to achieve estimated current and future effluent limits at the WWTFs in this study.

5.3.1 Background

Nitrogen and phosphorus are essential nutrients for all living things. As a result, they are ubiquitous in wastewater. In some cases, they need to be removed prior to discharge to prevent excess growth of algae downstream. Nutrients typically limit algae and bacterial growth in natural waters, so adding nutrients promotes growth which uses oxygen and decreases the dissolved oxygen. Low dissolved oxygen concentrations can kill fish. Some cold water species, such as trout and stoneflies, are especially sensitive to changes in dissolved oxygen.

5.3.1.1 Nitrogen

Nitrogen is typically present in municipal wastewater as about one-third organic nitrogen and two-thirds ammonia. Biological nitrogen removal uses two different types of bacterial growth – nitrification and denitrification – to remove 80 to 95 percent of inorganic nitrogen from wastewater. Organic nitrogen is more difficult to remove and can be a limitation for treatment facilities with a total nitrogen (TN) permit limit (reference (17)).

5.3.1.2 Phosphorus

Phosphorus can be removed from wastewater streams by either a biological process or through chemical addition depending on the form of phosphorus present. Phosphorus exists in municipal wastewater in one of three forms. Phosphate typically accounts for about half the total phosphorus, polyphosphate accounts for about a third, and organic phosphorus accounts for about a sixth (reference (17)). Phosphates are soluble and can be removed via a biological process or by chemical addition. Polyphosphates are also soluble but can only be removed through hydrolysis or a biological process. Organic phosphorus removal depends on its solubility and biodegradeability.

5.3.2 Existing Nutrient Removal Technologies at Evaluated WWTFs

Removal of nitrogen from wastewater is a biological process, while removal of phosphorus can be accomplished either biologically or chemically. In addition, nitrogen and phosphorus removal can be combined in biological or biological/chemical systems.

5.3.2.1 Biological Nitrogen Removal

Wastewater typically contains organic nitrogen and ammonia. Soluble organic nitrogen is biologically broken down to form ammonia. The ammonia can then be used as a food source by bacteria that respire oxygen. During this process called nitrification, ammonia is oxidized to nitrite then nitrate. Under conditions where oxygen is not present, denitrifying bacteria can convert nitrate to nitrogen gas, removing it from the wastewater flow.

Biological nitrogen removal is accomplished using treatment configurations that include suspended growth, fixed film, or a combination of these technologies. Each of these technologies uses bacterial cells to convert dissolved forms of nitrogen into nitrogen gas, which is then vented to the atmosphere and removed from the system.

Some existing systems achieve ammonia removal via nitrification in pond or mechanical secondary treatment systems. The bacteria that conduct nitrification grow more slowly than bacteria that eat organics, so ammonia removal requires more time and tank volume than removal of organic material. Nitrification only converts ammonia to nitrate, so if a nitrate or total nitrogen standard is expected, additional updates are needed to provide denitrification.

Nitrification in Ponds

Ponds can typically achieve about 80 percent ammonia removal during summer months, and some evaluated pond systems effectively remove ammonia. However, nitrification in pond systems is limited by cold weather conditions that inhibit the growth of bacteria. This may pose a problem for pond WWTFs that want to discharge before June, as water below 50 degrees F is too cold to support nitrification. Nitrifying bacteria are also slow growing, so require several weeks to become established in a pond after water temperatures warm. Some ammonia can be removed as a gas from the surface of the pond or by algal uptake but only in the absence of ice cover.

Nitrification in Mechanical Systems

Some existing WWTFs evaluated for this study remove ammonia via nitrification. Nitrification can be achieved by expanding the size of aerobic secondary treatment used for removal of organic compounds in activated sludge or fixed film systems and increase the recycle rate of biomass back to the system.

5.3.3 Potential Technologies to Improve Nutrient Removal

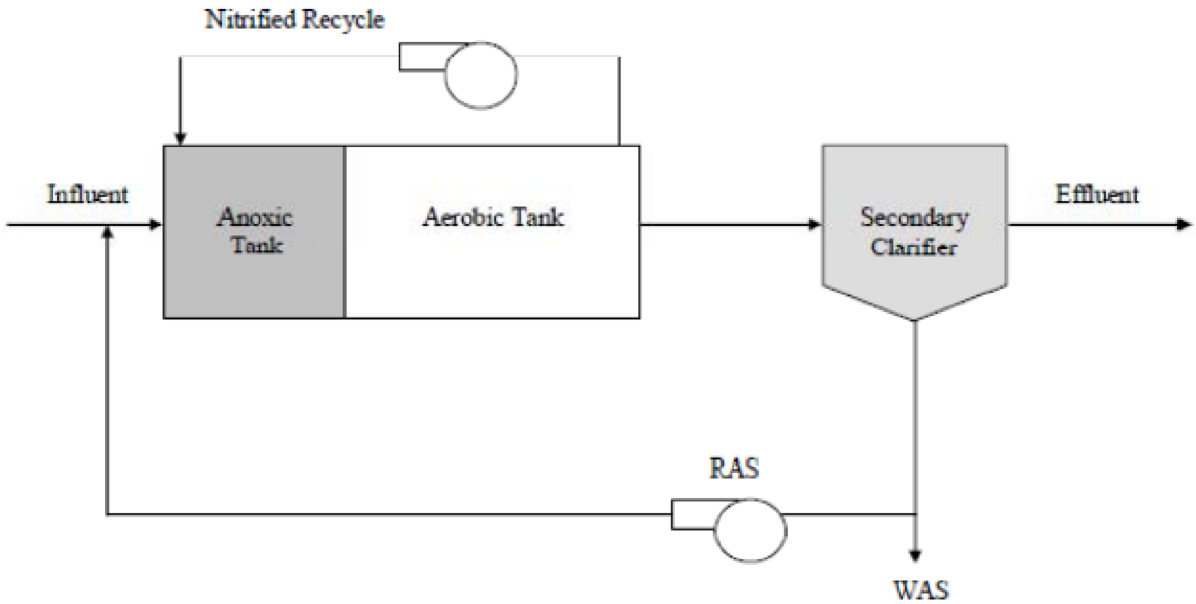
5.3.3.1 Biological Nitrogen Removal

Pond Upgrades

An existing pond treatment system can be expanded to achieve over 80 percent removal of ammonia or meet a spring limit as low as 8 mg/L (reference (19)). Additional removal can be achieved by adding a rock trickling filter with recycle to speed up establishment of a nitrifier population in the spring months and achieve up to 70 percent additional ammonia removal for a total removal of 95 percent (references (20) and (21)). The level of ammonia removal achievable depends on wastewater characteristics, pH, and temperature and pond size. If a system has a spring or summer effluent ammonia limit lower than 2 mg/L, the system should be upgraded to activated sludge. Ponds cannot reliably denitrify, so if a nitrate or total nitrogen standard is expected, additional updates are needed to provide denitrification.

Modified Ludzack-Ettinger

The Modified Ludzack-Ettinger (MLE) process is the most commonly used nitrogen-removal process at WWTFs in the United States. The MLE process consists of an anoxic (no dissolved oxygen) zone followed by an aerobic (dissolved oxygen present) zone, as illustrated in Figure 5-3. Nitrate produced in the aerobic zone via nitrification is reduced to nitrogen gas in the anoxic zone by recycling a portion of the aerobic zone effluent back to the anoxic zone.



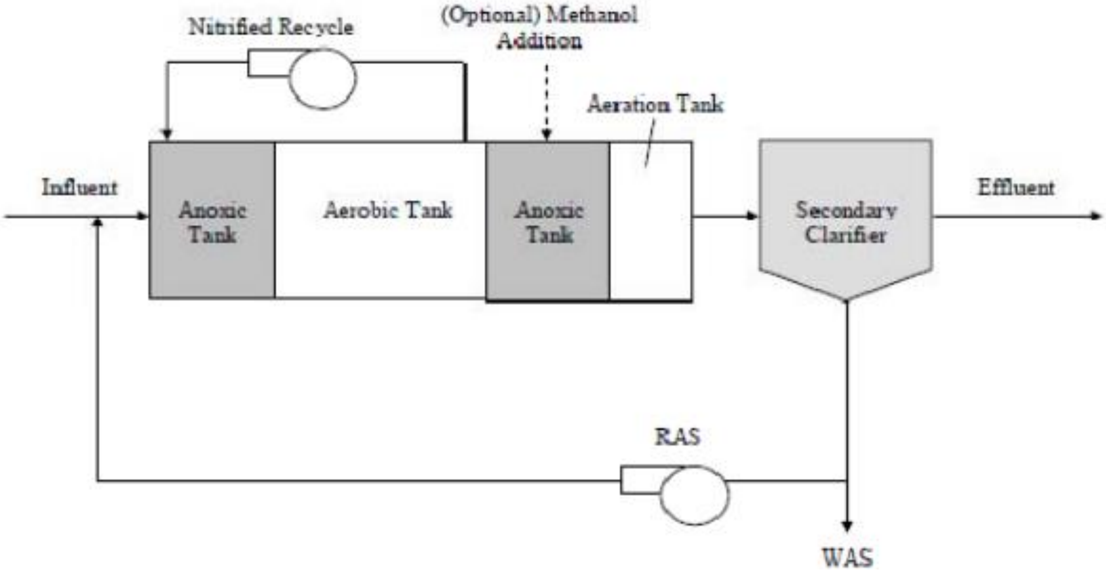
Source: (reference (17))

Figure 5-3 MLE process flow

Existing systems can be modified to MLE systems by adding walls within the aeration basin and turning off air diffusers to create an anoxic zone. The effectiveness of nitrogen removal depends on process kinetics, the size of the separate zones, and carbon supply. If the carbon-to-nitrogen ratio in the plant influent is greater than nine, there should be an adequate supply of carbon for denitrification, in which case, the MLE process can remove up to 85 percent of nitrogen down to a concentration of approximately 10 mg/L (reference (22)). If the carbon-to-nitrogen ratio in the plant influent is lower than nine, supplemental carbon addition may be necessary (reference (22)).

4-Stage Bardenpho

The first two zones of the 4-Stage Bardenpho process are identical to the MLE process. Additional nitrate is removed in a second anoxic zone. In a second aerobic zone, remaining nitrogen gas is stripped and dissolved oxygen added prior to clarification. In some applications, an additional carbon source, such as methanol, is added to the second anoxic zone to enhance denitrification. This also helps decrease the footprint needed for the process (reference (17)), which is diagrammed in Figure 5-4.



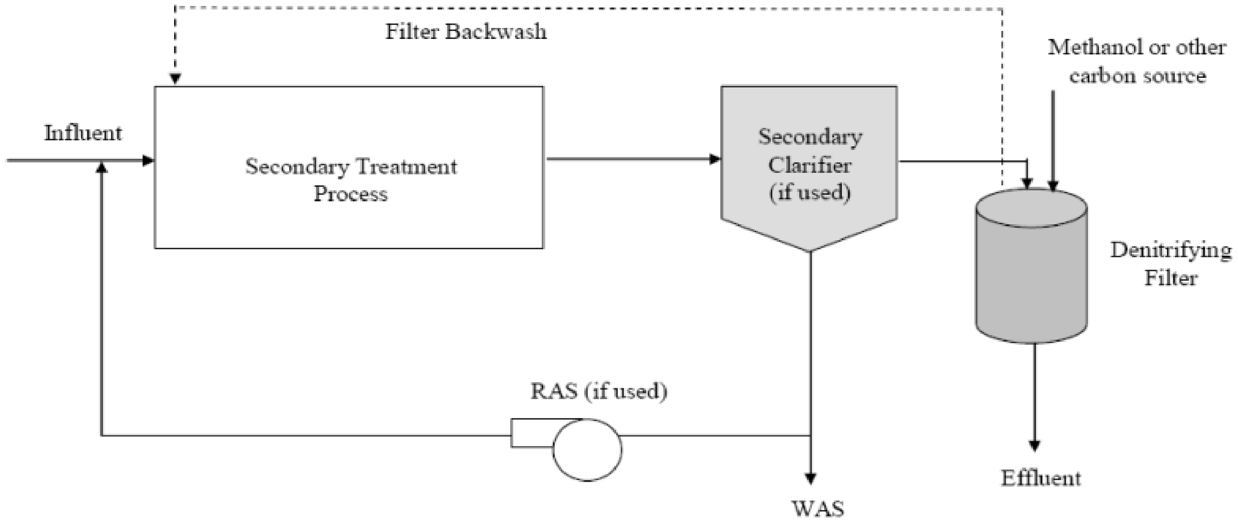
Source: (reference (17))

Figure 5-4 4-Stage Bardenpho process flow

Existing activated sludge plants can be modified into a 4-Stage Bardenpho system by adding baffles to existing tanks and building additional activated sludge tanks. 4-Stage Bardenpho system can also be incorporated into existing oxidation ditches, where a zone with low dissolved oxygen levels serves as the first two stages. In either configuration, this process can be combined with membrane bioreactors (MBRs) to meet low effluent nitrogen requirements or fixed-film media to reduce the system footprint (reference (17)). The addition of a second anoxic zone enables optimized 4-Stage Bardenpho systems to achieve nitrogen reduction to less than 5 mg/L (reference (17)).

Denitrification Filters

Denitrification, or the conversion of nitrate to nitrogen gas, can be conducted in a separate process downstream of the activated sludge process, as diagrammed in Figure 5-5. Denitrification filters provide both nitrate removal and effluent filtration (reference (17)).



Source: (reference (17))

Figure 5-5 Denitrification filter process flow

If separate-stage denitrification filters are used, a plant can meet restrictive nitrate limits using existing, aerated, activated sludge tanks without the need for anoxic zones. Nitrate produced can then be routed to the denitrification filters for conversion to nitrogen gas. This option has a lower footprint than full suspended-growth nitrogen-removal processes such as MLE or 4-stage Bardenpho. However, supplemental carbon must be added to the denitrification filter to act as a bacterial substrate. Filters also need to be backwashed regularly, which adds operational complexity (reference (17)).

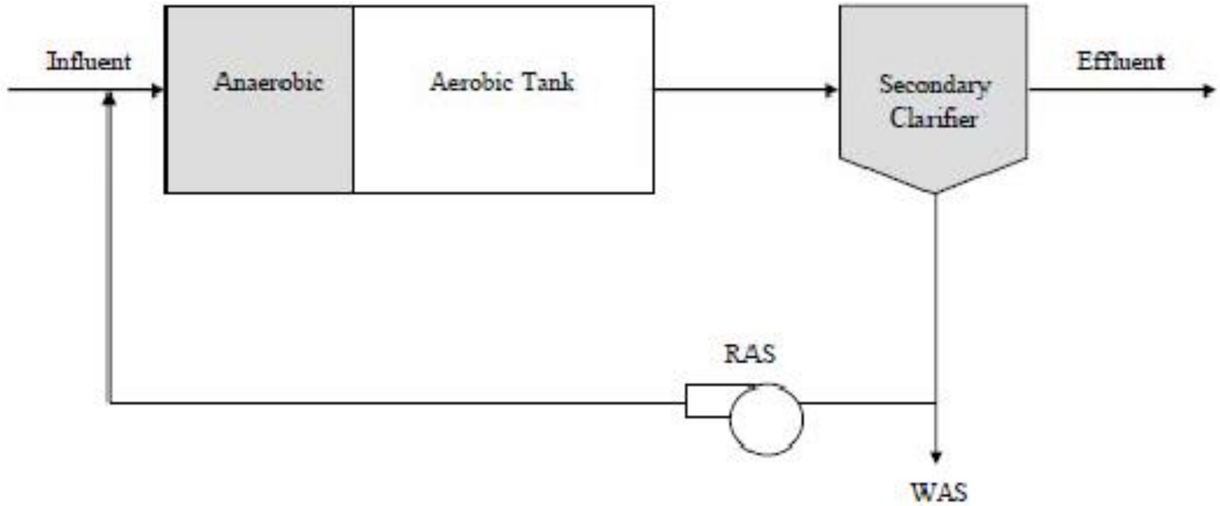
5.3.3.2 Biological Phosphorus Removal

Biological phosphorus removal (BPR) occurs in treatment systems that contain phosphate accumulating organisms (PAOs) and alternating anaerobic and aerobic conditions. PAOs exist naturally in the environment and aerobic activated sludge. If favorable conditions are achieved, these bacteria store phosphorus within their cells (reference (17)). Under aerobic conditions, PAOs store phosphorus in their cells as polyphosphates. Once the PAOs experience anaerobic conditions, they break bonds within the polyphosphate molecules providing energy for them to absorb volatile fatty acids (VFAs) from the wastewater. The PAOs store the VFAs within their cells until oxygen becomes available in aerobic conditions. Once oxygen is again available, the PAOs metabolize the stored VFAs and uptake and store phosphate within their cells. Phosphate is removed from the system during secondary clarification, when the PAO cells are separated from the wastewater in the sludge stream (reference (17)).

Effluent total phosphorus concentrations less than 1.0 mg/L can be achieved under favorable conditions, which require sufficient concentration of organic matter and VFAs, low concentrations of nitrate, and minimization of phosphate release during sludge handling (reference (17)). If VFA concentrations in the influent wastewater are not high enough to support phosphorus removal by PAOs, supplemental VFAs can be added.

Pho-Redox (A/O)

BPR can be integrated into an existing treatment system by adding a mixed anaerobic zone ahead of an existing activated sludge system. This process is called Pho-Redox or Anaerobic/Oxic (A/O) and is diagrammed in Figure 5-6. Because nitrate and dissolved oxygen in the anaerobic zone inhibit BPR in the anaerobic zone, nitrification in the aerobic tank should be limited. This system is not practical for WWTFs that have ammonia and phosphorus limits but have no nitrate or total nitrogen limit, as ammonia is transformed into nitrate, which prevents effective phosphorus removal. If nitrification is expected, an anoxic zone may be needed to remove nitrate in a 3-Stage Pho-Redox process (Section 5.3.3.3).



Source: (reference (17))

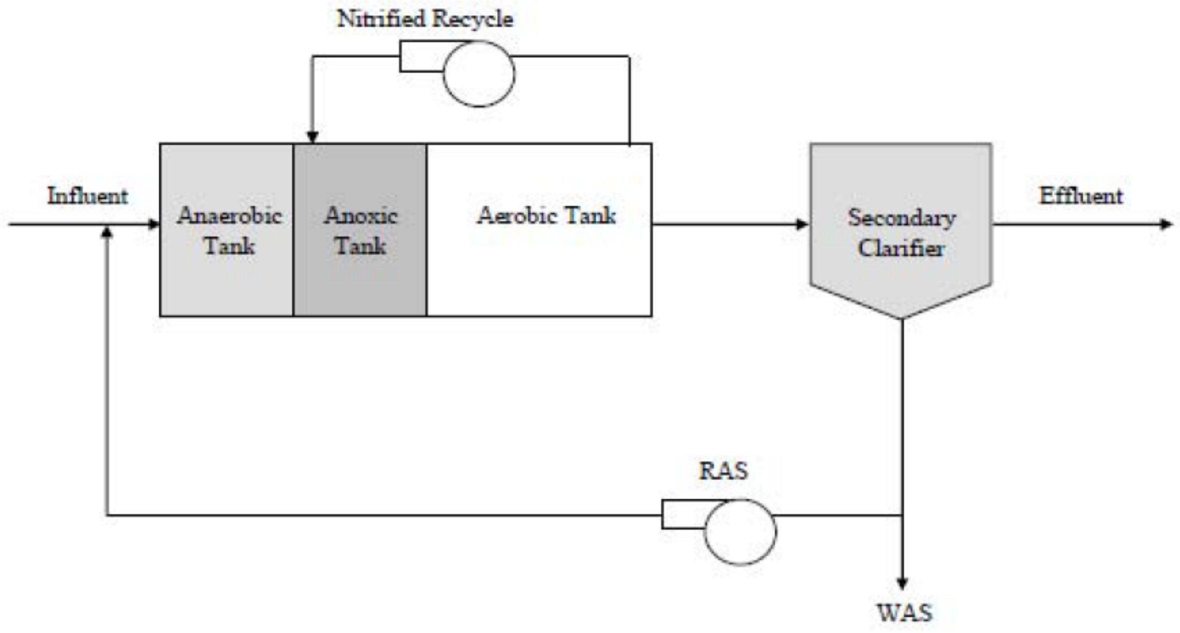
Figure 5-6 Pho-Redox Anaerobic/Oxic (A/O) process flow

5.3.3.3 Biological Removal of Nitrogen and Phosphorus

The concepts involved in biological nitrogen removal and BPR can be combined into activated sludge processes that remove both nutrients.

3-Stage Pho-Redox

A 3-Stage Pho-Redox process, or Aerobic/Anoxic/Oxic or A^2/O process, is essentially an MLE nitrogen-removal process (Section 5.3.2.1) with an anaerobic tank upstream to enhance BPR. This process is diagrammed in Figure 5-7. In order for phosphorus removal to be successful, nitrate removal in the anoxic zone needs to be effective, because nitrate returned to the anaerobic tank in recycled sludge can inhibit phosphorus removal.



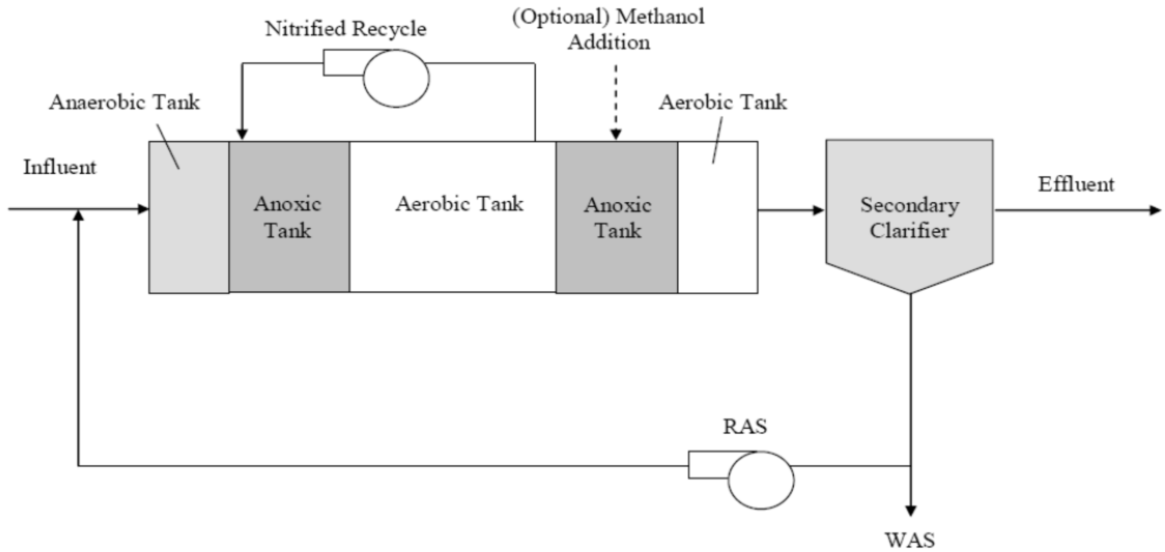
Source: (reference (17))

Figure 5-7 3-Stage Pho-Redox (A^2/O) process flow

The 3-Stage Pho-Redox process can remove both nitrogen and phosphorus in a suspended-growth activated sludge system without chemical addition. This corresponds to a lower operating cost compared to systems which must add metal salt and/or supplemental carbon. This process is most promising for implementation at sites that currently operate activated sludge treatment systems with excess capacity and anticipated total nitrogen limits between 5 and 10 mg/L.

5-Stage Bardenpho

Similarly, a 5-Stage Bardenpho process consists of a 4-Stage Bardenpho process (Section 5.3.2.1) with an upstream anaerobic zone to enhance phosphorus removal. It has the same advantages as the 3-Stage Pho-Redox (A2/O) process, and the sludge typically contains low nitrate concentrations, which makes the 5-Stage Bardenpho more reliable for phosphorus removal. In addition, total nitrogen can be reduced to less than 5 mg/L (reference (17)). The 5-Stage Bardenpho process is diagrammed in Figure 5-8.



Source: (reference (17))

Figure 5-8 5-Stage Bardenpho process flow

5.3.3.4 Modifications to Biological Removal Processes

Addition of Aerobic Zone to Pond

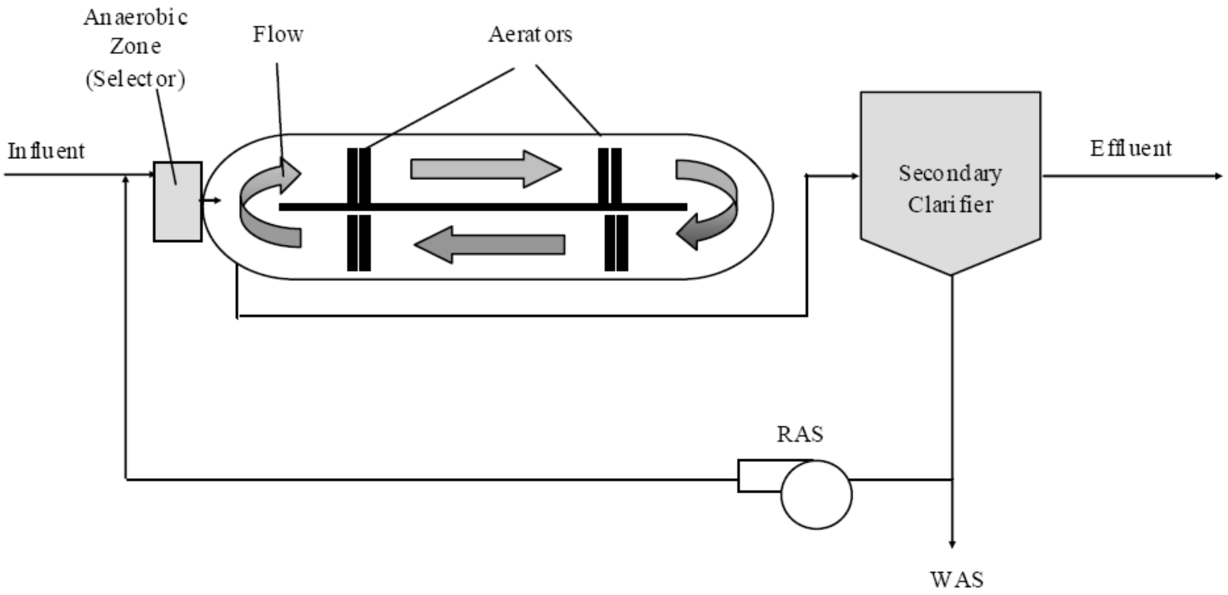
Ammonia removal in stabilization ponds is limited in cold temperatures due to limited biological activity. In cold climates, about 70 percent of ammonia can be removed during winter and spring months, and removal is primarily through volatilization of ammonia gas (reference (19)). Volatilization is very pH-dependent, and improved ammonia removal occurs at higher pH values, which can be caused by algal growth (reference (23)). If additional removal is required, an aerobic zone or additional aerobic pond can be added upstream of existing stabilization ponds to stimulate biological ammonia removal (nitrification). Addition of an aerobic zone or pond can remove ammonia down to about 5 mg/L (reference (23)). Exact removal rates will depend on site-specific conditions. Because the primary ammonia removal mechanism is volatilization rather than nitrification, effluent nitrate levels will also be low.

Addition of Effluent Rock Filter to Pond

Ammonia removal can be further improved by the addition of an aerated rock filter downstream of ponds. This treatment option should be implemented in conjunction with the addition of an aerobic zone to maximize upstream ammonia removal. The rock filter should start recirculating several weeks prior to spring discharge, which will help the filter warm faster than pond water in the spring and achieve more early-spring ammonia removal than would be possible in ponds. The addition of a recirculating effluent rock filter can remove ammonia down to about 2 mg/L (reference (24)), but exact removal rates will depend on site-specific conditions. If a lower ammonia limit must be met by a WWTF currently employing stabilization ponds, the system should be upgraded to activated sludge, which can meet ammonia requirements lower than 1 mg/L.

Addition of Anaerobic and/or Anoxic Zones to Oxidation Ditches or Ponds

Oxidation ditch systems can be modified to support nutrient removal by adding anoxic zones for nitrogen removal and/or anaerobic zones for phosphorus removal. Anoxic zones can be formed within oxidation ditches by adjusting aerator operation such that added oxygen is used up and anoxic conditions reached before the water reaches the next aerator. An anaerobic zone can be added upstream of the oxidation ditch, as illustrated in Figure 5-9. This process is only practical for WWTFs with existing oxidation ditch treatment.



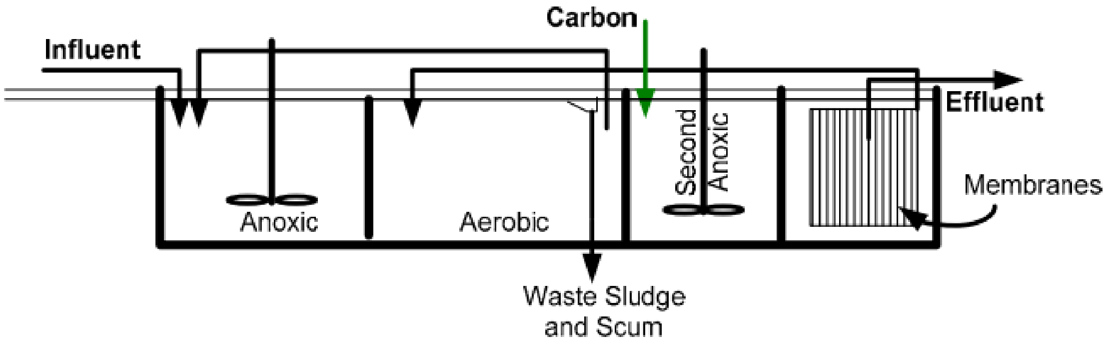
Source: (reference (17))

Figure 5-9 Oxidation ditch process with anaerobic zone

Membrane Bioreactors (MBRs)

MBRs include micro- or ultra-filtration membranes placed in the final zone of an activated sludge treatment system to act as a filter to retain biomass in the treatment tanks while removing cleaned water for downstream treatment and discharge. MBRs do not require secondary clarifiers downstream, so existing clarifiers can be repurposed into additional tank space. The membranes typically require intermittent cleaning.

MBRs enable higher biomass concentrations in the activated sludge basins and thus require a smaller footprint than systems using a clarifier for solids separation. However, MBRs are associated with more operational difficulties due to membrane biofouling, loss of system capacity during cold water conditions or membrane cleaning, and increased pumping requirements. Additionally, MBRs are associated with high chemical costs for cleaning and increased electricity costs for pushing water through the membranes (reference (17)). An example of MBRs as applied in a 4-Stage Bardenpho process is diagrammed in Figure 5-10.



Source: (reference (17))

Figure 5-10 Membrane bioreactor in 4-stage Bardenpho tank system

Addition of Fixed-Film Media to Reaction Tanks

Attached growth technologies for biological removal of nitrogen use biological cells attached to a surface to convert dissolved nitrogen to nitrogen gas. Integrated fixed-film activated sludge (IFAS) reactors are suspended growth systems that include attached growth media within the aerobic and/or anoxic zone. The inclusion of growth media increases the achievable biomass in the reactor and allows smaller footprints than suspended growth systems with the same level of treatment. IFAS media types include textile or rope media, free-floating sponge media, and free-floating plastic media.

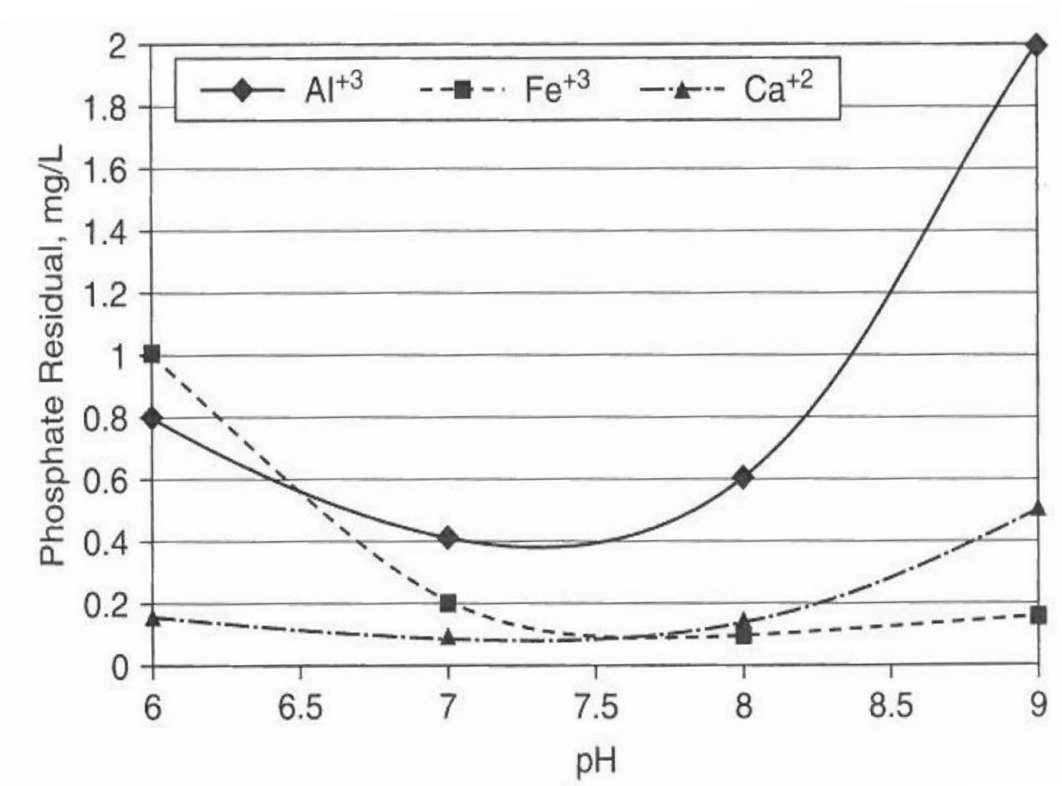
Most fixed-film systems are designed for biological nitrogen removal, but pilot-scale studies have shown that BPR can be combined with fixed-film media in the same treatment process. In these studies, phosphorus removal was observed when media was added in the anoxic zone (reference (17)). Fixed-film activated sludge systems require increased energy for mixing to keep the media suspended and downstream screens to keep the media within the reactor (reference (17)).

5.3.3.5 Chemical Phosphorus Removal

Phosphorus removal can be achieved through the addition of metals salts, which cause phosphate to precipitate out of solution. The phosphorus that precipitates out of solution will either settle out with the sludge in primary or secondary clarification or may require tertiary filtration to be fully removed from the wastewater (reference (17)). The two most common metal salts used for phosphorus precipitation are aluminum sulfate or alum ($Al_2(SO_4)_3 \cdot 14(H_2O)$) and ferric chloride ($FeCl_3$); chemical addition can happen at one or several points in the treatment system. Phosphate is then removed from the system as aluminum phosphate or ferric phosphate solids.

Conventional clarification in conjunction with chemical phosphorus removal is capable of removing total phosphorus (TP) to effluent concentrations between 0.5 and 1.0 mg/L (reference (17)). To achieve effluent concentrations below 0.5 mg/L, tertiary filtration is often required. To consistently achieve TP effluent concentrations below 0.10 mg/L, additional treatment using membrane filtration is often required (reference (25)).

The doses required for chemical phosphorus removal depend on pH, because the solubility of the solid phosphate salts produced varies with pH; however, pH does not limit phosphorus removal for most WWTFs (reference (22)). Figure 5-11 compares the theoretical remaining concentration of phosphate across a range of pH values for different types of chemical additives. The best pH range for precipitation of aluminum phosphate is 5.5-6.5 with an optimum at 6.0. The best pH range for the precipitation of ferric (Fe^{3+}) phosphate is 7.0-8.0. Lime (Ca^{+2}) can also be used for chemical phosphorus removal, but this process produces more sludge requiring removal (reference (26)). In the range of pH values generally observed in wastewater (approximately 7 to 9), higher pH decreases removal efficiency. This is a particular concern for pond system where algal growth can commonly increase pH close to 9. At optimum pH, ferric addition with filtration is capable of meeting a phosphorus limit of 0.1 mg/L. Below this, membrane filtration is required.



Source: (reference (26))

Figure 5-11 Residual phosphate concentrations following chemical phosphorus removal with metal salts at different pH values

5.3.3.6 Pond Expansion and Change in Discharge Timing to Meet Phosphorus Limits

Some pond systems may be able to meet phosphorus limits without process upgrades by adding pond volume to increase allowable storage times and opting not to discharge water during the June to September RES window. This approach is only likely to work for pond system WWTFs without restrictions on ammonia and total nitrogen, which often drive treatment technologies that also control phosphorus.

5.3.4 Summary of Nutrient Removal Methods

Table 5-3 lists the advantages and disadvantages of nutrient removal technologies.

Table 5-3 Biological nutrient removal technologies

	Removes	Advantages	Limitations	Achievable Effluent Concentrations
Stabilization Ponds	NH_3	• Does not require upgrade	• Not designed for ammonia removal • Limited removal, especially in cold months	About 12 mg/L NH_3-N (based on 70% removal from 40 mg/L NH_3-N)
Expanded Activated Sludge Aeration Tank	NH_3	• Does not require additional processes or recycle streams	• Need additional volume to remove ammonia	1 mg/L NH_3-N
Modified Ludzack-Ettinger	NH_3, NO_3	• Easy to modify existing activated sludge system	• Need to add recycle pumps and pipes	1 mg/L NH_3-N, 10 mg/L NO_3-N
4-Stage Bardenpho	NH_3, NO_3	• Easy to modify existing activated sludge system • Can remove TN to <5 mg/L	• Need to add recycle pumps and pipes • Need to add supplemental carbon source	1 mg/L NH_3-N, 5 mg/L NO_3-N
Denitrification Filters	NO_3	• Do not need to add recycle equipment • Do not need additional basin or pond capacity	• Need to add supplemental carbon source • Need to remove solids upstream to prevent filter clogging	5 mg/L NO_3-N
Oxidation Ditch with Anaerobic Zone	NH_3, TP	• Do not need to construct basins if currently using oxidation ditch	• Need more land area than activated sludge system	1 mg/L TP
Anaerobic/Oxic BPR	NH_3, TP	• Removes phosphorus without chemical addition	• Need sufficient VFAs to support BPR • Nitrate in aerobic zone effluent limits phosphorus uptake	1 mg/L TP
3-Stage PhoRedox	NH_3, NO_3, TP	• Easy to modify existing activated sludge system	• Need to add recycle pumps and pipes	1 mg/L NH_3-N, 10 mg/L NO_3-N, 1 mg/L TP
5-Stage Bardenpho	NH_3, NO_3, TP	• Easy to modify existing activated sludge system • Can remove TN to <5 mg/L • More reliable for phosphorus removal	• Need to add recycle pumps and pipes • Need to add supplemental carbon source	1 mg/L NH_3-N, 5 mg/L NO_3-N, 1 mg/L TP

Table 5-4 lists the advantages and disadvantages of nutrient removal technology enhancements.

Table 5-4 Enhancements to nutrient removal technologies

	Removes	Advantages	Limitations	Achievable Effluent Concentrations
Pond Aerobic Zone Addition		• Improves ammonia removal without upgrading to activated sludge	• Needs additional land space	About 5 mg/L NH_3-N
Pond Aerobic Zone and Effluent Rock Filter Addition		• Improves ammonia removal without upgrading to activated sludge	• Needs more additional land space • Requires additional pumping	About 2 mg/L NH_3-N
Membrane Bioreactors	Depends on baseline technology	• Improves activated sludge treatment without additional footprint • Do not need a clarifier downstream	• Need to limit membrane fouling • Increased system complexity	Depends on baseline technology
Fixed-Film Media Addition	Depends on baseline technology	• Improves activated sludge treatment without additional footprint	• Increased system complexity	Depends on baseline technology
Chemical Phosphorus Removal	TP	• Can remove TP to low levels • Can be added at any point in treatment	• Continuous operations cost of chemical addition • Only removes phosphate fraction of TP • Less effective at high pH • May need filtration to remove TP to <0.5 mg/L • Increased sludge production	0.1-1.0 mg/L TP (depending on solids separation process)

5.3.5 Process Evaluation

The primary factors that affect selection of technology to achieve effluent limits for nutrients are:

- ammonia effluent limit
- nitrate or total nitrogen effluent limit

- total phosphorus effluent limit
- existing biological treatment method

5.3.5.1 Ammonia Effluent Limit

If ammonia removal is required, the aerobic biological treatment step must be allowed more time than is needed for removal of organics. If a pond system is in place, adding an additional aeration pond may achieve ammonia nitrogen concentrations less than 8 mg/L. If ammonia needs to be removed to below 1 mg/L, activated sludge technology will be needed.

5.3.5.2 Nitrate or Total Nitrogen Effluent Limit

If the WWTF has a limit for nitrate or total nitrogen, then anoxic biological treatment is required to support denitrification. If the system does not already have ammonia removal via aerobic nitrification, this must also be included. If the effluent nitrate or total nitrogen requirement is lower than 5 mg/L, the system should include two anoxic zones, as in 4-Stage or 5-Stage Bardenpho processes. If a higher limit is set, a system with one anoxic zone such as MLE or Pho-Redox (A/A/O) may be sufficient.

5.3.5.3 Total Phosphorus Effluent Limit

If phosphorus removal is required, the WWTF could either use biological or chemical phosphorus removal. If the existing treatment system has activated sludge treatment with denitrification, an anaerobic tank may be added upstream with a recycle line to bring a portion of aerobic effluent back to the anaerobic tank, as in Pho-Redox (A^2/O) or 5-Stage Bardenpho processes. BPR will not consistently achieve total phosphorus concentrations less than 1 mg/L, so if the limit is lower, chemical addition for phosphorus removal will be required. Depending on how low the limit is, tertiary filtration may be required to remove phosphorus-containing solids.

5.3.5.4 Process Evaluation Summary

A flow chart outlining decision making for both sulfate and chloride reduction is diagrammed in Figure 5-12.

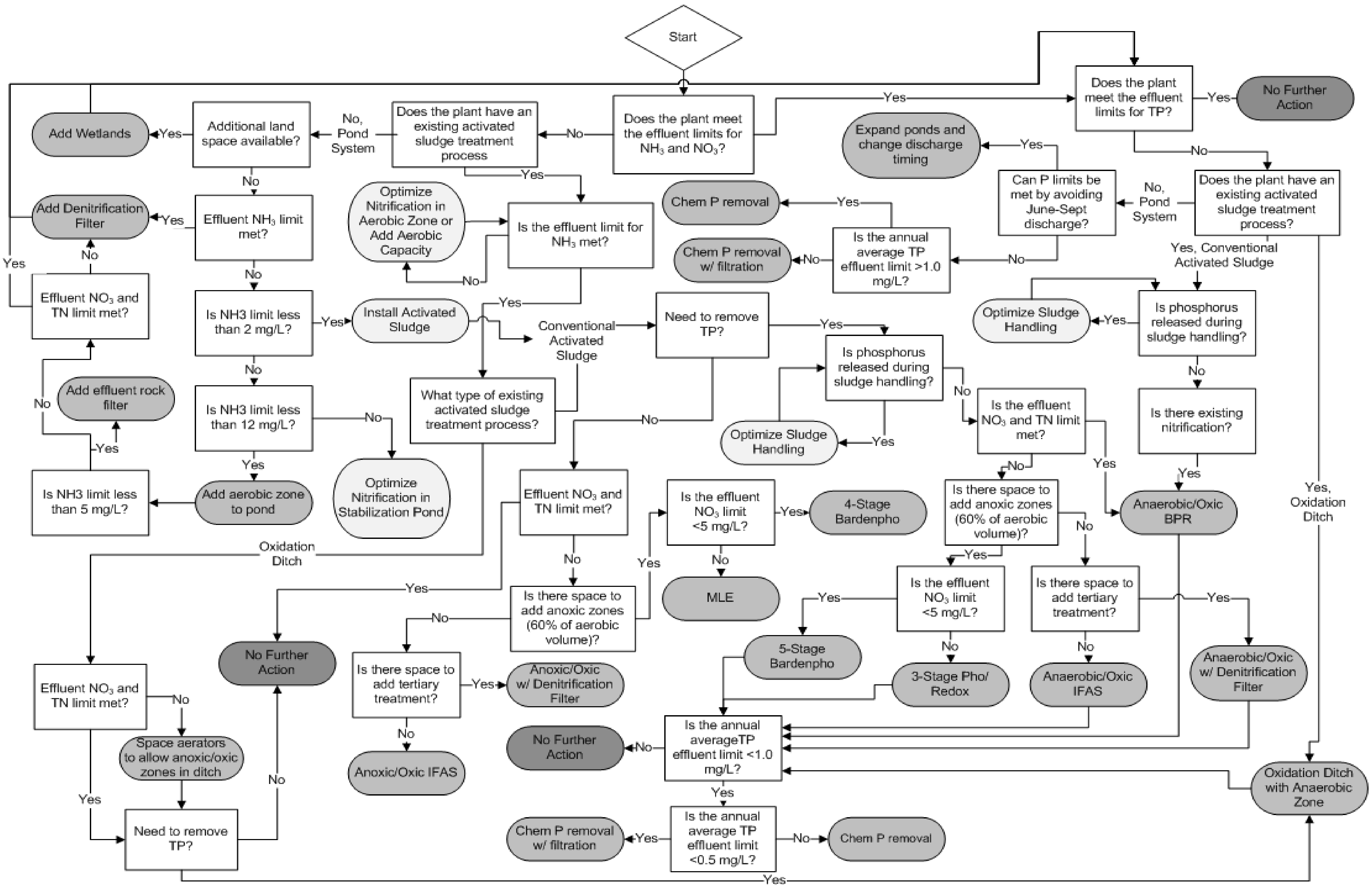


Figure 5-12 Nitrogen and phosphorus removal decision flow chart

5.4 Sulfate

This section describes potential technology upgrades that could be used to remove sulfate. None of the WWTFs evaluated for this study currently employ technology to remove sulfate. It also summarizes the logic used to determine the appropriate sulfate removal technology upgrades or sulfate reduction strategies to achieve estimated current and future effluent limits at the WWTFs in this study.

5.4.1 Background

Sulfate is a chemical commonly found in air, soil, and water. Since it is relatively soluble, sulfate can be found at elevated concentrations in many aquifers and in surface water. As water moves through soil and rock formations that contain sulfate minerals, some of the sulfate dissolves into the groundwater. Sulfate is also generated from sulfide minerals after oxidation via exposure to air, water, and biological activity.

The concentration of sulfate in most groundwater in Minnesota is less than 250 milligrams per liter (mg/L) (reference (27)). Sulfate occurs at higher concentrations, which sometimes can exceed 1,000 mg/L in certain areas of the state, particularly in the southwest and along the western boundary. Elevated concentrations of sulfate also occur, though less commonly, in some aquifers in the northeastern and southeastern parts of the state (reference (27)). Figure 5-13 below shows sulfate concentrations in different parts of the Midwest in the St. Peter-Prairie du Chien-Jordan and Mt. Simon aquifers. Sulfates have become an issue for wastewater treatment in Minnesota due to water quality regulations for wild rice waters. Typical sulfate concentrations in untreated domestic wastewater range from 20 to 50 mg/L (reference (14)). Because these values are higher than the estimated current and future WQBELs, source reduction will not be able to remove enough sulfate to meet limits.

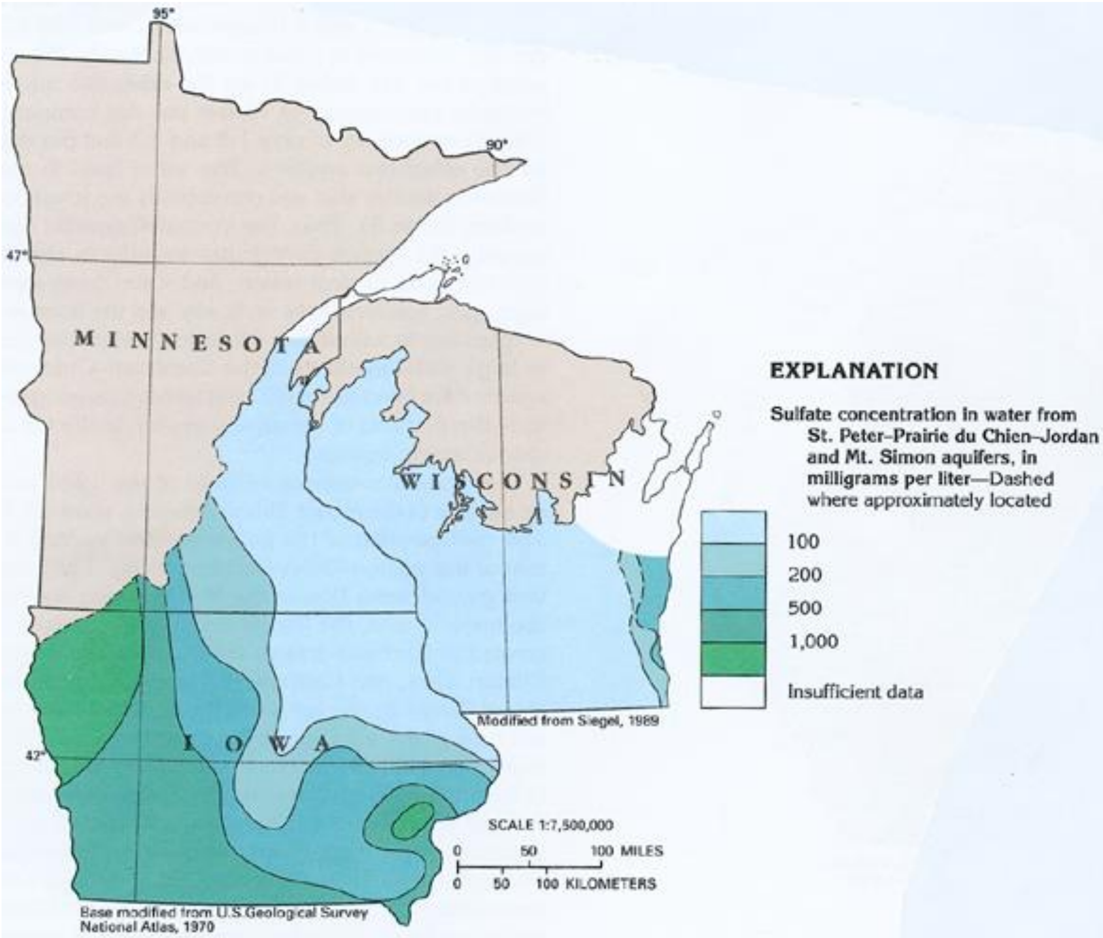


Figure 130. *Sulfate concentrations in water from the St. Peter–Prairie du Chien–Jordan and Mount Simon aquifers parallel concentrations of chloride and dissolved solids. The large sulfate concentrations in northwestern Iowa are due to recharge of sulfate-rich water from the Cretaceous aquifer.*

Source: Figure 130 of reference (28)

Figure 5-13 Sulfate concentrations in upper midwest

5.4.2 Potential Methods to Implement Sulfate Removal and Reduction

Removal of sulfate from wastewater is most practical using either source reduction or technologies to remove sulfate ions such as ion exchange and nanofiltration (NF).

5.4.2.1 Sulfate Source Reduction

If a municipality sources its drinking water from groundwater aquifers, sulfate naturally present in groundwater travels through drinking water distribution, water use, and disposal to wastewater treatment where it contributes to effluent sulfate concentrations. Groundwater has higher concentrations of sulfate and other dissolved minerals than surface water. If the amount of sulfate present in the groundwater source is above the sulfate effluent limit and there is a surface water source available, wastewater sulfate concentrations may be reduced by switching the drinking water source from groundwater to surface water. Additional treatment will still be needed to meet estimated effluent limits.

5.4.2.2 Lime Precipitation

Lime can be added to water streams to remove sulfate as gypsum; however, this method is only effective if the sulfate concentration is greater than 2,000 mg/L. This is significantly higher than the sulfate concentrations typically found in wastewater (reference (29)).

5.4.2.3 Biological Sulfate Removal

Bacterial cells can respire using sulfate instead of oxygen if oxygen is not present. Biological sulfate removal uses bacteria to reduce sulfate to sulfide, which can be removed via precipitation with metals in the water or via ventilation to the atmosphere as hydrogen sulfide gas. Organic material or other bacterial substrate (food) is required for this process. Metals may also need to be added to remove sulfide from the water phase (references (29) and (30)).

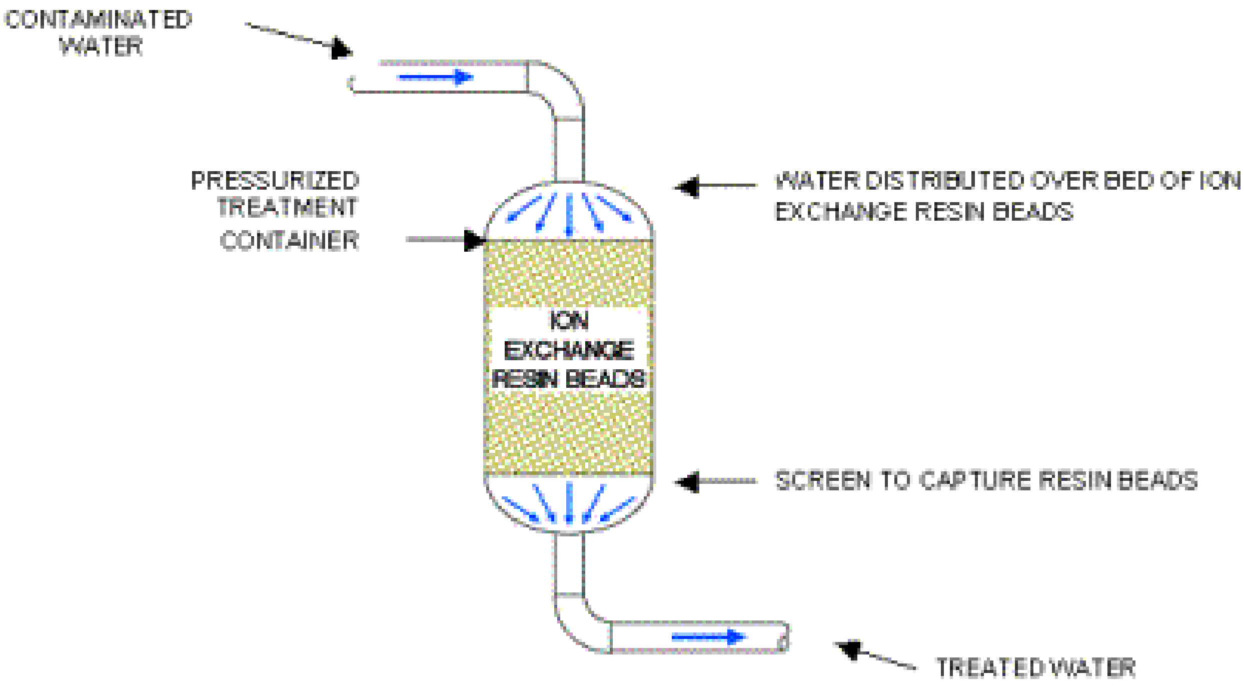
Biological sulfate removal can use either constructed wetlands or bioreactors and has been successfully used in the mining industry to remove sulfate from mining-impacted waters. The use of constructed wetlands can remove sulfate to 250 mg/L (reference (31)). Recent research has identified alternate processes for biological sulfate removal from wastewater, including processes tied to nitrogen and phosphorus removal. However, none of these have been implemented at full scale (30).

Due to its limited reliability and the need for carbon addition, biological sulfate removal has not been implemented by Minnesota wastewater treatment facilities.

5.4.2.4 Ion Exchange

Ion exchange resins have charged surfaces that can exchange similar ions between the resin surface and solution. For example, cation exchange resins are used to soften water in home water softeners; sodium attached to the resin surface is exchanged for hardness (calcium and magnesium) in the water, so sodium is added and hardness is removed. The ion-exchange process is diagrammed in Figure 5-14.

Ion exchange is the most common method used to remove large quantities of sulfate from water for commercial and public supply. Once the resin is loaded to capacity with sulfate, it is rinsed with a concentrated salt solution that regenerates the resin by removing the sulfate to a concentrated brine solution. Several sulfate-specific ion-exchange technologies, such as Sulf-IX™ and GYP-CIX are available on the market (BioteQ, 2015). Ion exchange for sulfate can also remove other anions such as nitrate.



Source: reference (32)

Figure 5-14 Ion exchange treatment process

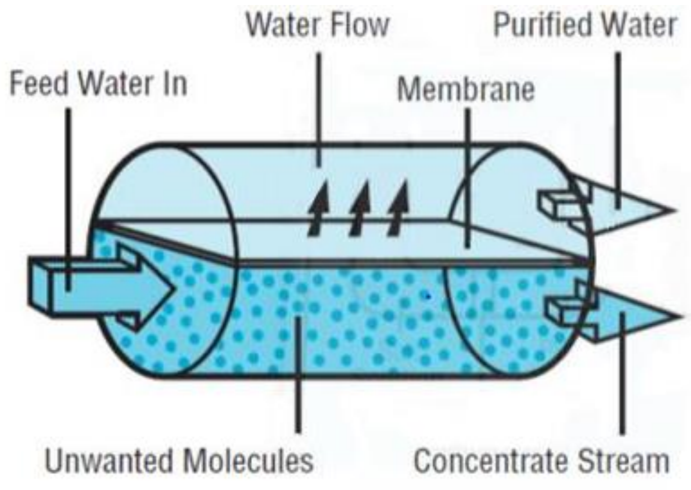
The disadvantages of ion exchange include the need to dispose of concentrated regeneration solution and the need to remove solids and organic material upstream to prevent resin fouling. Refer to Section 5.5.2.6 for a discussion of brine management technologies.

5.4.2.5 Membrane Filtration

In membrane filtration, pressure is applied to force a solution through the membrane. The membrane allows the water to pass through but restricts some salts and other compounds, which end up in a concentrated brine solution. Figure 5-15 shows the membrane filtration process. Different types of membranes have different pore sizes, which allows them to remove increasingly smaller compounds from the water phase. Nanofiltration (NF) membranes remove all particles, bacteria, and viruses as well as most organic compounds and polyvalent ions, such as sulfate.

Sulfate and other contaminants retained in membrane-separation processes end up in a concentrated brine solution that requires disposal, which adds to operational costs.

Reverse osmosis (RO) membranes can remove a higher percentage of sulfate from a wastewater stream than NF. However, NF treatment will have lower capital costs and operating costs than RO treatment of a similar flow due to the lower pumping pressure required. (reference (33)). For systems that will require treatment for both chloride and sulfate, it may be more cost effective to expand the RO system to treat sulfate rather than install a separate NF treatment train. For this analysis, the RO system capacities are determined for the purpose of meeting chloride limits. Additional capacity required to meet the sulfate limit is provided by NF treatment. RO is discussed in more detail in Section 5.5.2.4.



Source: reference (34)

Figure 5-15 Membrane filtration process

Membrane systems typically require pre-treatment to protect the membranes from solids or organic material that can clog pores and may require post-treatment to return some salts to the water and prevent downstream toxicity (reference (29)).

5.4.2.6 Electrodialysis Reversal

Electrodialysis reversal (EDR) can be used to remove sulfate from waste streams but is not typically applied for sulfate removal as it removes monovalent ions as well and is more expensive than NF. EDR is described in Section 5.5.2.5 as it is more practical for chloride removal than for sulfate removal.

5.4.2.7 Brine Treatment and Disposal

Ion exchange, NF, RO, and EDR technologies all produce a waste brine solution. Disposal of a brine solution can be accomplished through ocean discharge, subsurface injection, evaporation ponds, brine concentrators, or crystallizers. Subsurface injection involves injecting the brine into a well terminated in an underground rock formation, but this approach is not permitted in Minnesota. Evaporation ponds are effective at treating brine but require a large land area and a warm climate where evaporation exceeds precipitation to be effective.

Brine concentrators or evaporators are mechanical systems used to concentrate brine through a combination of thermal evaporation and increased surface area. Crystallizers use thermal energy to further remove water. Both types of systems can recover clean water which can be sent to discharge or used otherwise. Due to the high concentration and potential corrosivity of brines and slurries, concentrators and crystallizers typically must be constructed of durable materials, which increases the capital costs (reference (35)).

The final product of a concentrator or a crystallizer is a concentrated salt slurry or a dried salt cake which must be hauled offsite for landfill disposal (reference (36)). Heat generated in evaporators and crystallizers could potentially be reused onsite to heat sludge prior to digestion.

5.4.3 Summary of Sulfate Removal Methods

Table 5-5 summarizes advantages and disadvantages of technologies that may be applicable for sulfate removal at WWTF.

Table 5-5 Sulfate reduction and removal technology summary

	Advantages	Limitations	Achievable Effluent Concentrations
Lime Precipitation	Low cost treatment option	• Not effective for streams with under 2,000 mg/L sulfate	2,000 mg/L
Biological Sulfate Removal	Low cost treatment option	• Requires large footprint • Limited reliability • Not previously applied to wastewater treatment in Minnesota	250 mg/L
Ion Exchange	Low achievable effluent sulfate concentrations	• Requires pretreatment to preserve equipment life • Requires evaporator crystallizer for regeneration disposal and landfill of waste salt	100 mg/L or less
NF Membrane Filtration	Low achievable effluent sulfate concentrations	• Requires pretreatment to preserve equipment life • Requires evaporator crystallizer for brine disposal and landfill of waste salt	10 mg/L or less (assuming 95% removal from 200 mg/L)
RO Membrane Filtration	• Low achievable effluent sulfate concentrations • Also removes chloride	• Requires pre-treatment • Requires post-treatment • Energy-intensive • Requires evaporator crystallizer for brine disposal and landfill of waste salt • More expensive to install and operate than NF	2 mg/L (assuming 99% removal from 200 mg/L)
EDR	• Low achievable effluent sulfate concentrations Also removes chloride	• Requires some pre-treatment • Requires evaporator crystallizer for brine disposal and landfill of waste salt • More expensive to install and operate than NF	<50 mg/L (based on 70%-90% removal of nitrate)[(1)]
Sulfate Source Reduction	If feasible, may remove need for treatment upgrades	• Requires availability of a surface water for drinking water supply • Only practical if sulfate target can be met by switch	Reduction similar to difference in water source sulfate concentrations

(1) Reference (37)

5.4.4 Process Evaluation

The primary factors that affect selection of technology to achieve effluent limits for sulfate are:

- sulfate effluent limit

- primary sulfate source(s)
- water quality downstream of secondary clarifier

5.4.4.1 Required Level of Sulfate Removal

The level of sulfate removal required dictates whether source reduction could feasibly meet limits or whether additional treatment technology would be needed.

5.4.4.2 Primary Sulfate Sources

Sulfate source reduction may be a feasible alternative for WWTFs where the majority of the influent sulfate concentration is from groundwater and an alternate drinking water source is available.

5.4.4.3 Process Evaluation Summary

A flow chart outlining decision making for both sulfate and chloride reduction is diagrammed in Figure 5-16. These are grouped together because processes that remove chloride also remove sulfate. For this cost analysis, NF membrane treatment was selected for all WWTFs requiring sulfate removal because costs are expected to be comparable to ion exchange.

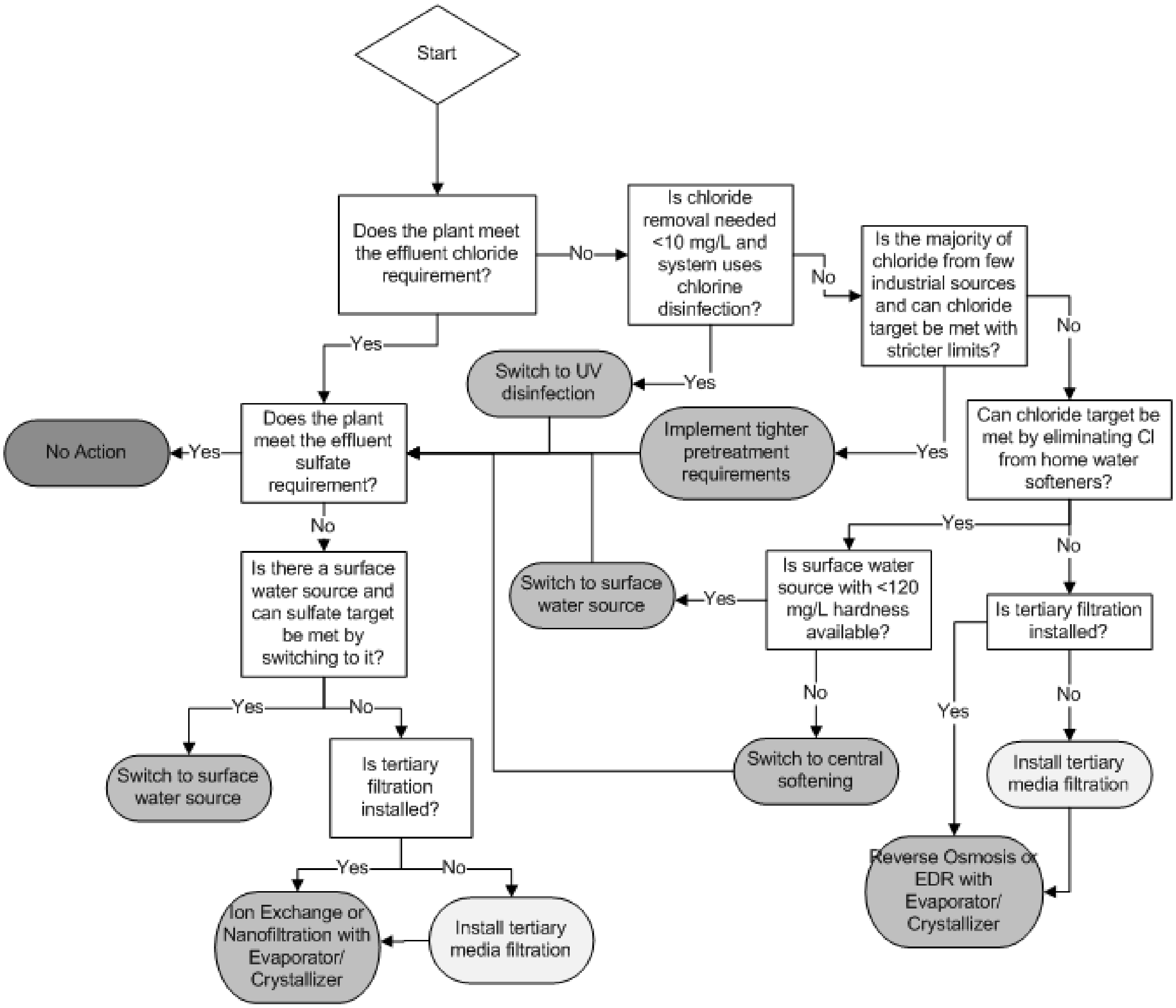


Figure 5-16 Sulfate and chloride reduction and removal decision flow chart

5.5 Chloride

This section describes potential source reduction approaches and technology upgrades that could be used to reduce chloride concentrations in WWTF effluent. None of the WWTFs evaluated for this study currently employ technology to remove chloride. It also presents the logic used to determine the appropriate chloride-removal technology upgrades to achieve estimated current and future effluent limits at the WWTFs in this study. Source reduction methods were not considered for this cost analysis. Source reduction has the potential to be effective for chloride, but implementation involves significant work with the community and industry, which is beyond the scope of this analysis.

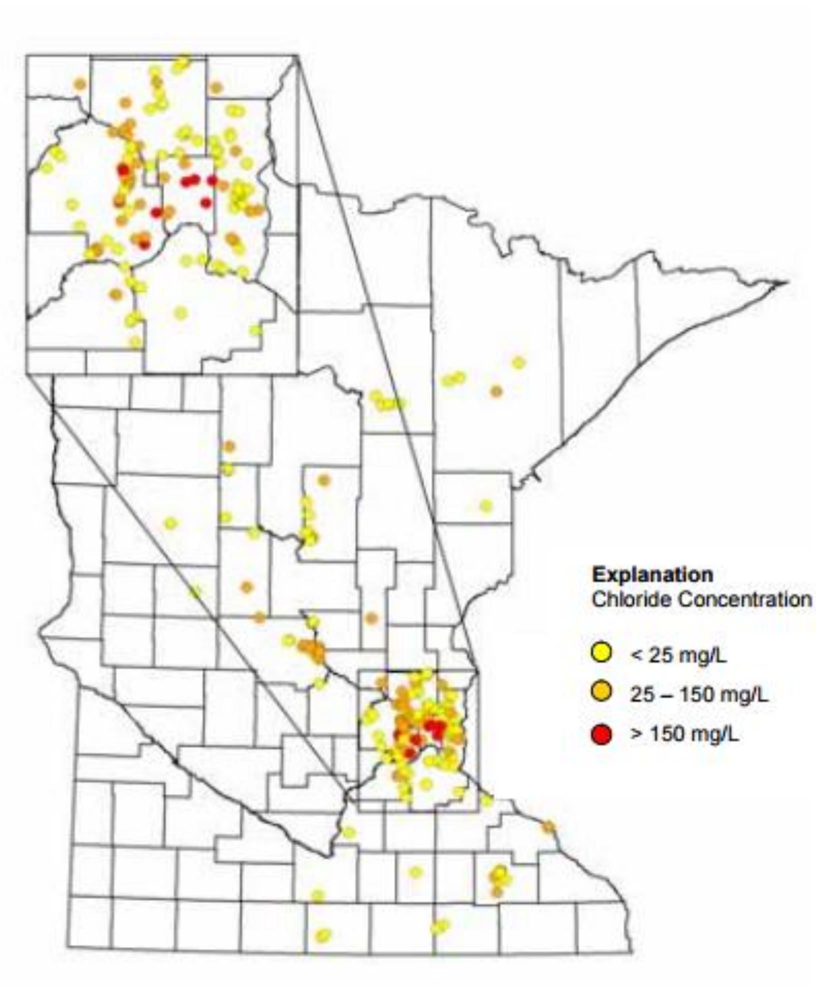
5.5.1 Background

Chloride in water comes from chloride salts, such as sodium chloride or table salt. It is present in water as a negatively charged ion. Most chlorides in wastewater come from industrial and commercial processes or from home water softeners and human waste. Concentrations vary from each source. Table 5-6 shows a typical breakdown of chloride concentrations in the previously mentioned sources. Source reduction of chloride can decrease chloride concentrations in wastewater effluents and is summarized in Section 5.5.2.1 through Section 5.5.2.3. A literature review indicated that the only widely accepted technology for removing chloride from a wastewater stream is RO filtration. Other less widely applied treatment processes include desalination and EDR. These technologies are described in Section 5.5.2.4 and 5.5.2.5.

Table 5-6 Breakdown of typical chloride source concentrations

	Minnesota Groundwater(1)	Home water softeners(1)(2)	Industrial Processes	Domestic strength wastewater(3)
Chloride concentration (mg/L)	1-250 mg/L	500-800 mg/L in wastewater influent	Varies	30-100 mg/L

(1) Reference (38)
(2) Reference (39)
(3) Reference (14)



Source: reference (40)

Figure 5-17 Chloride concentrations in Minnesota groundwater

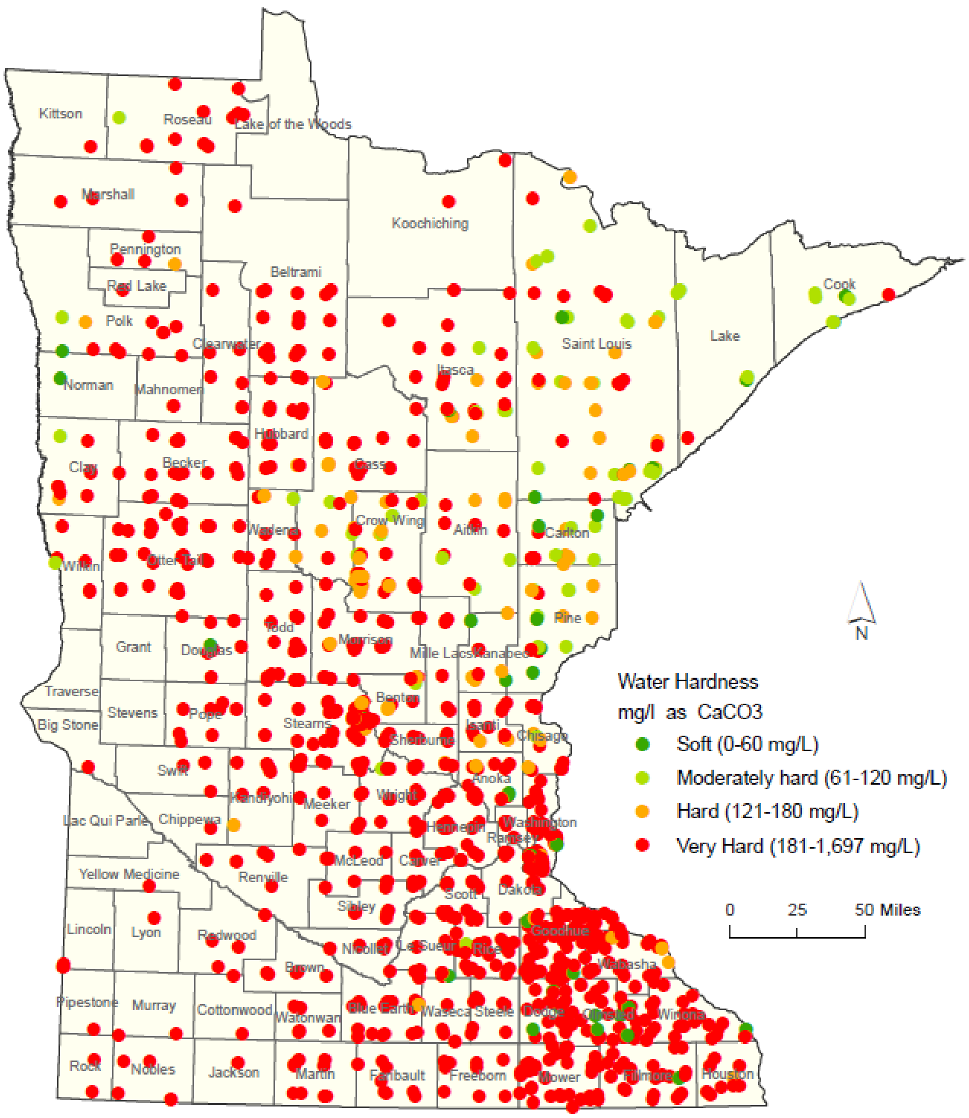
With a few exceptions, chloride concentrations in Minnesota groundwater are nearly all below 150 mg/L which is low enough to meet most chloride discharge standards with the typical concentration from domestic wastewater added. Surface waters typically contain less chloride than groundwater. Figure 5-17 illustrates chloride concentrations in groundwater across the state. Reducing the amount of chloride added between the source water and the WWTF may be a practical solution to meet chloride limits (refer to Section 4.6.5 for effluent limits).

5.5.2 Potential Methods to Implement Chloride Removal and Reduction

Since chloride is highly soluble in water and does not have a safe gaseous compound, it can only be removed from water by physically separating the chloride ions from the water phase into a concentrated brine solution. Depending on chloride sources, source reduction may be a reasonable alternative.

5.5.2.1 Chloride Source Reduction by Centralized Softening

In communities with a hard water source (hardness greater than 100 mg/L as $CaCO_3$), water softening is typically implemented, either at a centralized water treatment facility providing potable water to the municipal water distribution system or at point-of-use in a home, business, or industry. Point-of-use water softeners use ion-exchange technology to remove hardness and are periodically regenerated to remove the hardness using added salt that contains both sodium and chloride. The salt brine, which is sourced from salt pellets rather than from the water source, is discharged to the municipal sewer and ends up in wastewater treatment influent. This chloride source can be reduced or eliminated by either switching to centralized water softening or by switching to a water source that does not require softening. Centralized softening by lime softening or NF would not add salt, thus significantly reducing the chloride concentration in treated potable water and wastewater influent. While centralized softening by ion exchange would still add chloride, the amount added would be lower than in point-of-use softeners, so chloride concentrations in wastewater influent would still be reduced. As shown in Figure 5-18, nearly all groundwater sources in Minnesota require softening.



Source: reference (41)

Figure 5-18 Well water hardness concentrations across Minnesota

Centralized softening at a water treatment plant could reduce or remove chloride discharged to wastewater treatment plants from individual water softening units (reference (41)).

Implementing centralized softening at water treatment could be more cost effective than implementing chloride removal at wastewater treatment because wastewater has more dissolved constituents, which makes RO or EDR treatment costly. In addition, chloride brine disposal at the WWTF has very high capital and operation costs.

If centralized softening is implemented for the purpose of reducing chloride in municipal wastewater, it may also be necessary to ban the use of point-of-use ion exchange water softeners to achieve decreased chloride loading.

Centralized Ion Exchange Softening

The amount of chloride added to drinking water during ion exchange softening can be reduced if softening is conducted in a centralized process rather than at the consumer's point-of-use. Most point-of-use softeners remove nearly all hardness from water, but final hardness values of 100-150 mg/L are acceptable for municipal use. Thus, only a portion of the water would require ion exchange treatment. In addition, many point-of-use softeners regenerate more often than necessary and use more salt than a centralized system would. Switching from point-of-use ion exchange softening to centralized ion exchange can reduce the amount of chloride added but still adds some chloride. Ion exchange is further described in Section 5.4.2.4.

Centralized NF Softening

Hardness can be removed from drinking water through RO treatment, and brine produced can be routed directly to the wastewater treatment plant. Only a portion of water would require RO treatment. Similar to lime softening, NF softening does not contribute chloride to wastewater influent. Calcium and magnesium concentrated from the source water would still end up in the wastewater stream as they do with point-of-use ion exchange softeners, but the concentrate would not include the salt used in regenerating ion exchange softeners. Because about 25 percent of feed water is lost to the brine, NF softening would require increased feed capacity to meet the same water demand and may require additional wells. A significant part of the capital costs for NF softening is associated with building additional upstream well and treatment capacity. Brine produced in NF softening at water treatment plants can be routed to the wastewater treatment plant. Brine produced at wastewater treatment plants would require the high expense of thermal crystallization and landfill disposal of produced salt.

Centralized Lime Softening

Lime softening involves adding lime and sometimes soda ash to remove hardness from water. The hardness is removed in a clarifier as solid salts that precipitate from solution. This sludge requires dewatering and disposal. Lime softening does not add chloride to the water and would remove calcium and magnesium from the wastewater stream which could be beneficial for WWTF having low Total Dissolved Solids (TDS) limits. Lime softening is the most expensive centralized softening option due to large equipment required for chemical dosing and settling.

Centralized Softening Cost Comparison

Capital costs were estimated for upgrading water treatment to include centralized softening technologies, as shown in Figure 5-19. Costs assume initial water hardness of 400 mg/L as $CaCO_3$ and final treated water hardness of 100 mg/L as $CaCO_3$. Ion exchange costs were based on CapDetWorks™ models and assume additional well and water treatment capacity is not required.

Nanofiltration (NF) costs for membrane treatment were based on cost estimates described in Appendix C and include costs for additional well and water treatment capacity required to maintain the pre-softening production rate. Costs for additional water treatment capacity were estimated based on a survey of Minnesota water treatment plants with groundwater sources constructed in the past 20 years. Additional

WWTF required to treat the brine flow is not included in the estimate but could be substantial if the WWTF currently operates near its design capacity.

Lime softening costs were based on cost curves presented in reference (42). Estimated costs include equipment-associated contingency and contractor profit but do not include land, engineering, legal, and administrative costs or project-associated contingency.

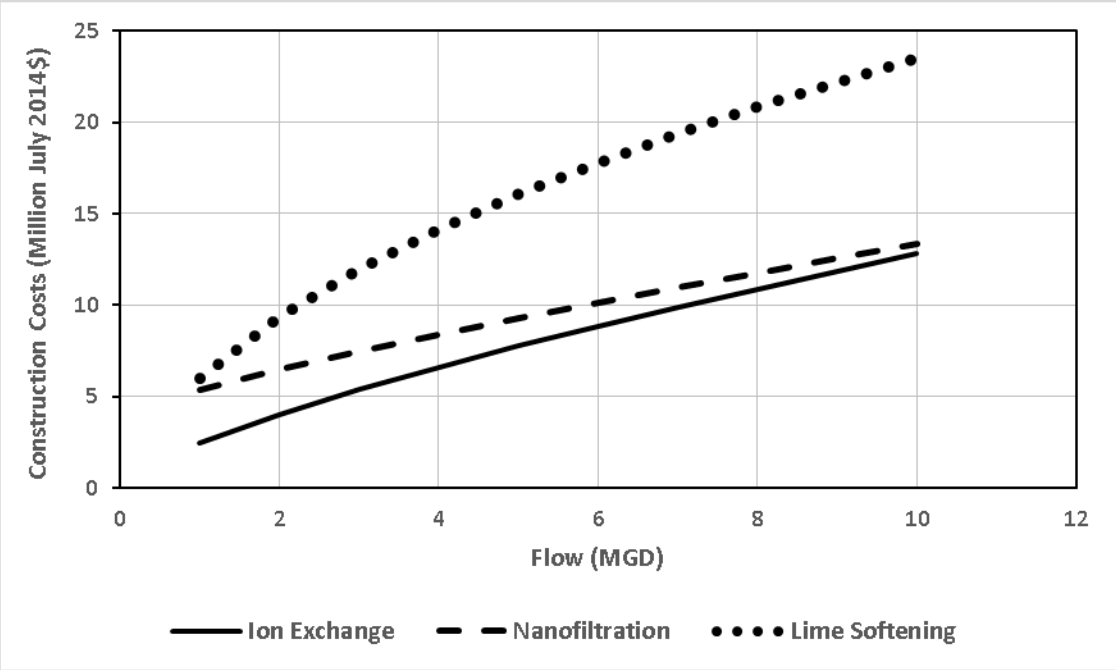


Figure 5-19 Comparison of costs for centralized softening options

5.5.2.2 Chloride Source Reduction by Industrial Pretreatment

Chloride in wastewater effluent originates from industrial, commercial, and municipal waste streams. If a substantial mass of chloride in a specific wastewater influent comes from industrial sources, the wastewater utility could implement more restrictive pre-treatment requirements for entities contributing significant amounts of chloride. The achievable chloride reduction is limited to the amount of chloride originating from industrial facilities.

5.5.2.3 Chloride Source Reduction by UV Wastewater Disinfection

Chloride in wastewater can also come from chlorine disinfection of wastewater effluent. Chlorine is frequently used to kill pathogens prior to discharge and results in formation of chloride. Use of an alternate disinfection mechanism, such as ozone or UV disinfection, can reduce the chloride contribution from wastewater disinfection. Because the concentration of chloride contributed by chlorine disinfection is typically less than 10 mg/L, this change will not reduce effluent chloride concentrations by more than 10 mg/L (reference (43)).

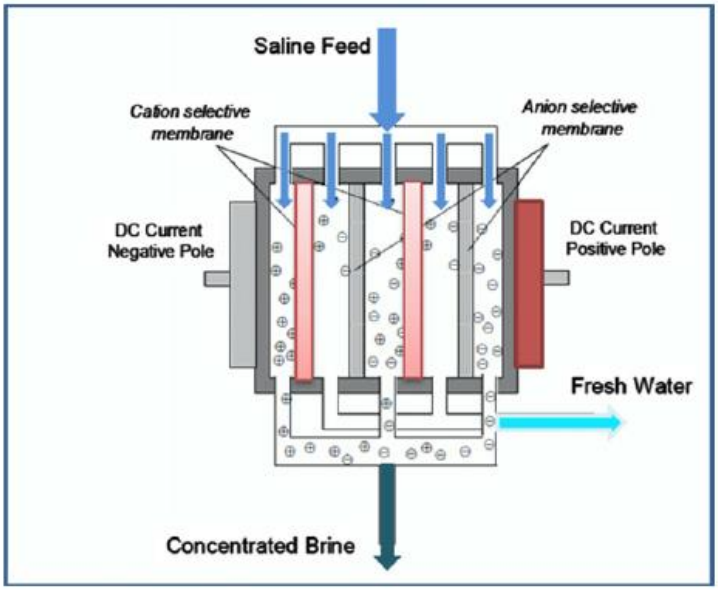
5.5.2.4 Reverse Osmosis Membrane Filtration

Membrane filtration was previously described in Section 5.4.2.5. The type of membrane that can remove the widest variety of contaminants from water is an RO membrane. RO membranes can remove salt (including chloride) from water and are used in desalination of salt water. These membranes also remove most other contaminants, including suspended solids, organic material, bacteria, viruses, phosphorus, nitrogen, and sulfate.

Chloride and other contaminants retained in the RO process end up in concentrated brine solution that requires disposal, which adds to operational costs. Refer to Section 5.5.2.6 for a discussion of brine management technologies.

5.5.2.5 Electrodialysis Reversal

EDR uses an electric current to move dissolved salt ions through layers of charged membranes. As a result, it can also remove nitrate. This process is diagrammed in Figure 5-20. EDR does not remove pathogens, suspended solids, or uncharged compounds (reference (33)). EDR technology was developed in the 1970s and has been applied in desalination applications in the Middle East and elsewhere (reference (37)). EDR has not been applied to wastewater treatment in Minnesota but has been used to treat wastewater as part of water reuse processes in California (reference (44).



Source: reference (45)

Figure 5-20 EDR technology diagram

Water should be pre-treated with microfiltration or sand filtration to remove suspended solids and organic material (that can reduce the EDR equipment lifetime) before it is fed into an EDR system (reference (46)). Relative to RO membrane filtration, EDR can treat water with higher concentrations of salts and organic material but has lower removal efficiency (reference (37)). EDR is more complex to operate than membrane filtration (reference (46)). However, it provides higher water recovery and less brine solution that needs to be managed. Refer to Section 5.5.2.6 for a summary of brine-management technologies.

5.5.2.6 Brine Treatment and Disposal

Reverse osmosis and EDR brines would require brine treatment and disposal as described in Section 5.4.2.6.

5.5.3 Summary of Chloride Removal and Reduction Technologies

The relative advantages and limitations of chloride reduction and removal technologies and achievable effluent concentrations are presented in Table 5-7.

Table 5-7 Chloride Reduction and Removal Technology Summary

	Advantages	Limitations	Achievable Effluent Concentrations
Reverse Osmosis Membrane Filtration	• Removes other contaminants • Well established technology • Low concentrations in treated water enable treatment of partial flow	• Requires pre-treatment • Requires post-treatment • Energy-intensive • Requires evaporator crystallizer for brine disposal and landfill of waste salt	4 mg/L (assuming 99% removal from 400 mg/L)
Electrodialysis Reversal	• Longer equipment life than RO • Can treat lower quality water than RO	• Requires pre-treatment • Operational complexity • Requires evaporator crystallizer for brine disposal and landfill of waste salt	<100 mg/L (IPEC, 2001) (Bureau of Reclamation, 2009)
Source Reduction – Industrial Pretreatment	• Reduces the need for chloride treatment • Does not require modifications to municipal water or wastewater treatment	• Requires negotiation with industry • Limited reduction achievable	Depends on contribution from industry
Source Reduction – UV Disinfection	• Reduces the need for chloride treatment • Modification less expensive than centralized softening	• Limited reduction achievable	Reduction less than 10 mg/L
Chloride Source Reduction – Centralized Softening	• Reduces the need for chloride treatment	• Requires community participation and water treatment plant upgrades • NF softening requires increased well capacity	Similar to hardness of groundwater source plus industrial additions

5.5.4 Process Evaluation

The primary factors that affect selection of technology to achieve effluent limits for chloride are:

- Required level of chloride removal
- Primary chloride source(s)
- Water quality downstream of secondary clarifier
- Community factors related to chloride source reduction

5.5.4.1 Required Level of Chloride Removal

The amount of chloride that needs to be removed dictates whether source reduction is feasible. Additionally, if only a slight amount (<10 mg/L) needs to be removed, the WWTF may be able to meet the limit by switching to UV disinfection.

5.5.4.2 Primary Chloride Sources

Chloride source reduction may be a feasible alternative for WWTFs where the majority of influent chloride originates from industries or from home water softeners. Depending on the sources of chloride and the utility's relationship with the water treatment utility, industries, and the community, these methods may be able to meet chloride limits if the required level of removal is fairly low.

5.5.4.3 Process Evaluation Summary

A flow chart outlining the decision-making process for both sulfate and chloride reduction is diagrammed in Figure 5-16. For this cost analysis, RO membrane treatment was selected for all WWTFs requiring chloride removal because costs are expected to be comparable to EDR.

5.6 Methods for Cost Analysis

Costs for WWTF upgrades to meet existing and recently adopted (current) water quality standards and for WWTF upgrades to meet proposed or anticipated (future) water quality standards were estimated using the following steps:

1. Determine current and future water quality standards
2. Estimate WWTF effluent limits based on current and future water quality standards
3. Conduct a site visit to the WWTF to get first-hand information
4. Select treatment units to meet effluent limits based on current and future water quality standards
5. Estimate costs based on CapDetWorks™ software

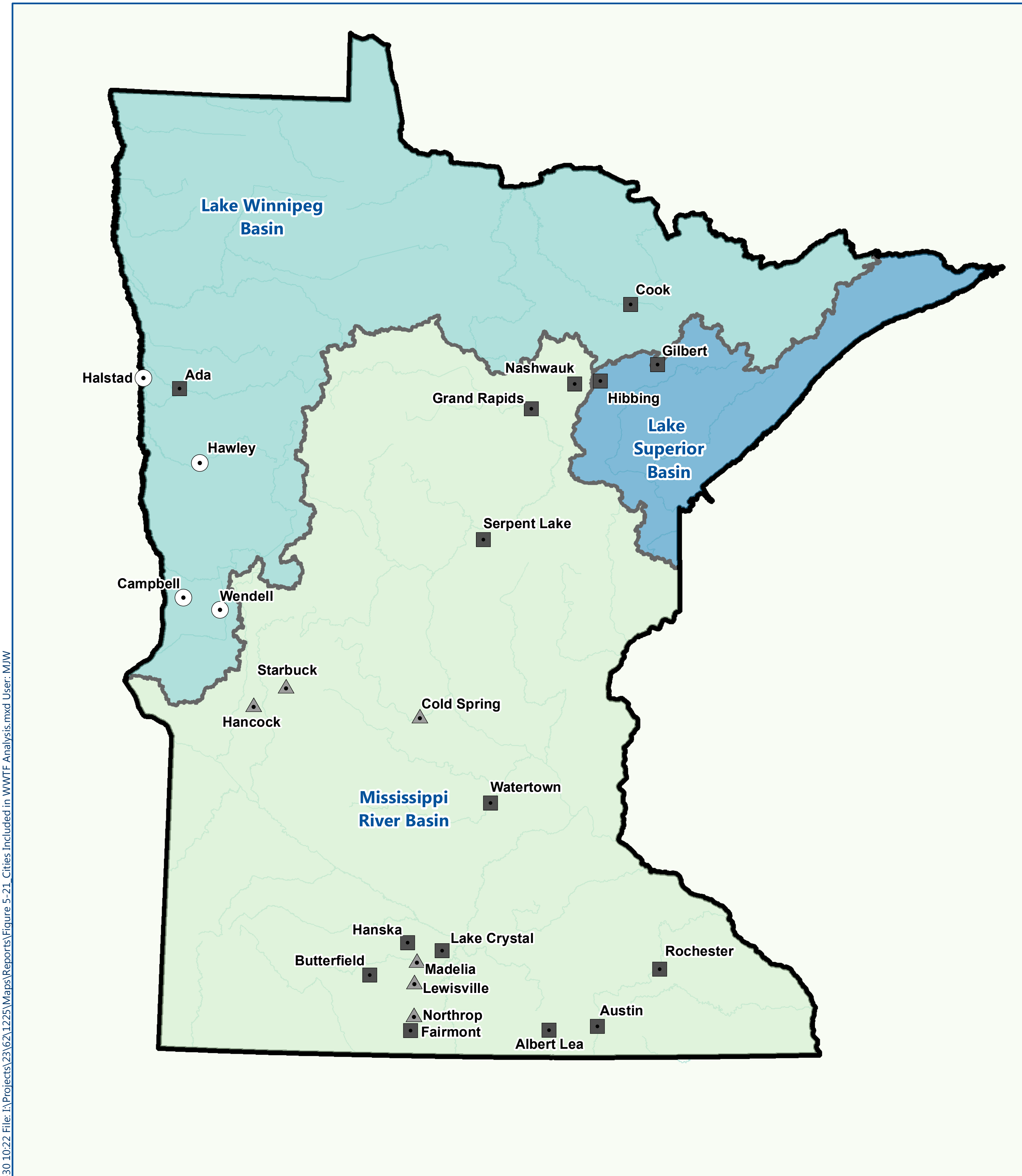
Steps to determine water quality standards and estimate WWTF effluent limits are described in Sections 3.0 and 4.0. Site visits are described below in Section 5.6.1, treatment technology selection is described in Section 5.6.3, and cost estimation based on CapDetWorks™ modeling is described is Section 5.6.4.

5.6.1 Selection of 15 WWTF for Cost Analysis

Of the 25 WWTFs included in the effluent limit evaluation described in Section 4.0, 15 were selected for the WWTF cost analysis. In the project proposal, Barr proposed six criteria for selecting WWTFs:

- Willingness (preference given to facilities with staff available to attend site visits)
- Completeness of data (preference given to facilities with more complete historic data analyses)
- Effluent limit development (preference given based upon quality of data used to develop effluent limits)
- Capacity (preference given to review a range of capacities)
- Location (preference given to more varied geographical and watershed locations and more varied classes of receiving water)
- Existing treatment technology (preference given to varied technologies)

When Barr asked whether the WWTF would like to be included in the cost analysis evaluation, six WWTFs declined participation, and four WWTFs did not respond. All of the remaining 15 were evaluated for costs to meet current and future WQS. WWTFs that declined participation generally did not have sufficient time to host a site visit and gather the data and documents required for the cost analysis. While other criteria were not used to select the 15 WWTFs for cost evaluation, they do span the geographical breadth of the state and include multiple facilities in each of the state's three river nutrient regions, as shown in Figure 5-21. The evaluated WWTFs also span a range of existing treatment technologies, capacities, and estimated effluent limits.



WWTFs Included in Wastewater Cost Section of "Cost Analysis of Water Quality Standards"

- City agreed to participate
- City declined participation
- City did not respond

Minnesota State Boundary

Major Basin Divide

- Mississippi River
- Lake Superior
- Lake Winnipeg

BARR

CITIES INCLUDED IN
WWTF COST ANALYSIS
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 5-21

5.6.2 Site Visits

Barr staff visited the 15 selected WWTFs to record information about the following:

- Existing treatment processes
- Typical WWTF operations
- Significant industrial users discharging to WWTF
- Discharge location and watershed
- Site-specific design considerations
- Plans for city growth and future wastewater flows

The data, existing facility plans, and record drawings (where available) were used to support treatment technology evaluations and cost estimates described below. Site visits were conducted in September and October 2016.

5.6.3 Treatment Technology Evaluation

Based on existing technology and system constraints identified during site visits, estimated effluent limits, and historical effluent water quality data, Barr's team selected the most cost-effective treatment upgrade or upgrades expected to meet estimated limits for each WWTF. This evaluation was performed twice for each WWTF - for estimated effluent limits under current and future WQS. In accordance with Minnesota anti-backsliding rules, limits in existing permits were assumed to apply to current and future limits if a more stringent current or future limit was not estimated and limits under current standards were assumed to apply to future limits if a more stringent future limit was not estimated.

Technology evaluations were performed using decision flow charts shown in Figure 5-2, Figure 5-12, and Figure 5-16. In some cases, circumstances at an existing WWTF required a different treatment process than recommended by the flow charts.

5.6.4 Development of Cost Models

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., was used to estimate capital, operations, and maintenance costs. CapDetWorks™ is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

Three cost estimate models were developed for each WWTF:

- Model of existing treatment system
- Model of proposed treatment system to meet current WQS
- Model of proposed treatment system to meet future WQS

Cost models for a given WWTF scenario were built by adding each treatment process in CapDetWorks™ and aligning model assumptions with conditions at the site. Estimated costs for upgrade scenarios were calculated by subtracting existing system costs from proposed system costs. All cost estimates were developed based on July 2014 US dollars.

Membrane filtration and brine management by evaporation/crystallization are not commonly used for wastewater treatment but are proposed for several WWTFs to meet chloride and/or sulfate effluent limits. These processes are not included in CapDetWorks™. Barr developed a separate cost estimate based on flow and water quality for each WWTF requiring the process, as documented in Appendix C.

An equipment installation contingency of 10 percent and contractor profit of 12 percent was added to CapDetWorks™ estimates for individual unit processes. An additional contingency of 15 percent was added to the equipment costs and other direct costs to estimate the total construction costs. Engineering, legal, and administrative costs are estimated at 20 percent of the total construction cost.

Upgrades to meet future WQS include upgrades to meet current WQS plus additional upgrades to meet limits only applicable to future WQS. As a result, costs estimated for upgrades to meet future WQS include the costs estimated for upgrades to meet current WQS.

5.6.5 User Cost Analysis

The number of equivalent residential units (ERUs), typical residential sewer rates, and median income were determined for each city. User costs were evaluated as an annual cost per ERU, which includes all domestic-strength wastewater from residential, commercial, and industrial sources. Commercial wastewater generation is allocated one ERU per 274 gpd of potential wastewater generation.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

5.6.6 Cost Estimate Review Process

Proposed WWTF upgrades and cost estimates were reviewed internally by Barr staff and summarized for each cost scenario for each WWTF in technical memos that are included in Appendix D. These memos were reviewed by Bolton and Menk and feedback was incorporated prior to publication of this report. Proposed upgrades and estimated costs are summarized below in Sections 5.7, 5.8, and 5.9.

5.7 Cost Analysis for Current Water Quality Standards

5.7.1 Technology Selection for Current WQS

Table 5-8 outlines the proposed WWTF changes to meet current WQS.

Table 5-8 Proposed treatment upgrades to meet current WQS

Site	TSS	Ammonia	Nitrate	Phosphorus	Sulfate	Cl
Ada	Existing OK	**Upgrade to activated sludge**	No Limit	No Limit	No Limit	No Limit
Albert Lea	Existing OK	Existing OK	No Limit	**Add Chem-P**	No Limit	**RO/Cryst**
Austin	Existing OK	Existing OK	No Limit	**Add Chem-P**	No Limit	**RO/Cryst**
Butterfield	Existing OK	**Upgrade to activated sludge**	No Limit	**Add Chem-P**	No Limit	No Limit
Cook	Existing OK	No Limit	No Limit	No Limit	No Limit	No Limit
Fairmont	Existing OK	Existing OK	No Limit	Existing OK	No Limit	**RO/Cryst**
Gilbert	Existing OK	Existing OK	No Limit	Existing OK	No Limit	Existing OK
Grand Rapids	Existing OK	Existing OK	No Limit	No Limit	No Limit	No Limit
Hanska	Existing OK	No Limit	No Limit	**Add Chem-P**	No Limit	No Limit
Hibbing	Existing OK	Existing OK	No Limit	Existing OK	No Limit	No Limit
Lake Crystal	Existing OK	No Limit	No Limit	Existing OK	No Limit	No Limit
Nashwauk	Existing OK	**Upgrade to activated sludge**	No Limit	No Limit	No Limit	No Limit
Rochester	Existing OK	Existing OK	No Limit	**Add Chem-P**	No Limit	**RO/Cryst**
Serpent Lake	Existing OK	**Upgrade to activated sludge**	No Limit	Existing OK	No Limit	No Limit
Watertown	Existing OK	Existing OK	No Limit	**Add Chem-P**	No Limit	**RO/Cryst**

Bolded cells indicate upgrades from current system

5.7.2 Summary of Cost Estimates for Current WQS

Table 5-9 summarizes estimate capital and operation and maintenance (O&M) costs for WWTF upgrades to meet current and future WQS. Upgrades to meet future WQS are discussed in Section 5.7.

Annual loan payments were estimated by assuming 20-year loans with an interest rate of three percent. User costs could be recovered with a combination of connection fees (typically applied to recover capital costs) and volume-of-use fees (typically applied to recover annual O&M costs). Loans can also be acquired from other agencies for longer terms at slightly higher interest rates. Grants were not assumed to be available for any of the communities but could be for some.

Table 5-9 Estimated additional capital and yearly O&M costs for upgrades to meet current WQS

City	Estimated capital costs (2014 $)	Estimated annual O&M costs (2014 $)	Estimated annual loan payment for capital costs (2014 $)	Estimated total annual costs for upgrades to meet current WQS (2014 $)
Ada	$3,758,000	$227,100	$254,000	$481,100
Albert Lea	$61,728,000	$4,378,900	$4,167,000	$8,545,900
Austin	$61,252,000	$4,106,000	$4,135,000	$8,241,000
Butterfield	$6,548,000	$383,000	$442,000	$825,000
Cook	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Fairmont	$32,668,000	$555,000	$2,206,000	$2,761,000
Gilbert	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Grand Rapids	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Hanska	$430,000	$24,800	$29,000	$53,800
Hibbing	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Lake Crystal	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Nashwauk	$3,880,000	$234,400	$262,000	$496,400
Rochester	$96,554,000	$6,528,000	$6,518,000	$13,046,000
Serpent Lake	$5,560,000	$407,000	$376,000	$783,000
Watertown	$29,126,000	$933,000	$1,967,000	$2,900,000

5.8 Cost Analysis for Future Water Quality Standards

5.8.1 Technology Selection for Future WQS

Table 5-10 outlines the proposed WWTF changes to meet future WQS.

Table 5-10 Proposed treatment upgrades to meet future WQS

Site	TSS	Ammonia	Nitrate	Phosphorus	Sulfate	Cl
Ada	Existing OK	**Upgrade to activated sludge**	No Limit	No Limit	No Limit	No Limit
Albert Lea	Existing OK	**Upgrade to activated sludge**	**5-Stage Bardenpho**	**5-Stage Bardenpho**	No Limit	**RO/Cryst**
Austin	Existing OK	**Upgrade to activated sludge**	**5-Stage Bardenpho**	**5-Stage Bardenpho**	No Limit	**RO/Cryst**
Butterfield	Existing OK	**Upgrade to activated sludge**	**4-Stage Bardenpho**	**Add Chem-P**	No Limit	No Limit
Cook	Existing OK	No Limit	No Limit	No Limit	No Limit	No Limit
Fairmont	Existing OK	**Upgrade to activated sludge**	**4-Stage Bardenpho**	Existing OK	No Limit	**RO/Cryst**
Gilbert	Existing OK	**Upgrade to activated sludge**	**4-Stage Bardenpho**	Existing OK	**NF/Cryst**	Existing OK
Grand Rapids	Existing OK	**Optimize Nitrification**	No Limit	No Limit	No Limit	No Limit
Hanska	Existing OK	No Limit	No Limit	**Add Chem-P**	No Limit	No Limit
Hibbing	Existing OK	Existing OK	**Denitrification Tank**	Existing OK	**NF/Cryst**	No Limit
Lake Crystal	Existing OK	**Upgrade to activated sludge**	No Limit	**A/O BPR**	No Limit	No Limit
Nashwauk	Existing OK	**Upgrade to activated sludge**	No Limit	No Limit	No Limit	No Limit
Rochester	Existing OK	Existing OK	**Denitrification Tank**	**Add Chem-P**	No Limit	**RO/Cryst**
Serpent Lake	Existing OK	**Upgrade to activated sludge**	No Limit	Existing OK	No Limit	No Limit
Watertown	Existing OK	**Upgrade to activated sludge**	**5-Stage Bardenpho**	**5-Stage Bardenpho**	No Limit	**RO/Cryst**

Bolded cells indicate upgrades from current system

5.8.2 Summary of Cost Estimates for Future WQS

Capital and annual O&M costs for WWTF upgrades to meet future WQS are included in Table 5-11. Cost detail for each estimate is available in Appendix D. Capital cost estimates for the current and future WQS are considered as separate projects to upgrade from the existing facility and not cumulative. Annual costs are considered as the increase over existing annual costs.

Table 5-11 Estimated additional capital and yearly O&M costs for upgrades to meet future WQS

City	Estimated capital cost (2014 $)	Estimated annual O&M costs (2014 $)	Estimated annual loan payment for capital costs (2014 $)	Estimated total annual costs for upgrades to meet future WQS (2014 $)
Ada	$3,758,000	$227,100	$254,000	$481,100
Albert Lea	$72,524,000	$4,130,000	$4,896,000	$9,026,000
Austin	$77,439,000	$5,155,000	$5,228,000	$10,383,000
Butterfield	$6,622,000	$473,000	$447,000	$920,000
Cook	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Fairmont	$38,421,000	$919,000	$2,594,000	$3,513,000
Gilbert	$22,216,000	$991,000	$1,500,000	$2,491,000
Grand Rapids	No Upgrades	No Upgrades	No Upgrades	No Upgrades
Hanska	$430,000	$24,800	$29,000	$53,800
Hibbing	$67,936,000	$5,793,300	$4,586,000	$10,380,000
Lake Crystal	$3,701,000	$205,300	$250,000	$455,300
Nashwauk	$3,880,000	$234,400	$262,000	$496,400
Rochester	$107,214,000	$8,366,000	$7,237,000	$15,603,000
Serpent Lake	$5,560,000	$407,000	$376,000	$783,000
Watertown	$33,046,000	$1,059,000	$2,231,000	$3,290,000

5.9 Cost Summary and Comparison

5.9.1 Comparison of Capital Costs for Upgrades to Meet Current and Future WQS

Capital and annual costs are shown in Figure 5-22 and Figure 5-23. In general, larger facilities have larger costs. A review of costs per user is provided in Section 5.9.3.

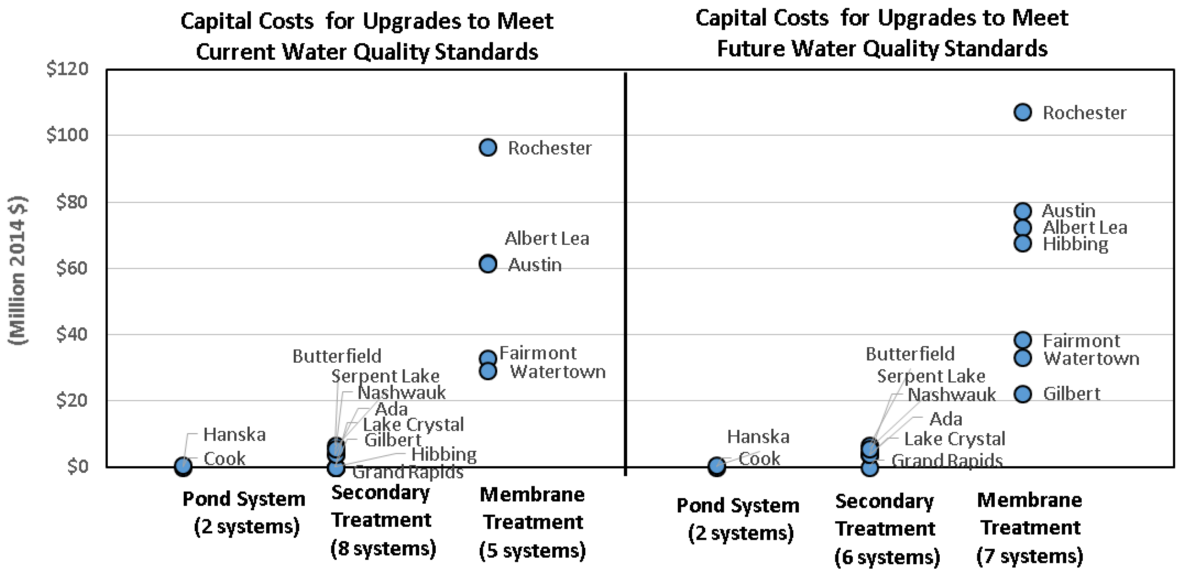


Figure 5-22 Estimated capital costs to meet current and future WQS

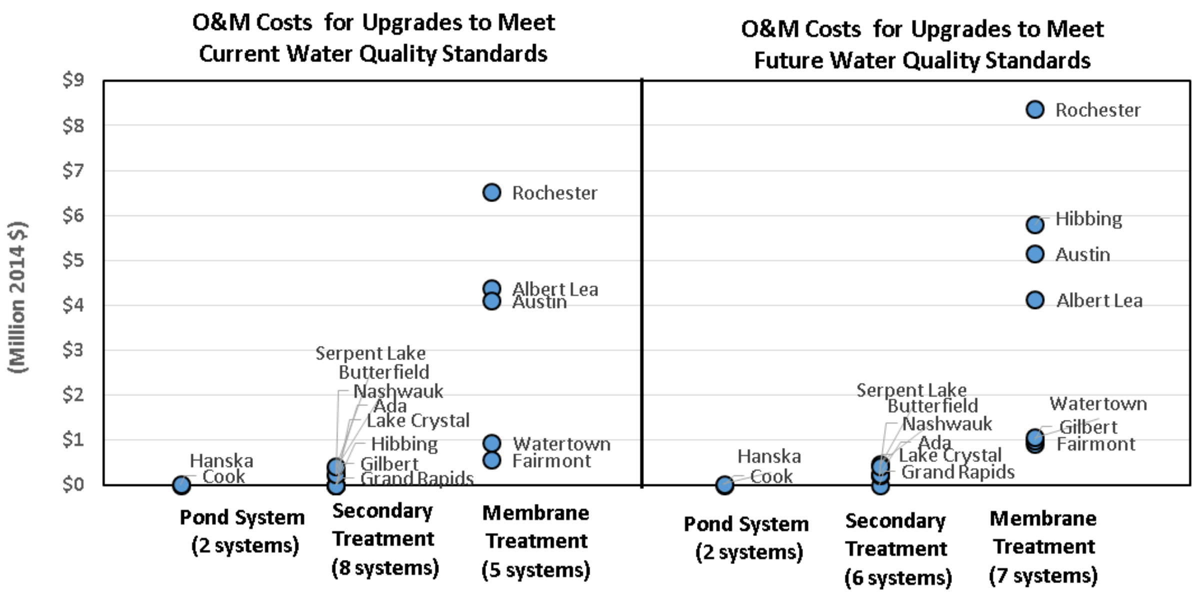


Figure 5-23 Estimated annual O&M costs to meet current and future WQS

5.9.2 Comparison of Relative Costs to Meet WQS for Parameters of Interest

5.9.2.1 Total Suspended Solids (TSS)

None of the 15 WWTF are expected to require upgrades to meet current WQBELs for TSS.

5.9.2.2 Nutrient

All but two of the 15 WWTFs evaluated would require plant upgrades to meet estimated current or future WQBELs for nutrients that are lower than current permit limits. Upgrades to meet current and future WQS for ammonia, nitrate, total nitrogen, and total phosphorus require upgrade or replacement of secondary treatment systems and chemical addition. Pond systems generally require upgrades for new ammonia and phosphorus WQBEL. Costs escalate for ammonia WQBELs lower than 5 mg/L and phosphorus WQBELs lower than 1 mg/L

Activated sludge systems would require upgrades for future nitrate and phosphorus WQBELs. Costs escalate for nitrate WQBELs lower than 10 mg/L and phosphorus WQBELs lower than 0.5 mg/L.

5.9.2.3 Sulfate WQS

Two of the 15 WWTFs evaluated have estimated WQBELs for sulfate. NF or ion exchange treatment is required to meet future sulfate WQS. For this estimate, NF was used to estimate costs. This process incurs a high cost, largely because NF treatment produces a large volume of brine that requires additional treatment by evaporation and/or crystallization (refer to Section 5.4.2.7) to produce a waste salt with water content low enough for landfill disposal. These technologies need durable materials of construction to withstand high temperatures and salt concentrations, which translates into high capital costs. They require large amounts of power to evaporate water and crystallize salts, which results in high annual energy costs. Landfill disposal of the crystallized salt also increases annual costs.

Fifteen to 30 mg/L of sulfate in domestic wastewater is typically sourced from human waste (reference (14)), so source reduction is unlikely to meet sulfate WQBELs. As a result, sulfate permit limits lower than the groundwater concentration plus 40 mg/L will require wastewater treatment upgrades that impart significant cost.

5.9.2.4 Chloride WQS

Six of the 15 WWTFs evaluated have estimated WQBELs for chloride. Chloride WQS can be met by treatment at the wastewater plant; however, source reduction is likely to be a more cost-effective solution for most cities. For this analysis, Barr assumed that tertiary treatment using RO membrane filtration would be needed to meet chloride WQBELs. Similar to costs for NF described for sulfate removal, RO costs are prohibitively high because brine treatment is very expensive.

None of the cities evaluated have both current chloride and future sulfate WQBELs; however, it is likely some Minnesota cities would have limits for both. Chloride treatment reduces the equipment required for sulfate treatment; however, sulfate treatment does not significantly reduce the equipment required for chloride treatment.

Chloride source control may be able to meet permit limits for current and future WQS. For some WWTFs, the level of chloride removal required to meet WQS is below the level contributed by home ion exchange softeners. In these cases, the chloride limit could be achieved by implementing centralized softening at the city's water treatment facility and phasing out home water softeners. Refer to Section 5.5.2.1 for details about centralized softening.

Other options for chloride source control include tightening industrial pretreatment requirements and switching to UV wastewater disinfection as described in Sections 5.5.2.2 and 5.5.2.3. The merit of these options depends on the level of chloride removal required and would require a detailed evaluation of the municipal water source and water treatment facility as well as an inventory of chloride from industrial sources.

5.9.3 Comparison of User Costs

The values used to estimate the impact of upgrades on user costs are outlined in Table 5-12. Generally, cities with estimated numbers of ERUs have higher estimated annual costs, with some exceptions. Grand Rapids has no required upgrades to meet either current or future WQS.

Table 5-12 Estimated number of ERUs and total annual costs for upgrades to meet current and future WQS

City	Estimated number of ERUs	Estimated total annual costs for upgrades to meet current WQS (2014 $)	Estimated total annual costs for upgrades to meet future WQS (2014 $)
Ada	1,059	$481,100	$481,100
Albert Lea	16,873	$8,545,900	$9,026,000
Austin	14,840	$8,241,000	$10,383,000
Butterfield	905	$825,000	$920,000
Cook	264	No Upgrades	No Upgrades
Fairmont	6,814	$2,761,000	$3,513,000
Gilbert	1,659	No Upgrades	$2,491,000
Grand Rapids	4,897	No Upgrades	No Upgrades
Hanska	208	$53,800	$53,800
Hibbing	12,499	No Upgrades	$10,380,000
Lake Crystal	1,270	No Upgrades	$455,300
Nashwauk	655	$496,400	$496,400
Rochester	67,586	$13,046,000	$15,603,000
Serpent Lake	1,123	$783,000	$783,000
Watertown	2,013	$2,900,000	$3,290,000

Total annual costs include O&M costs and annual loan payments, assuming 20-year loans with 3% interest.

The information presented in Table 5-13 links the increases in user costs to the type of upgrade proposed and the estimated effluent limits that require upgrades.

Table 5-13 Summary of treatment systems, limit changes, required upgrades, and estimated change in user costs

City	Existing effluent limits	Existing treatment system type	New or more stringent estimated effluent limits to meet current standards	Recommended upgrades to meet estimated current effluent limits	Estimated increase in cost per ERU to meet estimated current effluent limits	New or more stringent estimated effluent limits to meet future standards	Recommended upgrades to meet estimated future effluent limits	Estimated increase in cost per ERU to meet estimated future effluent limits
Ada	TSS	Stabilization ponds	Ammonia	Activated sludge	$454	Ammonia	4-stage Bardenpho	$454
Albert Lea	TSS, ammonia	Activated sludge	Phosphorus, chloride	Chemical phosphorus removal, filtration, RO and evaporator/crystallizer	$506	Ammonia, nitrate, phosphorus, chloride	5-stage Bardenpho, filtration, RO and evaporator/crystallizer	$535
Austin	TSS, ammonia	Trickling filters	Chloride	Filtration, RO and evaporator/crystallizer	$569	Ammonia, nitrate, phosphorus, chloride	5-stage Bardenpho, filtration, RO and evaporator/crystallizer	$717
Butterfield	TSS, phosphorus	Aerated ponds and stabilization ponds	Ammonia, phosphorus	Activated sludge, chemical phosphorus removal	$912	Ammonia, nitrate phosphorus	4-stage Bardenpho, chemical phosphorus removal	$1,017
Cook	TSS, phosphorus	Stabilization ponds	None	No upgrades	No upgrades	None	No Upgrades	No upgrades
Fairmont	TSS, ammonia TSS, ammonia, phosphorus	Activated sludge, chemical phosphorus removal	Chloride	Filtration, RO and evaporator/crystallizer	$405	Ammonia, nitrate, chloride	4-stage Bardenpho, filtration, RO and evaporator/crystallizer	$515
Gilbert	TSS, phosphorus	Trickling filters, chemical phosphorus removal, tertiary filtration	None	No upgrades	No upgrades	Ammonia, nitrate, sulfate	4-stage Bardenpho, NF and evaporator/crystallizer	$1,501
Grand Rapids	TSS, ammonia	Activated sludge with ponds	None	No upgrades	No upgrades	None	No Upgrades	No upgrades
Hanska	TSS, phosphorus	Stabilization ponds	Phosphorus	Chemical phosphorus removal	$258	Phosphorus	Chemical phosphorus removal	$258
Hibbing	TSS, ammonia, phosphorus	Trickling filters, chemical phosphorus removal	None	No upgrades	No upgrades	Nitrate, sulfate	Denitrification tank, filtration, NF and evaporator/crystallizer	$830
Lake Crystal	TSS, phosphorus	Stabilization ponds, chemical phosphorus removal	None	No upgrades	No upgrades	Ammonia	Activated sludge	$358
Nashwauk	TSS	Stabilization ponds	Ammonia	Activated sludge	$758	Ammonia	Activated sludge	$758
Rochester	TSS, ammonia, phosphorus	Activated sludge, partially high-purity oxygen	Phosphorus, chloride	Chemical phosphorus removal, filtration, RO and evaporator/crystallizer	$193	Nitrate, phosphorus, chloride	Denitrification filter, chemical phosphorus removal, filtration, RO and evaporator/crystallizer	$231
Serpent Lake	TSS, phosphorus	Stabilization ponds, chemical phosphorus removal	Ammonia	Activated sludge	$697	Ammonia	Activated sludge	$697
Watertown	TSS, ammonia	Activated sludge, traveling bridge filter	Phosphorus, chloride	Chemical phosphorus removal, filtration, RO and evaporator/crystallizer	$1,440	Ammonia, nitrate, phosphorus, chloride	5-stage Bardenpho, filtration, RO and evaporator/crystallizer	$1,634

For each WWTF, the increase in user costs for each scenario was divided by the median household income to determine the upgrade cost as a percent of median income presented in Table 5-14. This method may slightly overestimate the user cost if the city has been recovering costs for upgrades that are near the end of their service life and could be applied for future upgrades. In addition, cities collecting sewer access fees from new developments may have a significant source of additional revenue. The majority of cities considered in this analysis do not have substantial income from new developments. A detailed rate study would be necessary to determine the precise impact of upgrades on sewer use rates. The Minnesota Public Facilities Authority (PFA) offers grants for wastewater projects where the annual sewer cost exceeds 1.4 percent of median household income. The MPCA has referred to this value as the "affordability index" (MPCA, 2016). Estimated annual cost increases for users are summarized in Table 5-14, Table 5-15, Figure 1-5, Figure 5-25, and Figure 5-26.

Table 5-14 Estimated user costs for proposed upgrades to meet current WQS

City	Existing Sewer Fees as % of Median Income	Annual Increase in User Costs ($/ERU)	% Increase in User Costs	Affordability (% of Median Income)[1]
Ada	1.1%	$454	108%	2.4%
Albert Lea	1.5%	$506	93%	2.8%
Austin	1.0%	$569	145%	2.4%
Butterfield	1.0%	$912	199%	2.9%
Cook	1.6%	No upgrades	No upgrades	No upgrades
Fairmont	1.7%	$405	47%	2.5%
Gilbert	1.8%	No upgrades	No upgrades	No upgrades
Grand Rapids	1.1%	No upgrades	No upgrades	No upgrades
Hanska	0.6%	$258	86%	1.2%
Hibbing	1.6%	No upgrades	No upgrades	No upgrades
Lake Crystal	1.2%	No upgrades	No upgrades	No upgrades
Nashwauk	1.5%	$758	152%	3.7%
Rochester	0.9%	$193	33%	1.2%
Serpent Lake	2.5%	$697	94%	4.9%
Watertown	0.9%	$1,440	226%	2.8%

(1) Affordability is calculated by dividing the final estimated annual user costs per ERU by the median household income.

Table 5-15 Estimated user costs for proposed upgrades to meet future WQS

City	Existing Sewer Fees as % of Median Income	Annual Increase in User Costs ($/ERU)	% Increase in User Costs	Affordability (% of Median Income) [1]
Ada	1.1%	$454	108%	2.4%
Albert Lea	1.5%	$535	98%	2.9%
Austin	1.0%	$717	182%	2.8%
Butterfield	1.0%	$1,017	222%	3.1%
Cook	1.6%	No upgrades	No upgrades	No upgrades
Fairmont	1.7%	$515	60%	2.7%
Gilbert	1.8%	$1,501	183%	5.2%
Grand Rapids	1.1%	No upgrades	No upgrades	No upgrades
Hanska	0.6%	$258	86%	1.2%
Hibbing	1.6%	$830	134%	3.8%
Lake Crystal	1.2%	$358	49%	1.8%
Nashwauk	1.5%	$758	152%	3.7%
Rochester	0.9%	$231	40%	1.3%
Serpent Lake	2.5%	$697	94%	4.9%
Watertown	0.9%	$1,634	257%	3.0%

(1) Affordability is calculated by dividing the final estimated annual user costs per ERU by the median household income.

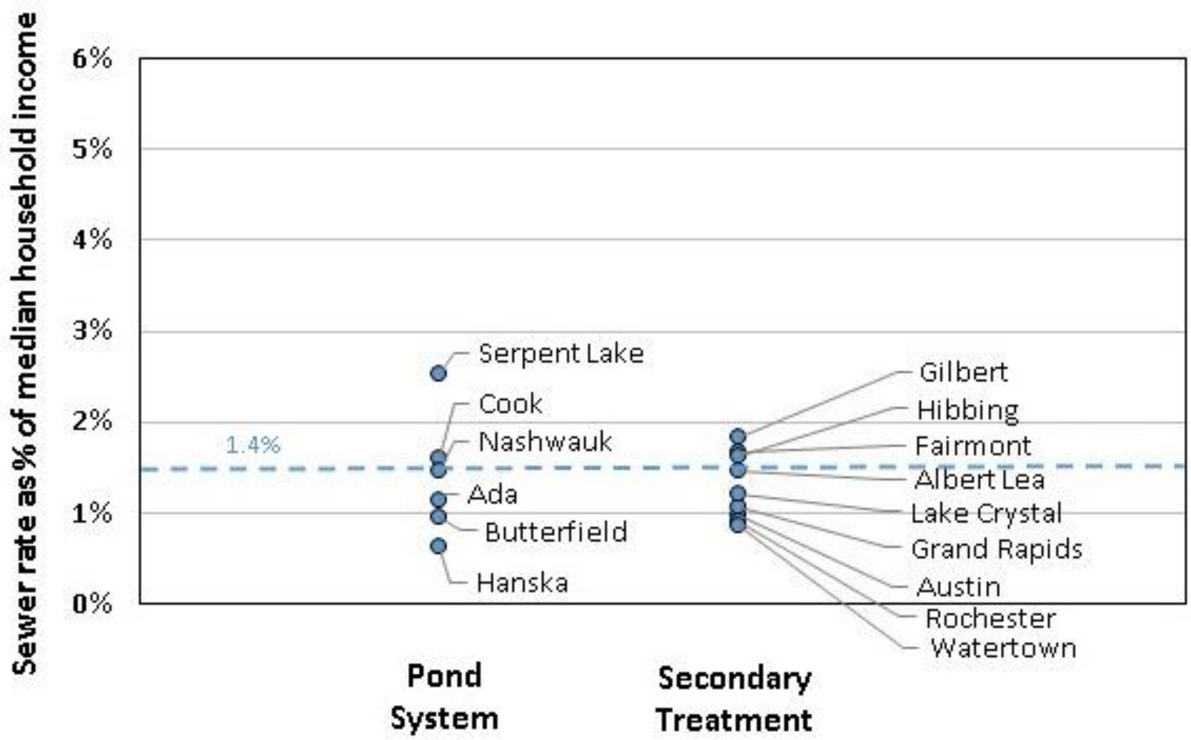


Figure 5-24 Existing sewer rate as a percent of median household income

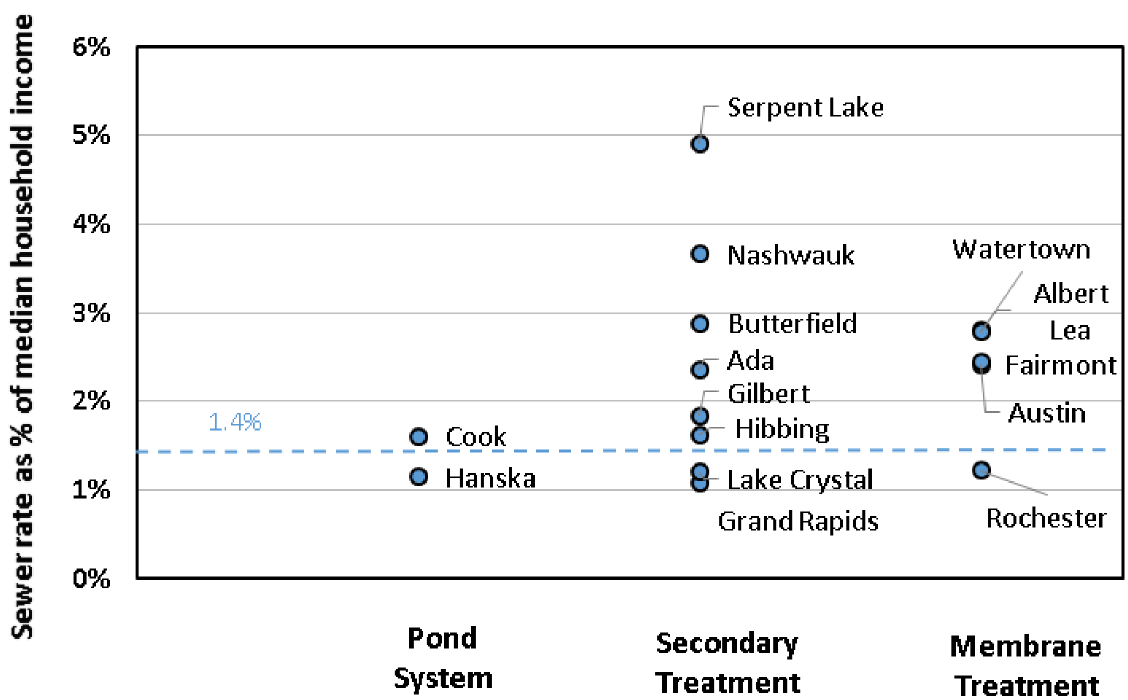


Figure 5-25 Estimated sewer rate with upgrades to meet current WQS as a percent of median household income

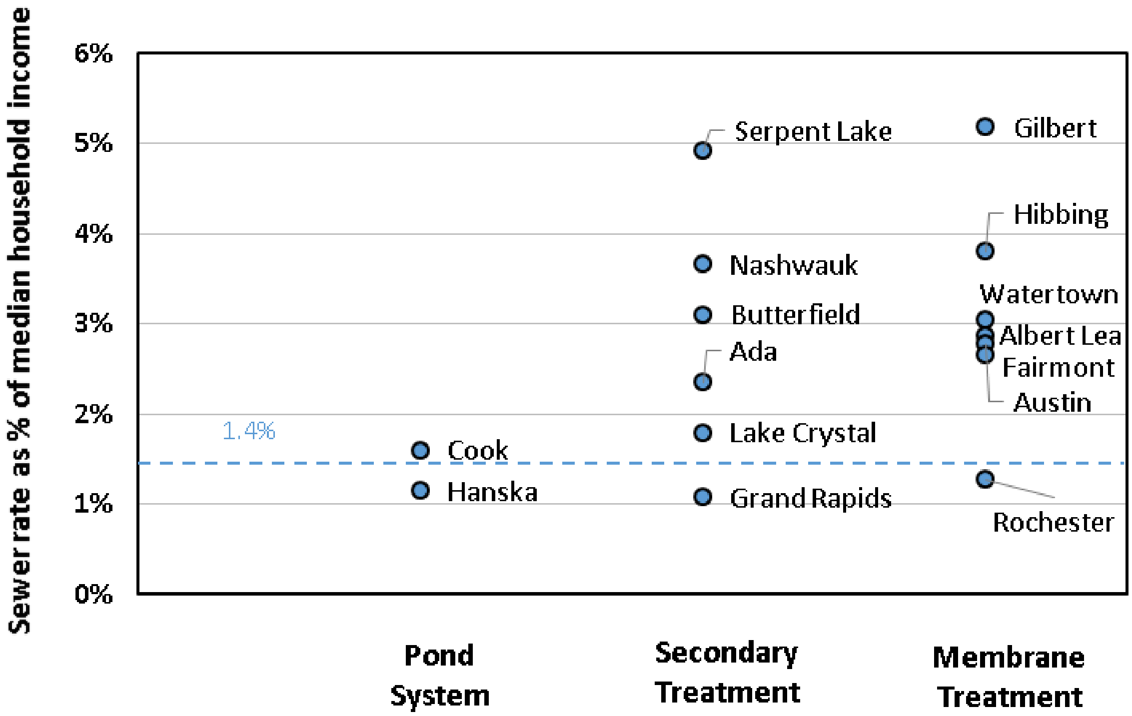


Figure 5-26 Estimated sewer rate with upgrades to meet future WQS as a percent of median household income

Estimated user costs to meet current and future WQS were grouped by WWTF capacity, discharge watershed, and existing treatment type. These are outlined below.

WWTF capacity was split into three categories and the ranges of estimated user costs for each are outlined in Table 5-16. The change in average user cost is generally greatest for facilities with lower treatment capacity. When there are more users to pay the capital costs for large projects, the increase to each average user's cost is less. This is in spite of the fact that most of the facilities that would be required to treat for chloride and/or sulfate are larger facilities. The two medium-sized facilities required to treat for chloride or sulfate (Gilbert and Watertown) show the impact of expensive treatment technologies on communities with fewer users.

Table 5-16 Annual increase in user costs by WWTF capacity

WWTF Capacity	Cities Included	Range of costs to meet current WQS (2014 $/ERU)	Range of costs to meet future WQS (2014 $/ERU)
Small (<0.5 MGD)	Ada, Butterfield, Cook, Hanska, Nashwauk	258-912 range 595 average	258-1,017 range 622 average
Medium (0.5 to 2 MGD)	Gilbert, Lake Crystal, Serpent Lake, Watertown	0-1,440 range 535 average	358-1,634 range 1,047 average
Large (>2 MGD)	Albert Lea, Austin, Fairmont, Grand Rapids, Hibbing, Rochester	0-569 range 278 average	0-830 range 465 average

Annual increase in user costs include O&M costs and annual loan payments, assuming 20-year loans with 3% interest. These costs assume all annual costs are covered by user rates.

Table 5-17 lists the major watersheds in Minnesota and the ranges and average of estimated user costs associated with WWTF upgrades for WWTF discharging to each watershed. No WWTFs were evaluated in the Missouri River or St. Croix River watersheds.

There is not a discernable difference in estimated user costs between the watersheds. This lack of trend is most evident in the Upper Mississippi watershed, which includes WWTFs with the lowest and highest cost increases. The lack of significant cost differences by watershed is not surprising as the costs for chloride and sulfate treatment are determined by local factors (low flow in the receiving stream or presence of wild rice waters) rather than basin factors.

Table 5-17 Annual increase in user costs by watershed

Watershed	Cities Included	Range of costs to meet current WQS (2014 $/ERU)	Range of costs to meet future WQS (2014 $/ERU)
Iowa Basin	Albert Lea, Austin,	506-569	535-717
Lake Superior	Gilbert, Hibbing	0	830-1,501
Lower Mississippi	Rochester	193	231
Minnesota River	Butterfield, Fairmont, Hanska, Lake Crystal,	0-912	258-1,017
Missouri River	*None analyzed*	*N/A*	*N/A*
Rainy River	Cook	0	0
Red River	Ada	454	454
St. Croix River	*None analyzed*	*N/A*	*N/A*
Upper Mississippi	Grand Rapids, Nashwauk, Serpent Lake, Watertown	0-1,400	0-1,634

Annual increase in user costs include O&M costs and annual loan payments, assuming 20-year loans with 3% interest. These costs assume all annual costs are covered by user rates.

5.9.3.1 User Costs by Treatment Type

Evaluated WWTF were sorted by level of existing treatment, and the ranges and average of estimated user costs for each are outlined in Table 5-18.

Existing pond systems would incur costs for meeting current WQS related to ammonia and phosphorus. The increase for future nitrate WQS would be addressed in upgrades to meet current WQS so there would be no additional cost impact to meet future WQS. Note that ponds do not typically monitor for chloride or sulfate, so the range and average is not skewed by the expensive technologies required to meet standards for those constituents.

Existing secondary treatment systems can typically meet ammonia standards and would not require upgrade to meet those. Some secondary treatment systems require upgrades to meet nitrate and phosphorus standards. Chloride treatment would be required to meet current and future WQBELs at some of the secondary facilities, and sulfate treatment would be required to meet future WQBELs at others.

Existing tertiary treatment systems can meet ammonia standards; however, all three require upgrades to meet future WQS for phosphorus and for nitrate or total nitrogen. Tertiary systems cannot meet chloride or sulfate standards. Because one of the tertiary treatment systems would have to treat for chloride and one would have to treat for sulfate, the systems with the highest degree of existing treatment would incur the greatest costs.

Table 5-18 Annual increase in user costs by existing treatment type

Existing Treatment Technology	Cities Included	Range of costs to meet current WQS (2014 $/ERU)	Range of costs to meet future WQS (2014 $/ERU)
Pond Systems	Ada, Butterfield, Cook, Hanska, Nashwauk, Serpent Lake	0-912	0-1,017
Secondary Treatment	Austin, Fairmont, Grand Rapids, Hibbing, Lake Crystal, Rochester	0-569	0-830
Tertiary Treatment	Albert Lea, Gilbert, Watertown	506-1,440	535-1,634

Annual increase in user costs include O&M costs and annual loan payments, assuming 20-year loans with 3% interest. These costs assume all annual costs are covered by user rates.

Because some evaluated WWTFs fell into different treatment-level categories for upgrades to meet current WQS than for upgrades to meet future WQS, they were sorted by level of proposed treatment separately. For meeting either current or future WQS, upgrades to tertiary membrane treatment are the most expensive. Figure 5-27 summarizes the estimated change in user costs per ERU for upgrades to meet current and future WQS.

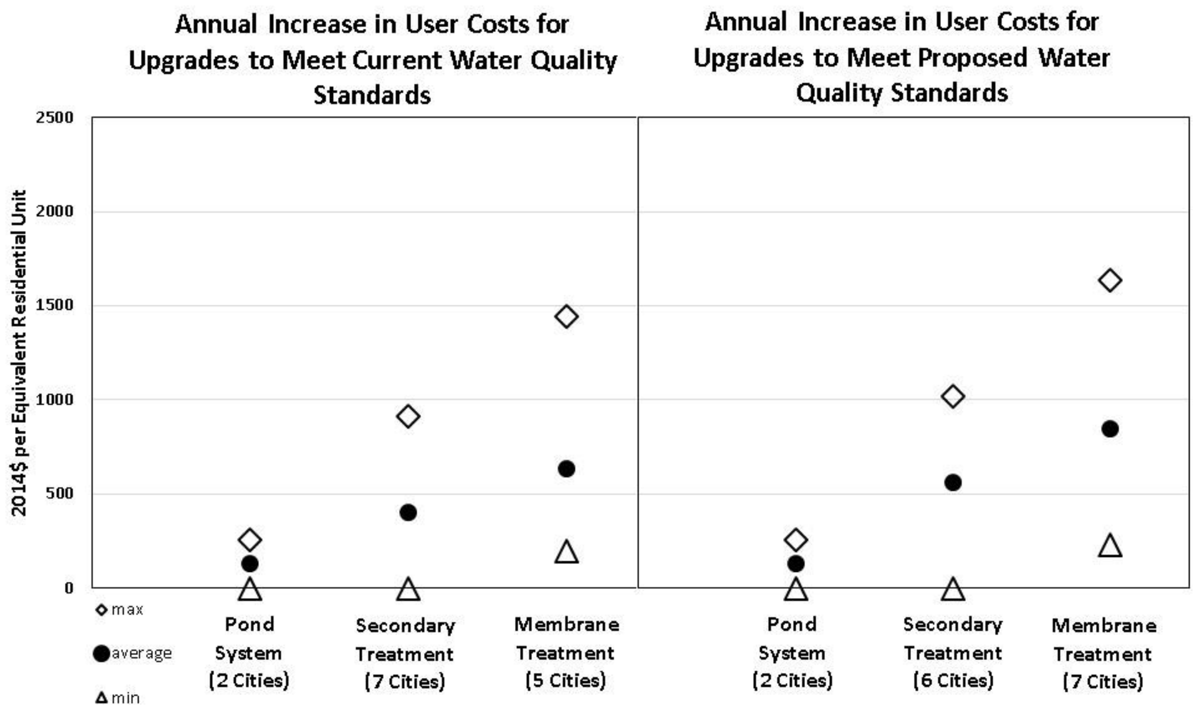


Figure 5-27 Annual increase in user costs to meet current and future WQS by proposed treatment type

The ranges and average estimated user costs by level of proposed treatment to meet current WQS are outlined in Table 5-19.

Two facilities could meet current WQS while continuing to operate pond systems. Both of these facilities would be required to meet a phosphorus WQBEL but would not be required to meet an ammonia WQBEL.

Seven facilities are proposed to have secondary treatment systems to meet current WQS. Some of these have existing secondary treatment, but four are upgraded pond systems. One existing tertiary treatment system could meet all current WQS without an upgrade.

There are no existing tertiary membrane treatment systems. Those proposed to meet current WQS would be upgraded with RO treatment for chloride.

Table 5-19 Annual increase in user costs by proposed treatment type for current WQS

Existing Treatment Technology	Cities Included	Range of costs to meet current WQS (2014 $/ERU)
Pond Systems	Cook, Hanska	0-258 range 129 average
Secondary Treatment	Ada, Butterfield, Grand Rapids, Hibbing, Lake Crystal, Nashwauk, Serpent Lake	0-912 range 402 average
Tertiary Treatment	Gilbert	0
Tertiary Membrane Treatment	Albert Lea, Austin, Fairmont, Rochester, Watertown	193-1,440 range 632 average

Annual increase in user costs include O&M costs and annual loan payments, assuming 20-year loans with 3% interest. These costs assume all annual costs are covered by user rates.

The ranges and average estimated user costs by level of proposed treatment to meet future WQS are outlined in Table 5-20.

Two facilities could meet future WQS while continuing to operate pond systems.

Six facilities are proposed to have secondary treatment systems to meet future WQS. Some of these have existing secondary treatment, but four are upgraded pond systems.

All existing tertiary treatment systems would require upgrade to tertiary membrane treatment to meet future WQS.

There are no existing tertiary membrane treatment systems. Those proposed to meet future WQS would be upgraded with RO treatment to meet estimated chloride WQBELs or NF treatment to meet estimated sulfate WQBELs

Table 5-20 Annual increase in user costs by proposed treatment type for future WQS

Existing Treatment Technology	Cities Included	Costs to meet future WQS (2014 $/ERU)
Pond Systems	Cook, Hanska	0-258 range 129 average
Secondary Treatment	Ada, Butterfield, Grand Rapids, Lake Crystal, Nashwauk, Serpent Lake	0-1,017 range 563 average
Tertiary Treatment	None	*N/A*
Tertiary Membrane Treatment	Albert Lea, Austin, Fairmont, Gilbert, Hibbing, Rochester, Watertown	231-1,634 range 852 average

Annual increase in user costs include O&M costs and annual loan payments, assuming 20-year loans with 3% interest. These costs assume all annual costs are covered by user rates.

5.10 Limitations of Analysis

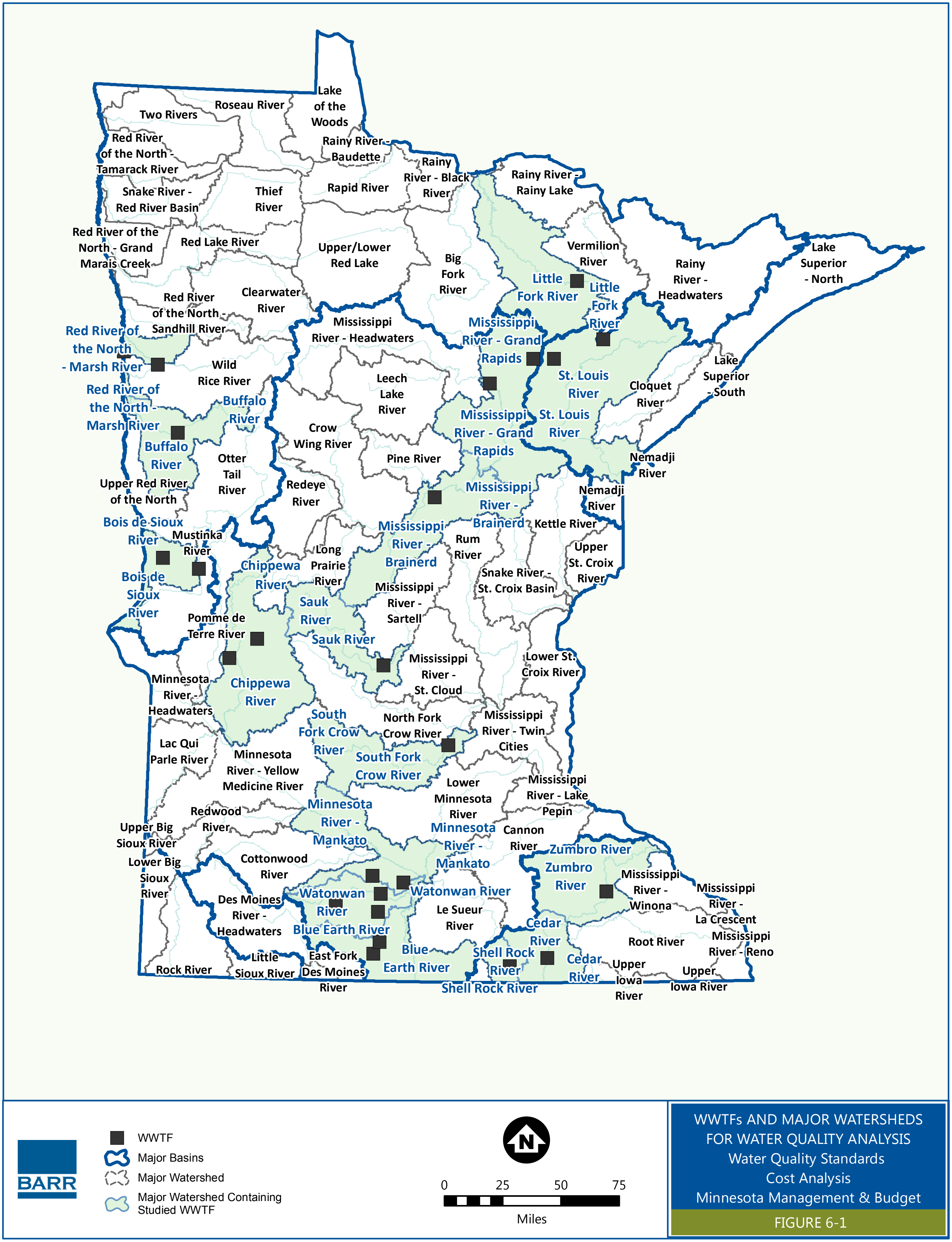
Specific limitations of the analysis presented in Section 5.0 are highlighted below.

- The 15 facilities selected for more detailed analysis were selected based on willingness to participate, which provided a representative range of geographical regions, existing treatment technologies, and level of upgrades required to meet estimated effluent limits.
- Not all cities were able to provide all information requested. Some cities did not have record drawings of their existing WWTFs.
- Cost-effectiveness analyses were not performed for each technology recommended for each city. As described in Sections 5, there are multiple process configurations of activated sludge treatment systems. Selection of a specific process can vary depending on site-specific variables.
- Upgrades were estimated to treat existing design flow capacity.
- Upgrades were estimated for new processes only and did not consider existing processes nearing the end of their service life. Existing equipment used in upgraded treatment plants would likely require replacement or repair at many facilities.
- Some cities were not able to provide records indicating the percent of sewer fees paid by commercial and industrial users. For these cities, the ERU were estimated based on flow and population. This system is subject to overestimate the commercial and industrial contribution for cities that have significant sources of inflow and infiltration to the collection system. In turn, this may underestimate the annual costs for the upgrades.
- The calculation of the final annual user cost was made by adding the increase in annual costs to the existing annual costs. This overestimates the total for cities that are near to paying off bonds for previous capital projects as the funds currently in use to pay the old bond could be applied to a new bond in the future.
- All costs developed are Class 5 cost estimates, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimates have an expected accuracy range of +50/-30 percent for projects with a maturity level less than two percent.

The limitations of analysis discussed above provide information on areas of uncertainty in specific assumptions. They do not change the overall conclusions of the report, or application for its intended purpose.

6.0 Incremental Water Quality Effects due to Wastewater Treatment Upgrades

This study estimated the incremental water quality effects due WWTF upgrades to meet current and future WQS by estimating pollutant load reductions to receiving waters downstream of the 25 municipal WWTFs shown on Figure 6-1. Existing loading was calculated based on DMR effluent concentrations, and loading under current and future WQS was calculated based on the current and future effluent limits estimated for this study (Section 4.0).



WWTFs AND MAJOR WATERSHEDS FOR WATER QUALITY ANALYSIS
Water Quality Standards Cost Analysis
Minnesota Management & Budget

FIGURE 6-1

6.1 Methods to Estimate Incremental Water Quality Effects Due to WWTF Upgrades

WWTF effluent pollutant load reductions were assessed for the following pollutants:

- TSS
- Chloride
- Nutrients
    - Phosphorus
    - Total nitrogen (TKN, ammonia, nitrate/nitrite)
- Sulfate

Total nitrogen was evaluated as ammonia (NH_3), TKN, and as nitrate/nitrite because, in many cases, facilities had limits for one or multiple nitrogen-based pollutants. After the pollutant reductions were determined for each of the nitrogen-based constituents, the total nitrogen reduction was calculated using the method outlined below.

The following steps outline the process to determine the pollutant reductions in existing effluent to meet the current and proposed WQSs.

1. Historic WWTF effluent data were collected from the respective DMRs for each of the 25 WWTFs used in this study. All effluent data from the facilities' DMRs between January 2010 and July 2016 was used. DMR data was used rather than existing permit limits because, in most cases, the DMR data is well below the permit limit; however, some instances occur where the average DMR data is above the permit limit. The averaged DMR historic data represents the existing effluent value whether or not a permit limit exists. In many cases, the available data is not complete throughout this entire date range. In all cases, all available DMR data for each WWTF was averaged and used as the existing effluent value.

2. The existing effluent concentration was then compared to the estimated effluent limit to meet current and future WQS in order to determine the pollutant load reduction for that parameter. The load was calculated by multiplying the effluent concentration by the ADW flow for each facility.

    a. Where multiple limits exist for a single pollutant (which occurs when both a loading [kg/d], and concentration-based [mg/L] limit are established), the concentration-based limit was used to determine the pollutant load reduction percentage. The concentration-based comparison was chosen because daily and annual loading depend on the outflow from the facility, which varies by season and can change due to future growth.

b. Where varying seasonal concentration limits exist for a single pollutant (often in the case of ammonia), the average time-weighted pollutant reduction was used to quantify an average concentration reduction. The time-weighted calculation was made by weighing each reduction percentage by the number of months the limit will be in place for any given year. If a new limit only applies to a few months out of the year, this was averaged over a 12-month period. Where a pond system exists, the load reduction percentage was only averaged over the number of months the pond will discharge, often from early spring to late fall.

3. Where a pollutant load reduction to meet the current or future WQS was calculated as a negative value, no effect (0% reduction) was assigned to the downstream water quality.

4. Pollutant reductions for nitrogen-based constituents were summarized into a total nitrogen (TN) load reduction (as N). The TN reduction was determined by converting the existing effluent to annual loads using the ADW flow (Q_e) of each facility. TN is the sum of TKN and nitrate/nitrite, and TKN is the sum of ammonia and organic nitrogen. Using the known pollutant reductions of nitrite/nitrate and ammonia (as these parameters were addressed to meet current and future WQSs) and knowing that no changes to organic nitrogen are being proposed, the percent TKN and TN reductions were calculated. As a hypothetical example, the process for determining pollutant reduction to meet the future WQS for TN is as follows:

- $TN = TKN + Nitrate$

$$TKN = Ammonia + Organic\ N$$

$$TKN\ = (Existing\ Effluent\ Concentration) \times (Qe)$$
$$= \left(3.82\frac{mg}{L}\right) \times \left(3.785\frac{L}{gallon}\right) \times \left(365\frac{days}{year}\right) \times (0.183\ MGD) = 965\frac{kg}{yr}$$

$$Ammonia\ Load\ = 248\frac{kg}{yr}$$

$$[\%\ TKN\ Reduction][TKN\ Annual\ Load] = [\%\ Ammonia\ Reduction][Ammonia\ Load] + [\%\ Organic\ N\ Reduction][Organic\ N\ Load]$$

Because there are no limits to meet current WQS for organic nitrogen, the organic N load reduction is zero (0% reduction).

$$[\%\ TKN\ Reduction] = \frac{[\%\ Ammonia\ Reduction][Ammonia\ Load]}{[TKN\ Load]}$$

$$[\%\ TKN\ Reduction] = \frac{[42\%]\left[248\frac{kg}{yr}\right]}{\left[965\frac{kg}{yr}\right]} = 11\%\ TKN\ Reduction$$

$$[\%\ TN\ Reduction][TN\ Load] = [\%\ TKN\ Reduction][TKN\ Load] + [\%Nitrate\ Reduction][Nitrate\ Load]$$

$$TN = TKN + Nitrate = 965\frac{kg}{yr} + 144\frac{kg}{yr} = 1{,}109\frac{kg}{yr}$$

Because there are no limits to meet current WQS for nitrate in this example, the nitrate load reduction is zero (0% reduction).

$$[\%\ TN\ Reduction] = \frac{[11\%]\left[965\frac{kg}{yr}\right]}{\left[1109\frac{kg}{yr}\right]} = 9\%\ TN\ Reduction$$

5. After the load reduction to meet current and future WQSs were determined for each of the 25 WWTFs, the percent reductions for total nitrogen and phosphorus were extrapolated watershed-wide and to the six basins outlined in Figure 6-1 and described below. Finally, the percent reductions for total nitrogen and phosphorus were extrapolated to the three major basins defined in the 2014 Minnesota Nutrient Reduction Strategy report (reference (47)). Chloride was not extrapolated to the major basin level because chloride effluent limits are dependent on a number of factors and conditions pertaining to each facility. As further described in Section 7.2.1, major basin-wide conclusions about water quality changes due to chloride load reductions cannot be determined. Flow-weighted average reductions for each of the WWTFs within each watershed and basin were used to give greater weight to reductions from larger facilities. The flow-weighted averages were calculated based on the ADW flow (Q_e) of each facility.

6. Two methods were considered to determine the percent contribution of discharges from municipal WWTFs to each of the three major basins. The first method (item a) was selected for use by this study because of limitations in coverage associated with the second method (item b).

    a. The percent contribution of discharges from municipal WWTFs to each of the three major basins were calculated from values in the 2014 Minnesota Nutrient Reduction Strategy report (reference (47)), which describes the contribution of NPDES permitted wastewater discharges from both industrial and municipal (referred to in the report as domestic) facilities. Table 6-1 summarizes the percent contribution for total nitrogen and phosphorus from municipal WWTFs to each of the three major basins as provided in the 2014 Minnesota Nutrient Reduction Strategy report (reference (47)).

    b. The percent contribution of discharges from municipal WWTFs was also calculated from TN and phosphorus loading data estimated by the MPCA for all monitored WWTFs in Minnesota applied to the six basins outlined in Figure 6-1 (reference (48)). Results are shown in Table 6-2. Figure 6-2 shows the location of these MPCA monitored WWTFs and streams and highlights the monitoring stations used to derive total loading to each basin. Stream monitoring data from the MPCA's Watershed Pollutant Load Monitoring Network

(WPLMN) was used to determine total loading to each major watershed (reference (49)). The WPLMN utilizes state and federal agencies, universities, and local partners to collect water quality and flow data to calculate pollutant loads. However, the WPLMN lacks complete coverage of all streams and direct drainage within the major basins. Additionally, the most extensive coverage provided was during year 2011. Therefore, the TN and phosphorus data provided in Table 6-2 reflect 2011 WWTF effluent and stream loading conditions which may contain percentages larger than actual WWTF loading contributions under current conditions. For these reasons, basin load contributions represented in Table 6-1 were used to estimate expected total load reduction comparisons throughout the state for nitrogen and phosphorus.

7. Finally, the flow-weighted average pollutant load reductions to meet current and future WQS and the percent contribution of phosphorus and nitrogen by municipal WWTFs were used to calculate the basin wide load reductions expected due to current and future WQS.

Table 6-1 Percent contribution of municipal WWTF discharges to major basins

Major Basin	Percent Contribution of NPDES permitted municipal WWTF discharges to each major basin(1)
Phosphorus	
Lake Superior	19
Lake Winnipeg	9
Mississippi River(2)	14
Total Nitrogen	
Lake Superior	24
Lake Winnipeg	5
Mississippi River(2)	7

Data source: reference (47)

(1) Percent contributions from Table 3-2 in the 2014 Minnesota Nutrient Reduction Strategy (reference (47)) Percent of municipal WWTF contribution was determined by scaling the total NPDES contribution by the ratio of state-wide municipal to industrial (659 to 180) WWTFs in 2011 from the 2014 Minnesota Nutrient Reduction Strategy (reference (47)).

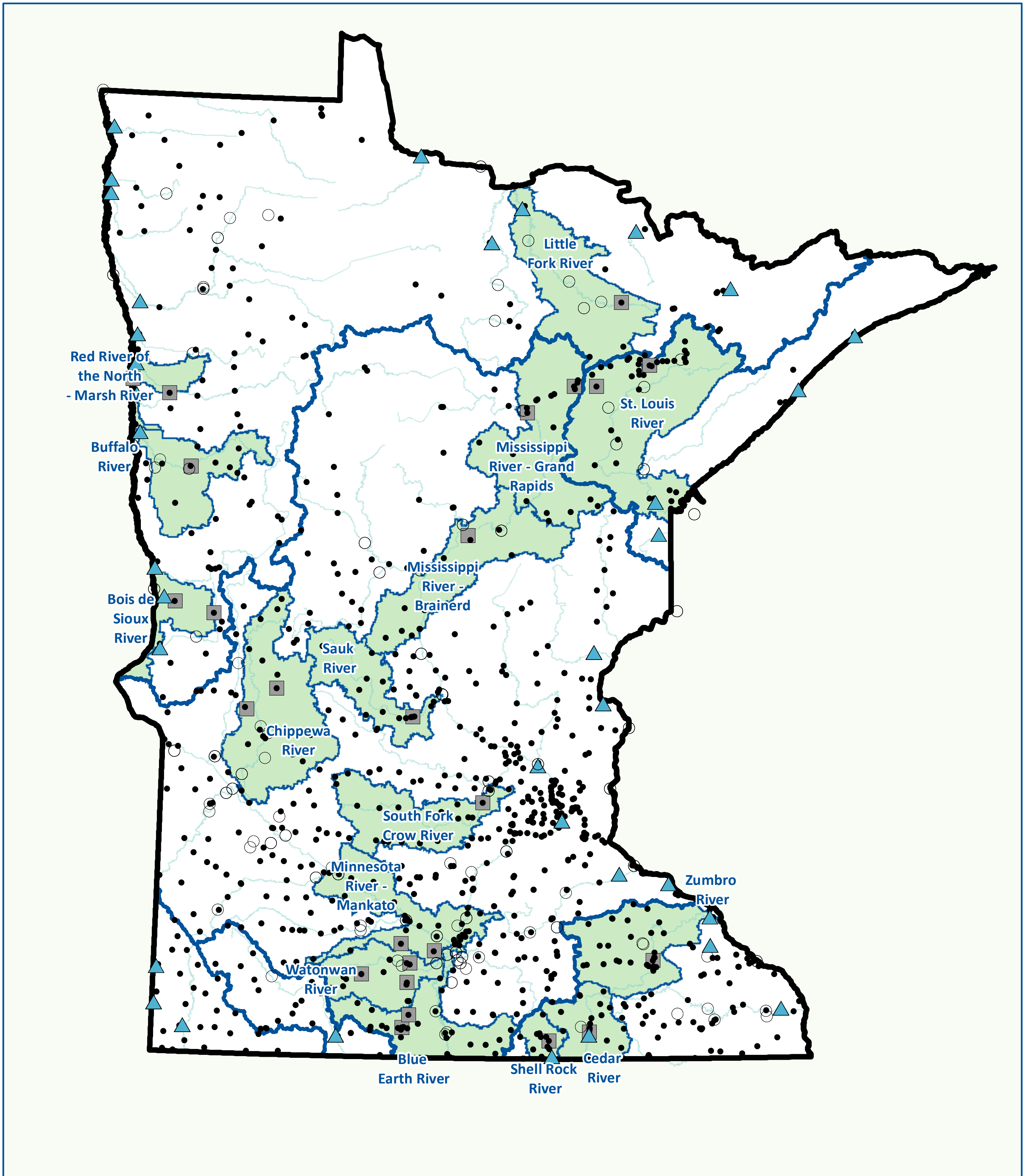
(2) Includes all WWTFs in Minnesota draining to the Gulf of Mexico, including those within the Des Moines and Missouri watersheds

Table 6-2 Percent contribution of NPDES permitted municipal WWTF discharges to basins

Basin	Basin Pollutant Loading Coverage from the MPCA's WPLMN(1)	Percent Contribution of NPDES permitted municipal WWTF discharges to basin(2)
Phosphorus		
Lake Superior	Not Full Coverage	3
Lake Winnipeg	Close to Full Coverage	2
Lake Pepin	Close to Full Coverage	8
Lower Mississippi	Mostly Full Coverage	0.3
Des Moines	Close to Full Coverage	9
Missouri	Not Full Coverage	2
Total Nitrogen		
Lake Superior	Not Full Coverage	40
Lake Winnipeg	Close to Full Coverage	2
Lake Pepin	Close to Full Coverage	8
Lower Mississippi	Mostly Full Coverage	1
Des Moines	Close to Full Coverage	19
Missouri	Not Full Coverage	1

(1) Basins listed as "Not Full Coverage" means that the WPLMN (reference (49)) lacks pollutant load monitoring data along many tributaries. The percent contribution of NPDES permitted WWTFs may be larger than the actual percent contribution. Basins listed as "Mostly Full Coverage" contain pollutant load monitoring data for the most significant streams within the basin. Basins listed as "Close to Full Coverage" contain pollutant load monitoring data for the all significant streams within the basin.

(2) Percent contributions are calculated from MPCA WWTF and stream monitoring data for year 2011.



WPLMN Monitoring Location

- Used to calculate basin loading
- Did not use to calculate basin loading

- MPCA Monitored WWTF
- WWTF
- Minnesota State Boundary
- Major Basins
- Major Watersheds

0 25 50 75

Miles

BARR

MONITORING LOCATIONS FOR BASIN-SCALE LOADING ANALYSIS

Water Quality Standards Cost Analysis

Minnesota Management & Budget

FIGURE 6-2

6.2 Summary of the Estimated Incremental Water Quality Changes Due to Current and Future Effluent Limits

Incremental water quality changes expected to result from meeting current and future effluent limits were evaluated for chloride, total phosphorus, and total nitrogen. In some cases, an effluent limit was calculated where there was reasonable potential for the water quality standard to be exceeded in the receiving water, but the long-term average of the DMR data did not exceed the calculated effluent limit. In those cases, the new or more stringent effluent limits would not result in incremental water quality changes.

Note that this study did not include any facilities within the Des Moines and Missouri basins. Pollutant reductions within the Missouri basin were estimated based on pollutant reductions in the neighboring Watonwan and Blue Earth River watersheds within the Lake Pepin basin. Pollutant reductions within the Des Moines basin were estimated to reflect the required 80 percent reduction to meet South Heron Lake and Talcot Lake eutrophication standards outlined in Table 2-4 of the 2014 Minnesota Nutrient Reduction Strategy report (reference (47)). In the 10 facilities for which this study estimated current or future chloride effluent limits, chloride concentrations are only being monitored under the existing permit. Many of the 25 studied facilities have nitrogen and phosphorus limits under the existing permit which could be superseded by effluent limits to meet current and future standards.

6.2.1 Chloride

6.2.1.1 Localized Chloride Reductions at Studied WWTFs

None of the 25 facilities studied have an existing permit limit for chloride; however, 36 percent (nine out of 25) may have a future chloride limit based on existing and future water quality standards. Of those nine, two facilities' long-term DMR data indicate that meeting the calculated effluent limits will not result in downstream water quality improvement. This determination was made by comparing each facility's long-term average chloride concentration to the calculated effluent limits. Therefore, current and future chloride limits will produce water quality improvements from 28 percent (seven out of 25) of the facilities studied. The reduction in chloride concentrations in the effluent of these seven facilities is shown in Table 6-3. These chloride reductions show the incremental change to the waters immediately downstream of the WWTFs' discharge.

Table 6-3 WWTFs with effluent chloride reductions to meet current and future WQS

WWTF	Percent Reduction in Existing Effluent to meet Current WQS	Percent Reduction in Existing Effluent to meet Future WQS
Albert Lea	29%	29%
Austin	28%	28%
Fairmont	8%	8%
Madelia	39%	39%
Rochester	20%	20%
Starbuck	5%	5%
Watertown	58%	58%

Because chloride effluent limits are dependent on a number of factors and conditions pertaining to each facility, extrapolating the water quality benefit of implementing current and future standards to other facilities across the state is not feasible at this time. Chloride limits depend on receiving water dilution capacity during critical low flows, size of a facility, location of a facility within a watershed, and hardness of source water, all of which are highly variable throughout Minnesota. As shown in Figure 5-18, groundwater is classified as "hard" and "very hard" throughout the southern half of the state, but much of the upper half of the state may not require chloride treatment because groundwater is mostly "moderately hard" or "soft." Additionally, facilities located near the headwaters of a watershed tend to require stricter chloride limits than facilities located close to the downstream end of a watershed, due to dilution during critical low flows. Even though 28 percent of the 25 studied facilities are expected to have current or future effluent limits, it cannot be said that 28 percent of all WWTFs statewide would need to meet chloride effluent limits. It is expected that the actual percentage of WWTFs that would need treatment could be higher than 40 percent based on a review of the hardness values across the state; however, the percentage could be lower if effluent limit determinations reflected the dilution that is provided for WWTFs that discharge near the downstream end of a watershed. As a result, quantifying the state-wide water quality benefit of meeting current and future chloride standards is not possible with the current level of monitoring and analysis.

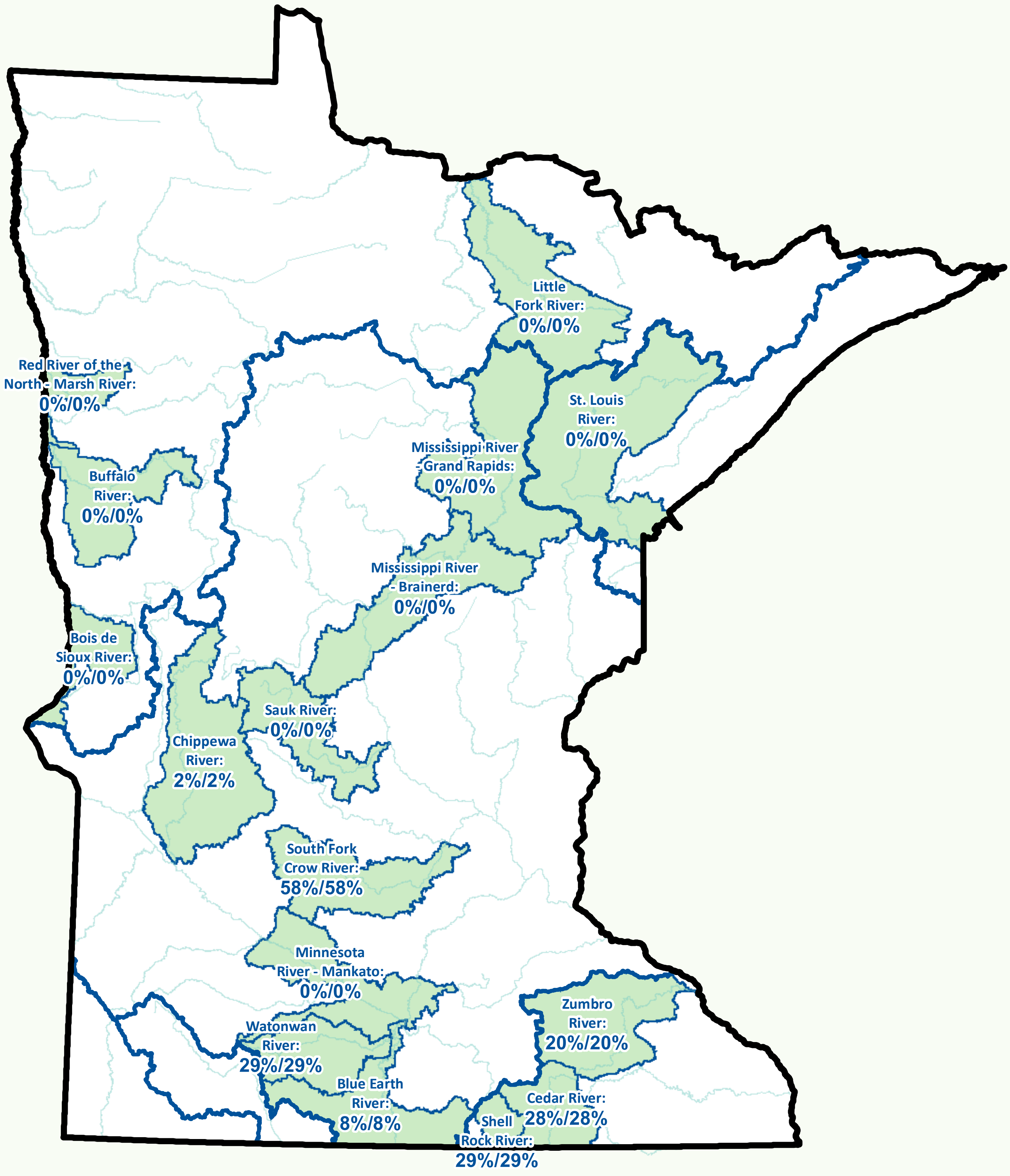
6.2.1.2 Watershed-Wide Chloride Reductions

Table 6-4 summarizes the reductions of chloride concentrations in effluent discharges for each major watershed containing an analyzed facility. Figure 6-3 highlights the major watersheds where a current or future limit is expected to result in a reduction in effluent chloride concentration. The percent reductions in Table 6-4 and Figure 6-3 are represented by the percent reduction in average effluent concentration to meet current and future WQS for the facility contained within the watershed. This assumes that the pollutant reductions at the facility are representative of the reductions for the entire watershed. In some cases, multiple facilities exist within a single watershed. Where this occurs, the flow-weighted average pollutant reductions were calculated using the WWTF Q_e as indicated in the methods described in Section 6.1. As shown, the pollutant reductions to reach current and future effluent limits are identical.

This occurs because the current and future effluent limits for chloride for each facility are not expected to change. Because chloride concentrations are diluted at downstream ends of watersheds, WWTFs located near the headwaters of major watersheds often require greater chloride reductions. For example, Figure 6-3 shows that no current or future chloride reductions are expected along the Mississippi or Minnesota River downstream of the headwaters. However, chloride reductions are expected within the Chippewa River, Blue Earth River, Watonwan River, and South Fork Crow River watersheds where headwaters are contained within these major watersheds. The percent reductions in Table 6-4 on a watershed-wide scale do not take into account the upstream benefits to intervening receiving waters that must also be protected for chloride. Benefits of chloride WQBELs at the upstream end of a receiving water will be conferred to all downstream waters. Therefore, chloride limits are set on a case-by-case basis largely to protect the receiving water immediately downstream of the discharge. Moving farther downstream, dilution is greater and the watershed-wide benefits of an upstream WQBEL may be reduced.

Table 6-4 Chloride reductions from existing effluent to meet current and future WQS in major Minnesota watersheds

Major Watershed	Percent Reduction in Existing Effluent to meet Current WQS	Percent Reduction in Existing Effluent to meet Future WQS
Red - Marsh River	0%	0%
Shell Rock	29%	29%
Cedar	28%	28%
Bois de Sioux	0%	0%
Sauk	0%	0%
Little Fork	0%	0%
Blue Earth	8%	8%
St. Louis	0%	0%
Mississippi - Grand Rapids	0%	0%
Chippewa	2%	2%
Minnesota - Mankato	0%	0%
Buffalo	0%	0%
Watonwan	29%	29%
Zumbro	20%	20%
Mississippi - Brainerd	0%	0%
South Fork Crow	58%	58%



BARR

Minnesota State Boundary

Major Basins

Major Watersheds

Percent loading reductions due to upgrades to municipal WWTFs to meet current and future WQSs are shown as:
current (%)/future (%)

N

0 25 50 75

Miles

CHLORIDE LOADING REDUCTION BY MAJOR WATERSHED

Water Quality Standards Cost Analysis

Minnesota Management & Budget

FIGURE 6-3

6.2.2 TSS

The recently adopted WQS for TSS did not result in more stringent effluent limits, even in the North River Region where the WQS for TSS is the lowest, due in part to the accounting for the portion of the TSS that is NVSS and the application of MPCA guidance for considering the water quality impacts of NVSS when setting WQBLES for TSS.

6.2.3 Sulfate

Sulfate reduction requirements to meet the sulfate WQS at the wild rice stand are site-specific. Generally, the closer the discharge is to a wild rice receiving water, the larger potential impact that its reduction will have on the water quality. Wild rice located farther from the discharge in a water with a larger flow may not be impacted significantly by that discharger's reduction due to dilution or degradation. The assumption of potential impact for wild rice waters within 50 miles could be too conservative or not conservative enough depending on actual receiving stream conditions, dilution, and degradation. This study assessed potential sulfate limits where downstream listed wild rice locations were within 50 miles to balance the significance of a discharger's impact. This limitation also addresses the uncertainty in using a fixed WQS of 10 mg/L that could vary by site in a final rule. Because there was limited receiving stream sulfate data, the sulfate reduction was calculated in the immediate receiving stream rather than at the nearest wild rice location. Table 6-5 provides an overall summary of the estimated sulfate reduction in the respective receiving stream for sites with potential limits.

Table 6-5 Receiving water sulfate reduction estimates

City	Percent Sulfate Reduction in the Receiving Stream	Annual Mass Reduction in the Receiving Stream
Hibbing	85%	0.6×10^6 lbs
Cold Spring	17%	0.2×10^6 lbs
Gilbert	80%	0.02×10^6 lbs
Total		**0.82×10^6 lbs**

6.2.4 Phosphorus

Twelve of the 25 facilities have new or reduced phosphorus effluent limits as a result of current or future WQS and/or WLAs. Of the 12, eight will incur a reduction in phosphorus concentrations in the effluent in order to meet the calculated effluent limits. As previously stated, the MPCA phosphorus memos and (RES were used to define the current WQBEL for each facility. Because there are no future WQBELs for phosphorus, no phosphorus reductions to meet future WQS exist. Table 6-6 shows the reductions in effluent phosphorus concentrations to the immediate receiving stream for each of the eight facilities with a current WQBEL reduction.

Table 6-6 WWTFs with effluent phosphorus reductions to meet current WQS

WWTF	Percent Reduction in Existing Effluent to meet Current WQS
Albert Lea	69%
Austin	94%
Hancock	69%
Hawley	83%
Madelia	13%
Rochester	86%
Watertown	83%
Wendell	24%

Table 6-7 summarizes the percent loading reductions for phosphorus for each major watershed containing an analyzed facility. Figure 6-4 highlights the watersheds where a current limit is expected to cause a reduction in effluent phosphorus concentration. In some cases, multiple facilities exist within a single major watershed. Where this occurs, the flow-weighted average pollutant reductions were calculated from the Q_e as described in Section 6.1. Because no studied facilities exist within the St. Croix watershed where a 20 percent reduction in phosphorus levels is required in order to meet Lake Pepin TMDLs (reference (47)), the percent reduction to meet current WQS in the St. Croix watershed was calculated by comparing MPCA TMDL allocations to the 2015 effluent phosphorus load at each monitored municipal WWTF within the St. Croix watershed. Table 6-8 is a list of all TMDL allocations and 2015 phosphorus effluent loading for municipal facilities within the St. Croix watershed. These were used to determine that an overall flow-weighted phosphorus reduction of eight percent would be needed to meet the current WQS for the St. Croix watershed. An average WWTF discharge rate calculated from all municipal WWTFs was applied to the St. Croix watershed in order to incorporate the eight percent reduction into the overall reduction for the Lake Pepin basin. Because the average municipal WWTF effluent discharge rate is small (0.3 MGD) in comparison to other municipal WWTFs within the Lake Pepin basin, the reduction within the St. Croix watershed has little effect on the overall phosphorus reduction for the Lake Pepin basin.

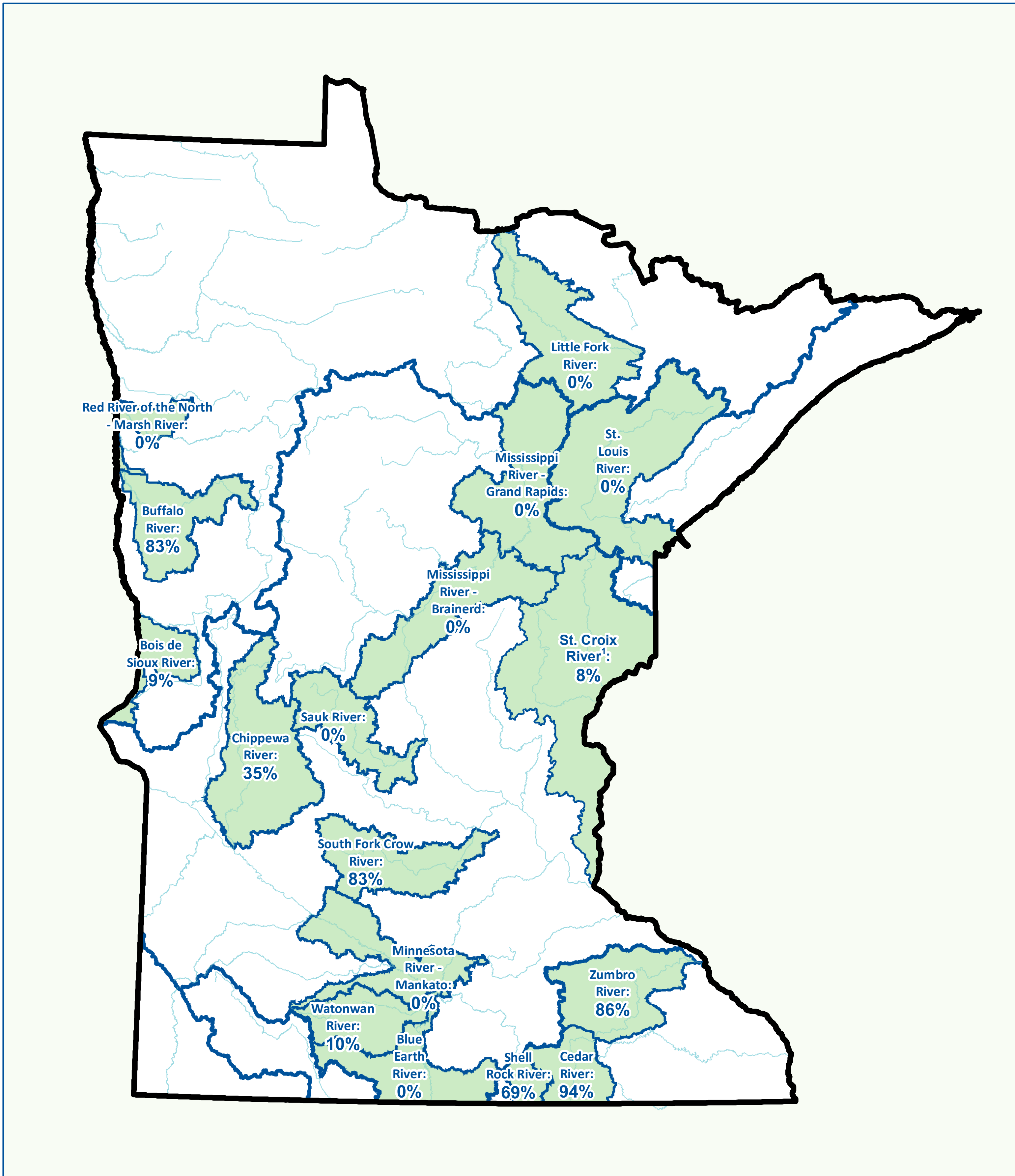
Table 6-7 Phosphorus reductions to meet current WQS in major Minnesota watersheds

Major Watershed	Percent Load Reduction to Meet Current WQS
Red - Marsh River	0%
Shell Rock	69%
Cedar	94%
Bois de Sioux	9%
Sauk	0%
Little Fork	0%
Blue Earth	0%
St. Louis	0%
Mississippi - Grand Rapids	0%
Chippewa	35%
Minnesota - Mankato	0%
Buffalo	83%
Watonwan	10%
Zumbro	86%
Mississippi - Brainerd	0%
South Fork Crow	83%
St. Croix[1]	8%

(1) The St. Croix major watershed contains no studied WWTFs. The percent reduction to meet current WQS was calculated as the flow-weighted reduction to meet the TMDL allocations for all municipal facilities within the watershed (Table 6-6.)

Table 6-8 Minnesota effluent phosphorus loading and TMDL requirements for the St. Croix watershed

WWTF	TMDL Allocation (kg/yr)	2015 WWTF Effluent (kg/yr)	Load Reduction to meet TMDL Allocation (kg/yr)	% Reduction Required to meet TMDL
Askov WWTP	128	33	0	0%
Barnum WWTP	402	0	0	0%
Chisago Lakes Joint STC	2039	1889	0	0%
Finlayson WWTP	414	0	0	0%
Harris WWTP	164	13	0	0%
Hinckley WWTP	942	227	0	0%
Isle WWTP	276	121	0	0%
John Iacarella - Linwood Terrace Co	231	5	0	0%
Kettle River WWTP	97	42	0	0%
Met Council - St Croix Valley WWTP	4808	2142	0	0%
Moose Lake WWTP	684	1095	411	38%
Mora WWTP	1105	1710	605	35%
North Branch WWTP	1122	481	0	0%
Ogilvie WWTP	318	0	0	0%
Pine City WWTP	1036	18	0	0%
Rush City WWTP	552	822	270	33%
Sandstone WWTP	529	2024	1495	74%
Shafer WWTP	553	76	0	0%
Shorewood Park Sanitary District	41	138	97	70%
Taylors Falls WWTP	390	163	0	0%
Wahkon WWTP	334	26	0	0%
Willow River WWTP	122	40	0	0%
			Flow-weighted Reduction Requirement to Meet TMDL for St. Croix Watershed:	**8%**



Minnesota State Boundary

Major Basins

Major Watersheds

Percent loading reductions due to upgrades to municipal WWTFs to meet current WQSs are shown as:
current (%)

[1] The percent reductions within the St. Croix major watershed were calculated by comparing TMDL allocations to 2015 phosphorus loading from all MPCA monitored domestic WWTFs.

N

0 25 50 75

Miles

BARR

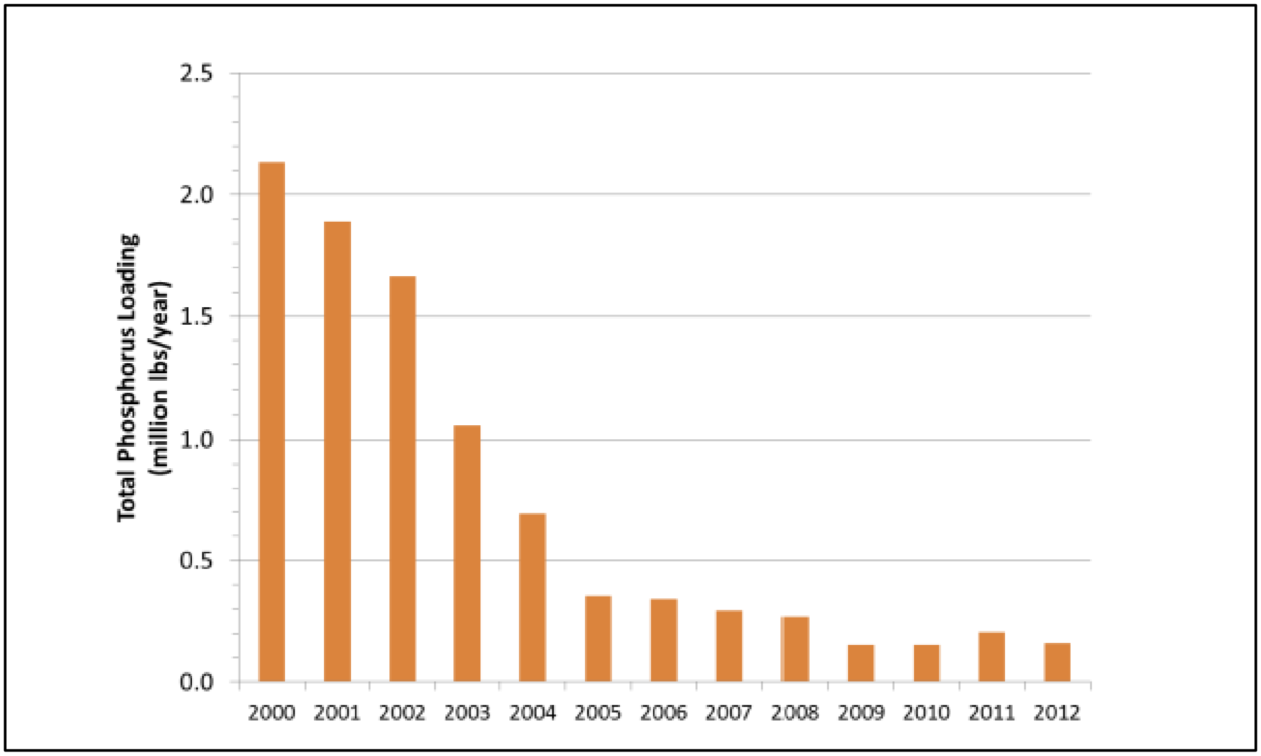
PHOSPHORUS LOADING REDUCTION BY MAJOR WATERSHED

Water Quality Standards Cost Analysis

Minnesota Management & Budget

FIGURE 6-4

Table 6-9 extrapolates the phosphorus reductions to the six basins outlined in Figure 6-1 by means of a flow-weighted (Q_e) average. Load reductions within the Lake Pepin major basin are minimal (four percent), indicating that DMR data does not exceed the current limits in most of the studied facilities. This is due to the fact that most studied facilities in the Minnesota River basin meet the requirements of the Lower Minnesota River Dissolved Oxygen TMDL as reflected in the DMR data after year 2010. The effluent for these facilities also meet the limits for RES which are generally more restrictive than the five-month total mass limits for the Lower Minnesota River Dissolved Oxygen TMDL. Although complete compliance with RES and Lower Minnesota River DO TMDL within the Lake Pepin basin is still pending (for example, facilities in Marshall, Blue Earth, Le Center, and Walnut Grove do not meet TMDL allocations as of 2015), the studied facilities within the Lake Pepin basin reflect similar trends in phosphorus loading as the Metropolitan (Metro) WWTF in St. Paul, which now consistently achieves less than 1 mg/L total phosphorus in the effluent. Figure 6-5, taken from the 2014 Minnesota Nutrient Reduction Strategy report (reference (47)), shows the trend in total phosphorus loading in million pounds per year at the Metro WWTF. The Metro WWTF now consistently achieves less than 1 mg/l total phosphorus in the effluent. The same is true for the Fairmont, Madelia, Lake Crystal, and Starbuck facilities within the Lake Pepin basin which require <1.0 mg/l total phosphorus in the effluent to meet the RES.



Source: reference (47)

Figure 6-5 Metropolitan WWTF phosphorus loading trends

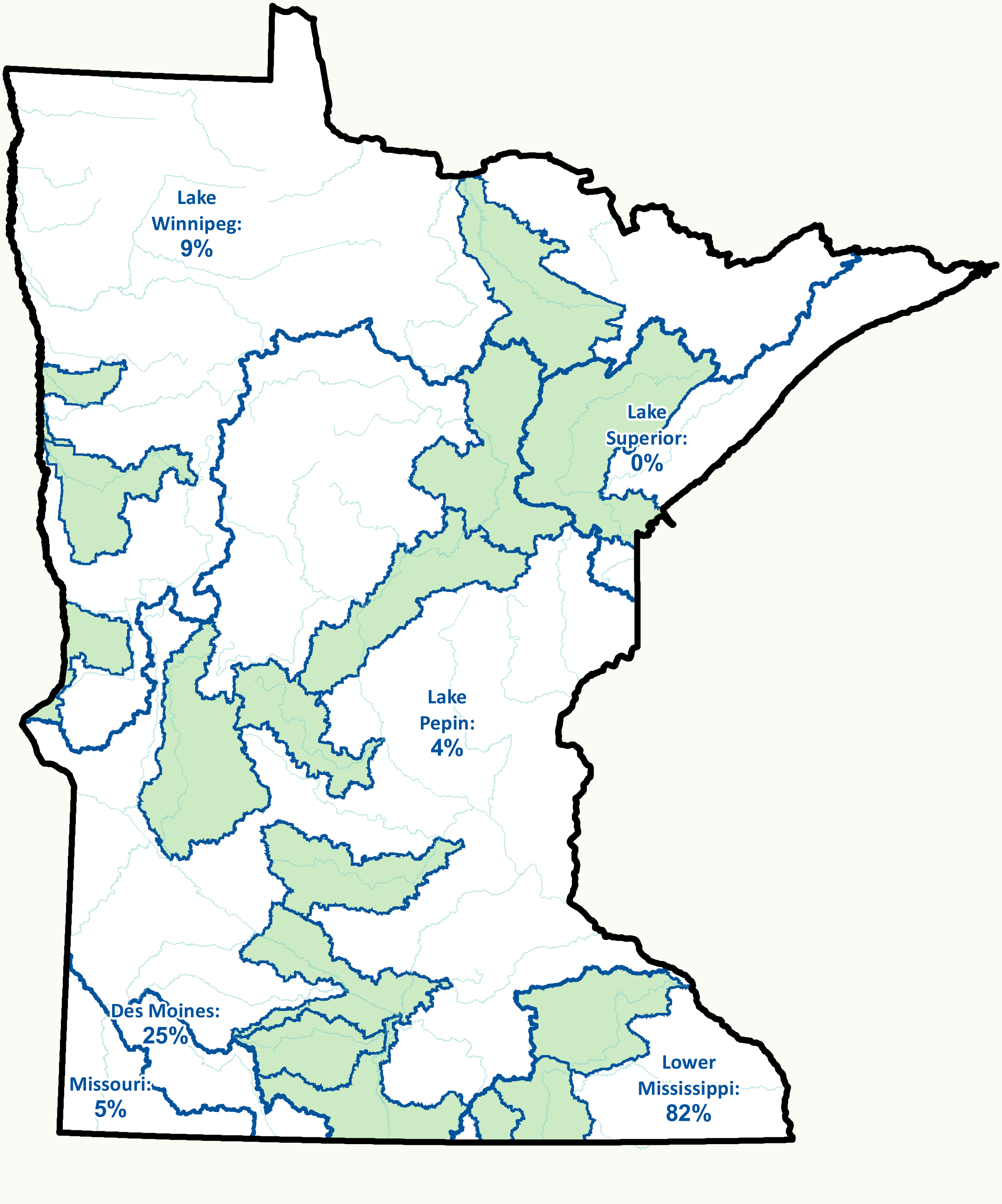
Table 6-9 also shows that the total phosphorus load reductions to the Mississippi River watershed based on current effluent limits will mainly come from load reductions within the Lower Mississippi River basin. No current phosphorus effluent limits are foreseen in the Lake Superior basin, so no load reduction is expected. Figure 6-6 shows the basin-wide flow-weighted effluent phosphorus load reductions outlined in Table 6-9.

Table 6-9 Phosphorus reductions to meet current WQS on a basin-wide scale

Basin	Percent Load Reduction to Meet Current WQS
Lake Pepin	4%
Lake Superior	0%
Lake Winnipeg	9%
Lower Mississippi	82%
Des Moines(1)	25%
Missouri River(2)	5%

(1) No facilities within the Des Moines basin were evaluated. The current percent reduction for the Des Moines River – Headwaters watershed was assumed to be the required 80% reduction to meet Heron Lake and Talcot Lake eutrophication standards outlined in Table 2-4 of the 2014 Minnesota Nutrient Reduction Strategy report (reference (47)). The extrapolated value assumes the two other Minnesota watersheds within the Des Moines basin downstream of South Lake Heron and Talcot Lake (Lower Des Moines River and East fork Des Moines River) will provide no treatment.

(2) No facilities within the Missouri River basin were evaluated. The current pollutant reduction was estimated with similar reductions to neighboring Watonwan and Blue Earth River watersheds within the Lake Pepin basin.



Minnesota State Boundary
Major Basins
Major Watersheds

Percent loading reductions due to upgrades to municipal WWTFs to meet current WQSs are shown as: **current (%)**

0 25 50 75
Miles

BARR

PHOSPHORUS LOADING REDUCTION BY BASIN
Water Quality Standards Cost Analysis
Minnesota Management & Budget

FIGURE 6-6

6.2.5 Nitrogen

6.2.5.1 Localized Nitrogen Reductions at Studied WWTFs

Nitrogen was analyzed on the basis of both nitrate/nitrite (NO_x-N) and ammonia. As described above, the WQBELs for each parameter were used to determine the overall total nitrogen reduction. Of the 25 facilities in the study, 20 require effluents limits to meet current or future ammonia water quality standards. Of those 20, nine facilities would require loading reductions to meet the calculated effluent limits. Table 6-10 shows the level of ammonia reduction that would result from the calculated effluent limits for the nine facilities.

Of the 25 facilities in the study, 14 would require effluent limits to meet future nitrate water quality standards in the receiving waters. Of those 14, nine would require effluent loading reductions to meet the effluent limits. Table 6-11 shows the nine facilities which would result in a reduced effluent nitrate (NO_x-N) concentration in order to meet the future WQBELs. No current nitrate WQBELs exist.

Table 6-10 WWTFs with effluent ammonia reductions to meet current and future WQS

WWTF	Percent Reduction in Existing Effluent to meet Current WQS	Percent Reduction in Existing Effluent to meet Future WQS
Ada	48%	61%
Austin	55%	68%
Butterfield	46%	50%
Hancock	42%	43%
Hawley	62%	73%
Lake Crystal	0%	13%
Serpent Lake	45%	46%
Watertown	0%	72%
Wendell	0%	86%

Table 6-11 WWTFs with effluent nitrate (NO_x-N) reductions to meet future WQS

WWTF	Percent Reduction in Existing Effluent to meet Future WQS
Albert Lea	76%
Austin	92%
Cold Spring	36%
Fairmont	78%
Gilbert	41%
Hibbing	66%
Rochester	83%
Starbuck	67%
Watertown	78%

These tables were used to determine the total nitrogen reductions shown in Table 6-12. As shown in Table 6-10 and Table 6-11, reductions in total nitrogen under current WQBELs are driven by ammonia effluent limits. Reductions in total nitrogen under future WQBELs are mostly driven by nitrate effluent limits. Once discharged into a receiving water, all ammonia eventually converts to nitrate, so both ammonia and nitrate/nitrite were addressed in establishing effluent limits. Ammonia and NO_x-N standards are established in order to protect aquatic life during critical conditions in the receiving water. New nitrogen limits are most important during critical low flow conditions when WWTFs have a much greater impact on total nitrogen concentrations in the immediate receiving stream. Table 6-12 shows how the new nitrogen limits impact the effluent concentrations at the WWTF discharge location along the receiving stream. Depending on the discharge of the facility, these reductions may incur major benefits to the receiving stream, especially during critical low flow conditions. For many facilities, estimated ammonia effluent limits are higher than the ammonia concentration in the existing effluent. This occurs in the Albert Lea, Cold Spring, Fairmont, Gilbert, Grand Rapids, Hibbing, Lake Crystal, Nashwauk, Rochester, Starbuck, and Watertown WWTFs. For these WWTFs, even though a new standard may be applicable, no total nitrogen reduction is expected.

Table 6-12 WWTFs with effluent total nitrogen reductions to meet current and future WQS

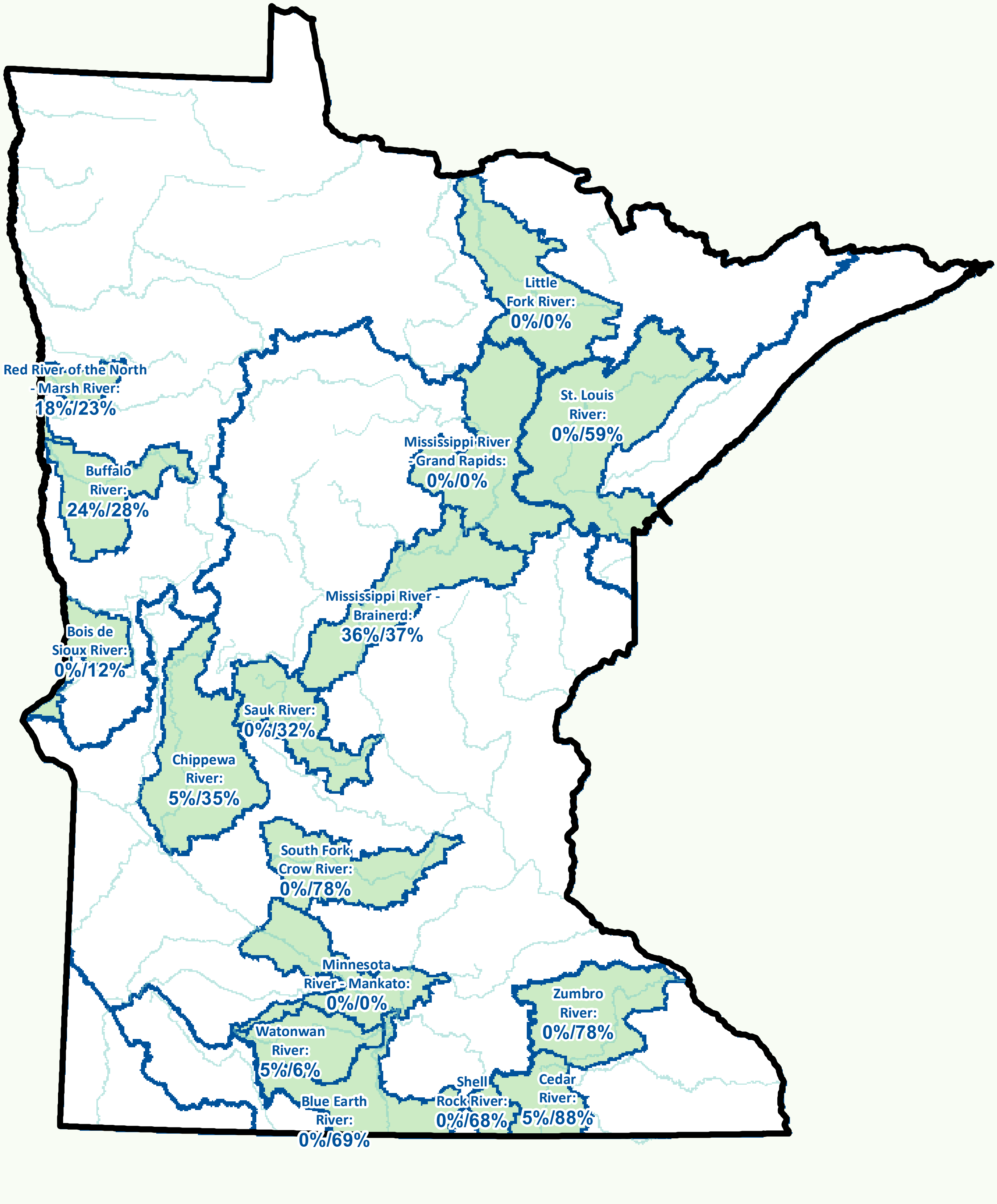
WWTF	Percent Reduction in Existing Effluent to meet Current WQS	Percent Reduction in Existing Effluent to meet Future WQS
Ada	18%	24%
Albert Lea	0%	68%
Austin	5%	88%
Butterfield	26%	28%
Cold Spring	0%	32%
Fairmont	0%	70%
Gilbert	0%	28%
Hancock	9%	10%
Hawley	24%	28%
Hibbing	0%	62%
Rochester	0%	78%
Serpent Lake	36%	37%
Starbuck	0%	61%
Watertown	0%	78%
Wendell	0%	31%

6.2.5.2 Watershed-Wide Nitrogen Reductions

The reductions in total nitrogen for each facility were then extrapolated to the major watershed level. Table 6-13 shows the reductions in total nitrogen for each major watershed containing an analyzed facility. Figure 6-7 highlights the major watersheds where a current or future limit is expected to cause a reduction in effluent nitrogen concentration. These reductions may vary during low or high flow conditions in the receiving stream and when considering annual loads at a watershed scale. For example, the current total nitrogen (in the form of NO_3-N) concentration of a receiving water downstream of a facility may be 15 mg/L during low flows. After the facility meets its new nitrogen limit, the concentration of the receiving water may be 5 mg/L during low flow. This is a large change during critical conditions that will benefit the aquatic life of the receiving water. However, the impact of the new nitrogen limit for the facility would likely be small when considering annual loads at the watershed and basin scale.

Table 6-13 Total nitrogen reductions to meet current and future WQS in major Minnesota watersheds

Major Watershed	Percent Load Reduction to Meet Current WQS	Percent Load Reduction to Meet Future WQS
Red - Marsh River	18%	23%
Shell Rock	0%	68%
Cedar	5%	88%
Bois de Sioux	0%	12%
Sauk	0%	32%
Little Fork	0%	0%
Blue Earth	0%	69%
St. Louis	0%	59%
Mississippi - Grand Rapids	0%	0%
Chippewa	5%	35%
Minnesota - Mankato	0%	0%
Buffalo	24%	28%
Watonwan	5%	6%
Zumbro	0%	78%
Mississippi - Brainerd	36%	37%
South Fork Crow	0%	78%



Minnesota State Boundary

Major Basins

Major Watersheds

Percent loading reductions due to upgrades to municipal WWTFs to meet current and future WQSs are shown as: **current (%)/future (%)**

0 25 50 75

Miles

BARR

TOTAL NITROGEN LOADING REDUCTION BY MAJOR WATERSHED

Water Quality Standards Cost Analysis

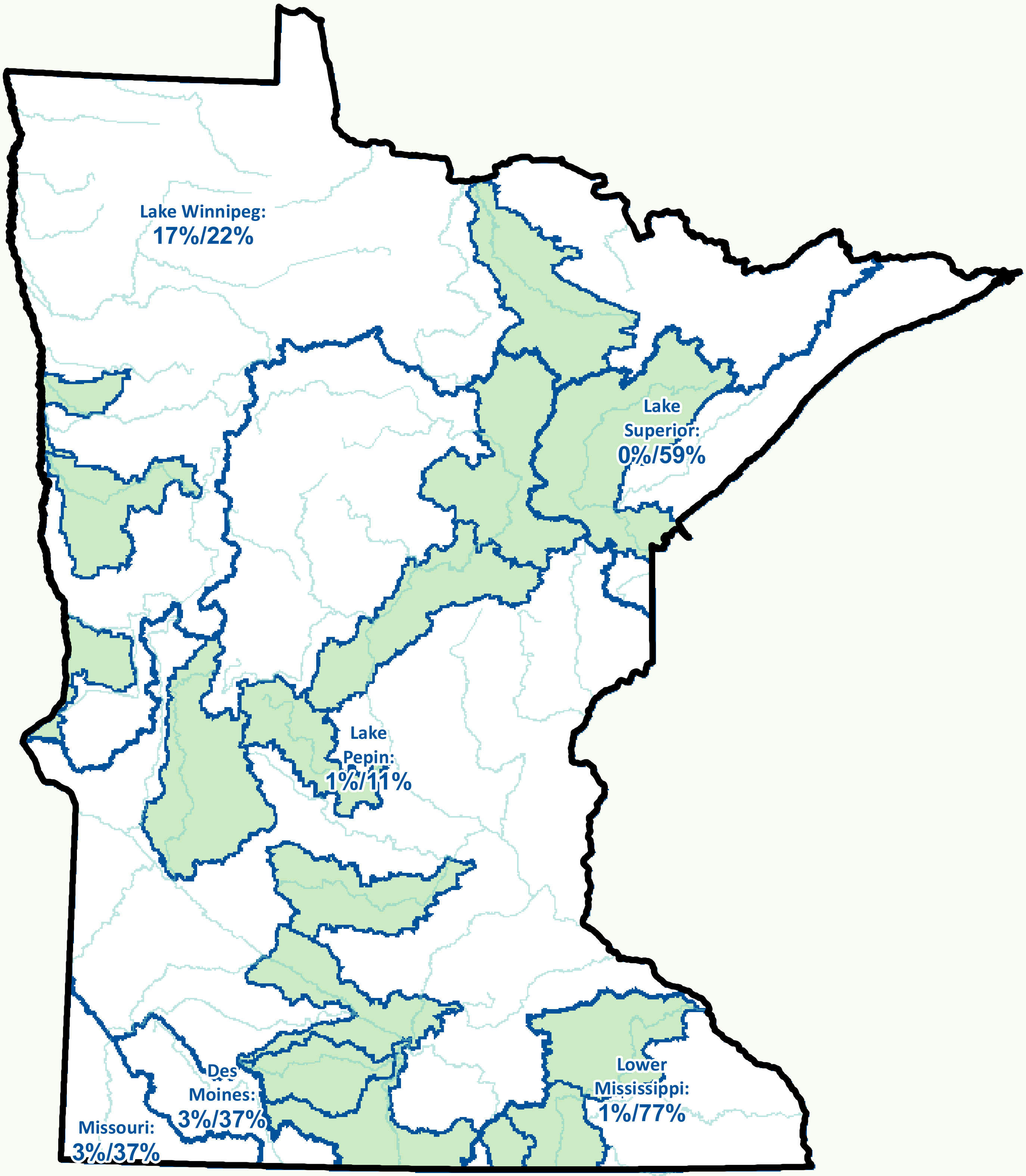
Minnesota Management & Budget

FIGURE 6-7

Table 6-14 extrapolates the total nitrogen reductions out to the six basins outlined in Figure 6-1 by means of a flow-weighted (Q_e) average. Figure 6-8 shows the pollutant percent reductions to each basin for total nitrogen. The reductions to total nitrogen loading to the receiving streams is due to current and future effluent limits on either ammonia or nitrite/nitrate.

Table 6-14 Total nitrogen reductions to meet current and future WQS on a basin-wide scale

Basin	Percent Load Reduction to Meet Current WQS	Percent Load Reduction to Meet Future WQS
Lake Pepin	1%	11%
Lake Superior	0%	59%
Lake Winnipeg	17%	22%
Lower Mississippi	1%	77%
Des Moines(1)	3%	37%
Missouri River(1)	3%	37%



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Minnesota State Boundary

Major Basins

Major Watersheds

Percent loading reductions due to upgrades to municipal WWTFs to meet current and future WQSs are shown as:
current (%)/future (%).

N

0 25 50 75

Miles

TOTAL NITROGEN LOADING REDUCTION BY BASIN

Water Quality Standards Cost Analysis

Minnesota Management & Budget

FIGURE 6-8

6.2.6 Summary of Estimated Incremental Water Quality Changes due to Current and Future Effluent Limits

Incremental water quality changes resulting from WWTF upgrades will primarily be realized immediately downstream of the discharge point under lower flow conditions (when less stream flow is available to dilute the flow). Reduced pollutant levels in the treated water provides the greatest benefits to aquatic life and recreational users in the segment of the receiving water immediately downstream of the discharge location. The reduction of each pollutant in the WWTF discharge, at the point that the treated water enters the receiving water at the critical flow is shown in Figure 6-9 and Figure 6-10.

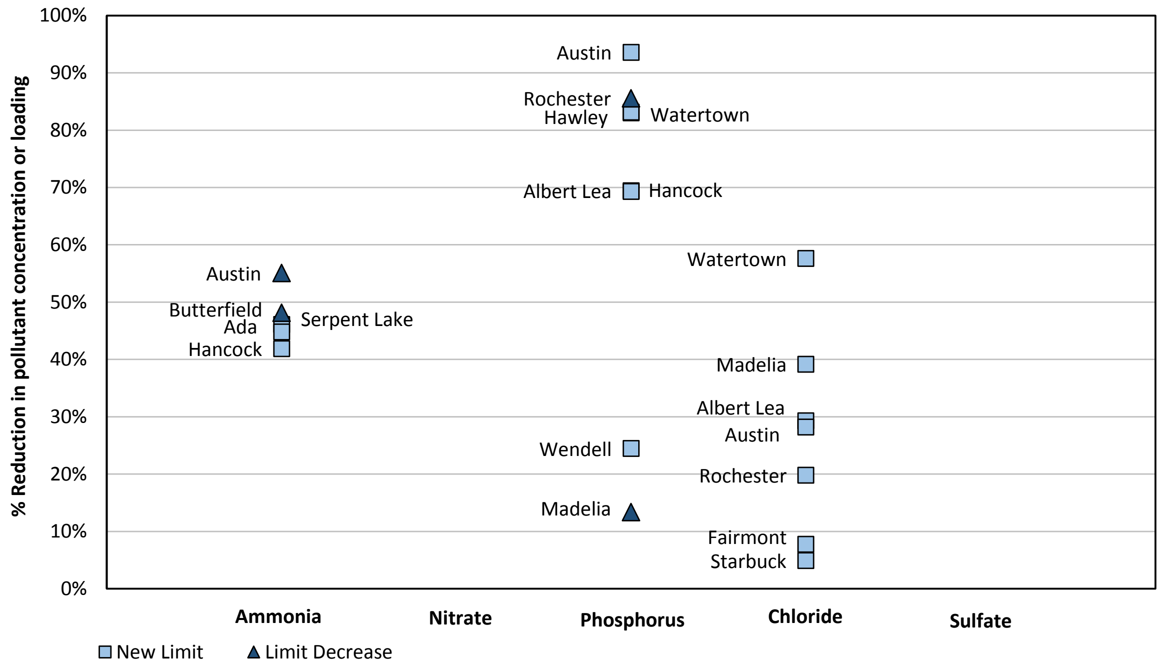


Figure 6-9 **Pollutant reduction in wastewater treatment facility (WWTF) discharge from upgrades to meet current effluent limits**

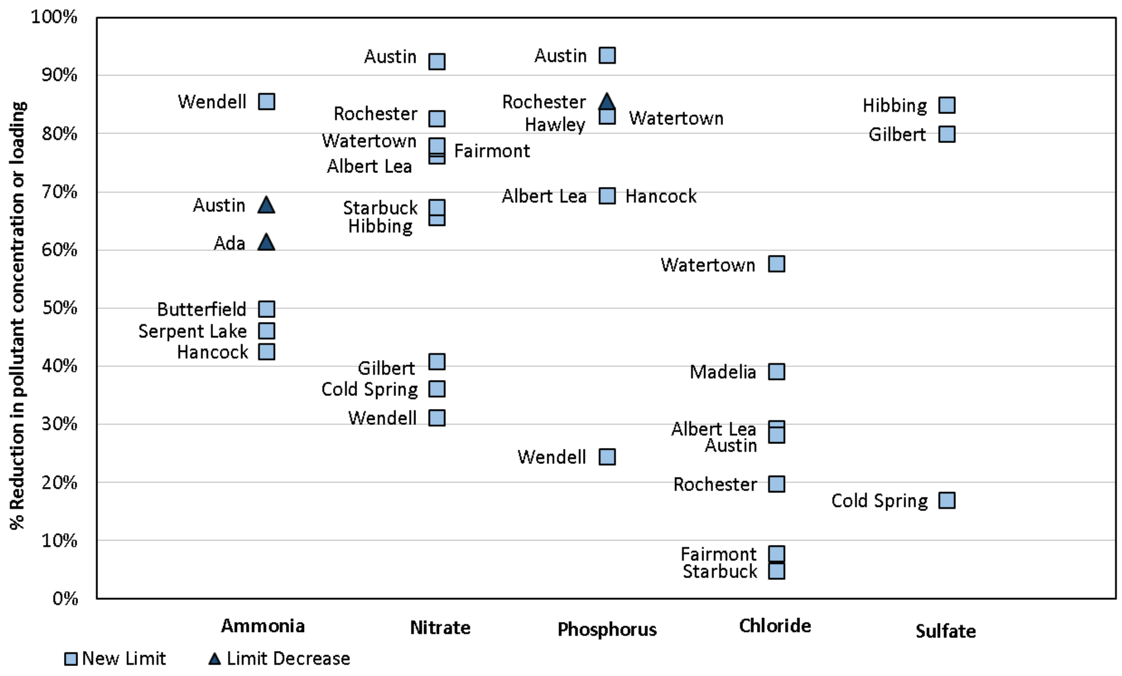


Figure 6-10 Pollutant reduction in wastewater treatment facility (WWTF) discharge from upgrades to meet future effluent limits

6.2.7 Incremental Effect on Water Quality due to Phosphorus and Nitrogen Effluent Reductions

The phosphorus and total nitrogen basin-wide WWTF effluent reductions were extrapolated to the three major Minnesota river basins (Lake Superior, Lake Winnipeg, and Mississippi River) in order to evaluate the effect on water quality to meet current and future phosphorus and total nitrogen WQS at a state-wide level.

State-wide current and future water quality changes were determined as follows:

- Municipal WWTF phosphorus and nitrogen loading to each major basin were determined from 2015 monitoring data (Table 6-15).
- The load reduction to each major basin was calculated by multiplying the WWTF effluent percent load reductions for phosphorus and nitrogen (provided in Table 6-9 and Table 6-14, respectively) by the percent contribution of municipal WWTF discharges to basin-wide load from Table 6-1. Results are shown on Figure 6-11 and in the middle columns of Table 6-16.
- The resulting basin-wide load reduction percentages were multiplied by the municipal phosphorus and nitrogen loading shown in Table 6-15 to determine the mass loading reductions for each pollutant in each basin. Results are shown in the far right columns of Table 6-16 and on Figure 6-11.

Table 6-15 Wastewater phosphorus and nitrogen loading to each major basin in 2015

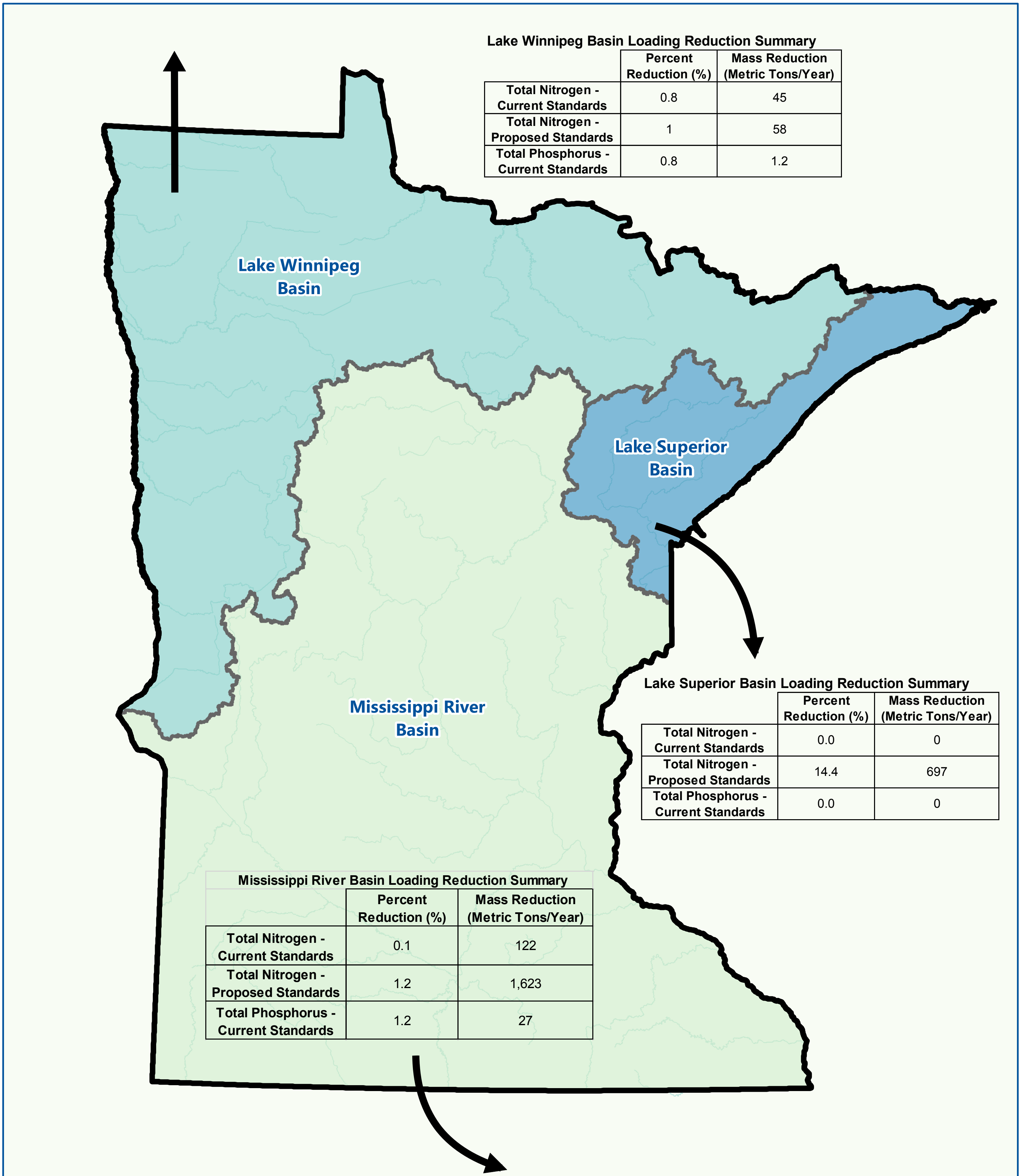
Major Basin	Phosphorus Loading in 2015 (MTs/yr)	Nitrogen Loading in 2015 (MTs/yr)
Lake Winnipeg	13	262
Lake Superior	2	1,178
Mississippi River(1)	313	9,473

Note: Phosphorus and TN loading for major basins are from the MPCA monitoring data for municipal WWTFs in 2015 (48).

(1) The contribution to the Mississippi River major basin includes all basins in Minnesota which drain to the Gulf of Mexico, including the Missouri and Des Moines basins.

As shown in Table 6-16, meeting the current and future WQS for phosphorus and total nitrogen would generally result in only minor reductions to overall loading in the major Minnesota basins. For example, no phosphorus load reductions are expected in the Lake Superior Basin, and total nitrogen loading to the Mississippi River Basin would decrease by approximately 0.1 percent and one percent to meet current and future WQS, respectively. Phosphorus and total nitrogen loading to the Lake Winnipeg Basin would decrease by approximately one percent to meet both current and future WQS. The exception is total nitrogen loading to the Lake Superior Basin. Upgrades to municipal WWTFs to meet future total nitrogen standards would result in a 14 percent decrease in total nitrogen loading to the Lake Superior Basin. It is important to note additional factors contributing to the minor reductions of overall nutrient loadings in the major basins include the following.

- As indicated in Table 7-1, WWTF discharges already represent less than 25 percent of the nutrient sources to each major basin. WWTF discharges contribute nine percent and five percent of the respective phosphorus and nitrogen loadings in the Lake Winnipeg basin and 14 percent and seven percent of the respective phosphorus and nitrogen loadings in the Mississippi River basin.
- Most of the studied facilities in the Minnesota River basin are already meeting the requirements of the Lower Minnesota River dissolved oxygen TMDL and RES.



Lake Winnipeg Basin Loading Reduction Summary

	Percent Reduction (%)	Mass Reduction (Metric Tons/Year)
Total Nitrogen - Current Standards	0.8	45
Total Nitrogen - Proposed Standards	1	58
Total Phosphorus - Current Standards	0.8	1.2

Lake Superior Basin Loading Reduction Summary

	Percent Reduction (%)	Mass Reduction (Metric Tons/Year)
Total Nitrogen - Current Standards	0.0	0
Total Nitrogen - Proposed Standards	14.4	697
Total Phosphorus - Current Standards	0.0	0

Mississippi River Basin Loading Reduction Summary

	Percent Reduction (%)	Mass Reduction (Metric Tons/Year)
Total Nitrogen - Current Standards	0.1	122
Total Nitrogen - Proposed Standards	1.2	1,623
Total Phosphorus - Current Standards	1.2	27

Minnesota State Boundary

Major Basin Divide

- Mississippi River
- Lake Superior
- Lake Winnipeg

The three major basin divides are from the 2014 MPCA Nutrient Reduction Strategy Report.

0 25 50 75

Miles

BARR

TOTAL NITROGEN AND PHOSPHORUS LOADING REDUCTIONS TO MAJOR BASINS DUE TO CURRENT AND FUTURE WWTF EFFLUENT LIMITS

Water Quality Standards Cost Analysis

Minnesota Management & Budget

FIGURE 6-11

Table 6-16 Total basin-wide nitrogen and phosphorus annual load reductions due to upgrades to municipal WWTFs to meet current and future WQS

Basin	Average Municipal WWTF Load Reduction to Meet Current WQS	Average Municipal WWTF Load Reduction to Meet Future WQS	Contribution to Basin from Municipal WWTFs (Table 6-1)	Basin-Wide Load Reduction due to Municipal WWTFs Meeting Current WQS[4]	Basin-Wide Load Reduction due to Municipal WWTFs Meeting Future WQS[4]	Municipal WWTF loading (MTs/yr) (Table 6-15)	Pollutant Reduction from Municipal WWTFs Under Current WQS (MT/yr)	Pollutant Reduction from Municipal WWTFs Under Future WQS (MT/yr)
Phosphorus								
Lake Superior	0%	-	19%	0%	-	2	0	-
Lake Winnipeg	9%	-	9%	1%	-	13	1	-
Mississippi River	9%	-	14%	1%	-	313	27	-
Total Nitrogen								
Lake Superior	0%	59%	24%	0%	14%	1,178	0	697
Lake Winnipeg	17%	22%	5%	1%	1%	262	45	58
Mississippi River	1.30%	17%	7%	0.10%	1%	9,473	122	1,623

6.3 Limitations of the Analysis

Specific limitations of the analysis presented in Section 6.0 are highlighted below.

- The percent pollutant reductions were determined by comparing the existing effluent to the AML WQBEL.
- The percent pollutant reductions extrapolated to the watershed and basin scales were based solely on the reduction in WWTF effluent concentrations to meet the current or future WQBEL. It was assumed that a reduction within a facility was characteristic of the reductions of all facilities within the watershed. For example, a 10 percent reduction in a parameter at Facility Y within watershed X incurred a 10 percent reduction in the parameter for watershed X.
- Often, complete coverage in the DMR data was not provided. Therefore, it was assumed that DMR data provided for each facility accurately represents the current concentrations and loading in the facility's effluent. Averaging all provided data (often spanning from 2010 to 2016) was assumed to provide an acceptable estimate of each parameter in the existing effluent.
- Determining annual loads from a facility to a receiving stream was calculated by multiplying the average effluent concentration by the facility's ADW flow (Q_e). This assumes the ADW flow is representative of the yearly average flow for the facility consistently discharging the average concentration for the parameter of interest.
- Even when a permit limit existed for a given parameter, the average DMR data was used to determine the existing effluent concentration. This assumes that the DMR data better reflects existing conditions at the facility.
- Estimating load reductions to the major basins was calculated using the following approach:
    - X percent of the loading for pollutant Y in a basin originates from municipal WWTFs.
    - Based on the analysis of the 25 studied WWTFs, the effluent limit for pollutant Y will decrease by Z percent.
    - Therefore, the total loading for pollutant Y in a basin will decrease by X*Z percent.
    - This process oversimplifies the results, but provides a rough estimate in pollutant reduction for each basin. Pollutant reductions to basins which contain no data were estimated based on surrounding basins.
    - The percent TN and phosphorus loading to a basin originating from WWTFs provided in the 2014 Nutrient Reduction Strategy report (reference (47)) is assumed to reflect current conditions. These values were scaled to reflect the municipal contribution by multiplying by the 2011 industrial-to-municipal WWTF ratio.
- Chloride reductions at the watershed and basin scale assume that the pollutant reductions at the facility are representative of the reductions for the entire watershed. Where multiple facilities exist

within a single watershed, the flow-weighted average pollutant reductions, calculated as described in Section 6.1, were assumed to provide acceptable estimates of the watershed-wide pollutant reduction. Additional benefit of upstream limits to downstream watersheds was not accounted for in this analysis.

- For facilities without nitrogen monitoring data, the assumed average ammonia concentration was 4.7 mg/L and the assumed total nitrogen concentration was 6.7 mg/L.
- For all “non-discharging” ponds, it was assumed that no water quality change occurs in the watershed. Since these pond systems are discharging their flow to groundwater, future management in the form of a liner or other retrofit may be required. Analyzing the number of pond systems across the state experiencing similar impacts to groundwater may provide additional insight on methods to improve downstream surface water quality.

The limitations of analysis discussed above provide information on areas of uncertainty in specific assumptions. They do not change the overall conclusions of the report or application for its intended purpose.

7.0 Stormwater Treatment Costs and Water Quality Benefits

In accordance with the Clean Water Act and under authority from Minnesota Statutes, the MPCA has established rules and National Pollutant Discharge Elimination System (NPDES) permitting programs to regulate discharges of stormwater from MS4s, construction activities, and industrial activities for the purposes of abating water pollution associated with stormwater discharges from these point sources. This study addresses MS4s.

Municipal separate storm sewers are publicly owned or operated stormwater infrastructure used solely for stormwater and are not part of a publicly owned wastewater treatment system. Examples of stormwater infrastructure include curbs, ditches, culverts, stormwater ponds, and storm sewer pipes. Common owners or operators of MS4s include cities, townships, and public institutions. Owners and operators of MS4s which are required to obtain a permit are identified in one of three ways: the federal Clean Water Act, state rule, or by public petition to the MPCA. Stormwater in communities not subject to stormwater permits is managed according to non-point source best management practices (BMPs), non-point sources are not regulated and are not addressed in this study.

The number of regulated MS4s in Minnesota is growing as urban areas expand. As of November 2016, 260 MS4s are regulated for their stormwater discharges under a MS4s permit. This study addresses the 164 municipal/city owners of MS4s.

The general permit for municipal separate storm sewers requires the operator or owner to create and implement a Stormwater Pollution Prevention Program (SWPPP) with six important components:

1. Public education and outreach, which includes teaching citizens about stormwater management
2. Public participation to include citizens in solving stormwater pollution problems
3. A plan to detect and eliminate illicit discharges to the storm sewer system
4. Construction-site runoff controls
5. Post-construction runoff controls
6. Pollution prevention and municipal “good housekeeping” measures

Where a TMDL study for a particular body requires a WLA for regulated stormwater to meet the water quality standard in an impaired water, MPCA guidance specifies the procedures for establishing that allocation. For each applicable WLA not met, a compliance schedule is required which must include:

- Dates for implementation of interim milestones, expressed as progress toward implementation of BMPs
- Strategies for continued BMP implementation
- Target dates the applicable WLA will be achieved

7.1 Selection of Municipal Separate Storm Sewer Systems for Cost Analysis

Stormwater treatment by MS4s would need to be upgraded to meet Minnesota's water quality standards, which are primarily applied through TMDLs and their resulting WLAs. To estimate the potential total capital and operating costs associated with upgrading existing stormwater treatment systems throughout the state to meet current and future TMDL WLAs and NPDES permit requirements, an in-depth cost analysis was performed on the six MS4s required to have permits: Albert Lea, Austin, Fairmont, Grand Rapids, Hibbing, and Rochester.

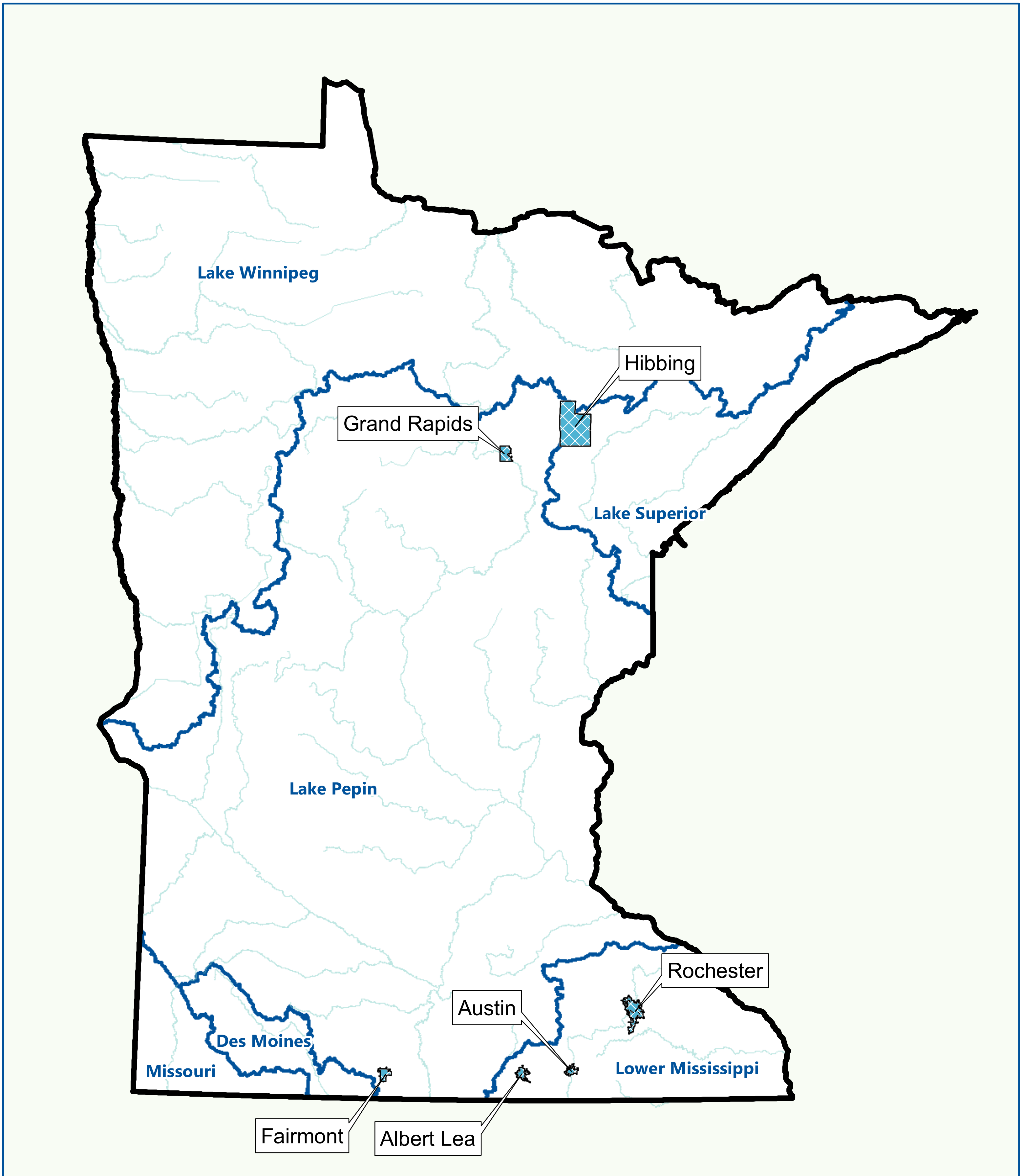
The six MS4s shown in Figure 7-1 and Table 7-1 were selected to represent a cross-section of geographic areas, population, and existing TMDL requirements within the state. Each of the six MS4s was investigated to determine the existing pollutant load, existing TMDL loading requirements, and pollutant loading reduction provided by existing stormwater treatment systems.

Existing pollutant load and load reduction was then compared to anticipated TMDL requirements to estimate the cost required to upgrade existing stormwater treatment systems and/or meet existing requirements or newly approved TMDL WLAs. Because sediment and nutrient TMDLs often establish the degree of stormwater treatment required by an MS4, the pollutants TSS, TP, and TN were considered within this analysis. The methods used to estimate existing pollutant loading and load reduction, the anticipated TMDL requirements, and the cost to upgrade existing stormwater treatment systems for each of the six MS4s are described in the following sections.

Table 7-1 MS4s selected for stormwater treatment cost analysis.

MS4	Population (2010)(1)	Municipal Area (acres)	Major Drainage Basin(2)
Albert Lea	18,016	9,454	Lower Mississippi
Austin	24,718	7,705	Lower Mississippi
Fairmont	10,666	10,792	Lake Pepin
Grand Rapids	10,869	15,664	Lake Pepin
Hibbing	16,361	119,188	Lake Superior
Rochester	106,769	34,878	Lower Mississippi

(1) Population values source: reference (50).
(2) Major drainage basins shown in Figure 7-1 and discussed in Section 7.4.



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MS4s selected for cost analysis
Minnesota State Boundary
Major Basins

*MS4 - Municipal Seperate Stormwater System

0 25 50 75
Miles

MS4 LOCATIONS FOR STORMWATER COST ANALYSIS
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 7-1

Barr Footer: ArcGIS 10.4, 2016-12-30 11:12 File: I:\Projects\23\62\1225\Maps\Reports\Figure 7-1 MS4s for Cost Analysis ADA.mxd User: MJW

7.2 Summary of Expected Treatment Requirements for Select MS4s

7.2.1 Existing Pollutant Loading and Pollutant Load Reduction

Existing pollutant loading and pollutant load reduction provided by existing stormwater treatment systems was calculated as the first step in estimating the cost that would be incurred by each of the six MS4s to comply with current and future water quality standards and associated TMDL loading requirements.

Existing annual runoff volume and associated pollutant loading was estimated using the Simple Method (reference (51)):

$$L = (A \times P \times R_v) \times EMC \quad (51)$$

Where:

L = annual pollutant load (mass)
A = drainage area
R_v = runoff coefficient = 0.05 + 0.9 x impervious fraction
EMC = event mean concentration of pollutant

Annual runoff volumes and pollutant loads for TSS, total phosphorus (TP), and total nitrogen (TN) calculated using the Simple Method are shown in Table 7-2. As outlined in Table 7-2, annual runoff volumes and pollutant loads were calculated based on the developed area within each MS4, as defined by the 2011 National Land Cover Dataset (NLCD) (reference (52)). Existing loading was calculated from developed areas for two reasons – BMP implementation intended to comply with the MS4 permit is focused on treating runoff from developed and developing areas, and the municipal boundary of some MS4s extends far beyond the developed portion of the MS4 (e.g., Hibbing, Grand Rapids, etc.) causing the Simple Method to over-predict runoff volume and pollutant loading when the calculation is performed based on the entire municipal boundary.

The Simple Method and data sources cited in Table 7-2 are based on methods and sources cited by the MPCA Estimator tool (reference (53)). The MPCA Estimator tool is used by many MS4s within the state to track pollutant loading, pollutant load reduction provided by BMPs, and progress toward meeting TMDL WLAs. To maintain consistency with methods and reporting practices already established within the state, the methods cited within the MPCA Estimator tool was adhered to as closely as possible throughout this study.

Table 7-2 Estimated annual runoff and pollutant loading for select MS4s

MS4	Total municipal area (ac)	Developed municipal area (ac)(1)	Developed area impervious fraction(2)	Annual precipitation (in)(3)	Annual runoff volume (ac-ft/yr)(4)	Annual TSS load (lbs/yr)(5)	Annual TP load (lbs/yr)(5)	Annual TN load (lbs/yr)(5)
Albert Lea	9,454	5,708	0.327	34.06	5,600	2,368,000	4,900	24,300
Austin	7,705	5,636	0.346	34.55	5,900	2,486,000	5,100	25,500
Fairmont	10,792	3,760	0.304	32.71	3,300	1,406,000	2,900	14,400
Grand Rapids	15,664	4,727	0.325	28.93	3,900	1,657,000	3,400	17,000
Hibbing	119,188	7,932	0.238	25.27	4,400	1,874,000	3,800	19,200
Rochester	34,878	22,292	0.365	34.02	23,900	10,136,000	20,800	104,000

(1) Developed area based on 2011 NLCD developed land use types (reference (52)). Runoff and pollutant loading calculated from only developed land use types within each MS4 ("Developed, Open Space", "Developed, Low Intensity", "Developed, Medium Intensity", and "Developed, High Intensity")

(2) Zonal average impervious fraction of developed area land use types within each MS4, based on 2011 NLCD impervious raster dataset.

(3) Average annual precipitation depths from NOAA 1981-2010 US Climate Normals (reference (54)).

(4) Annual runoff volume calculated using the Simple Method (reference (51)), where A = developed municipal area, P = annual precipitation, and R_v = 0.05 + 0.9 x developed area impervious fraction.

(5) Total pollutant loads calculated using Event mean concentrations reported in The National Stormwater Quality Database, Zone 1, land use type "all land uses" [TSS = 156 mg/L; TP = 0.32 mg/L; TN = 1.6 mg/L] (reference (55)).

The pollutant load reduction provided by existing stormwater treatment systems within each of the six MS4s was determined from 2015 MS4 Permit Annual Reports generated by each MS4 and submitted to the MPCA. Load reductions reported in the TMDL Annual Report Form within each 2015 MS4 Annual Report are shown in Table 7-3. As shown in Table 7-3, only the Cities of Fairmont and Rochester provided annual load reduction estimates. The other four MS4s were not required to or did not provide TMDL Annual Report Forms within their 2015 MS4 Annual Reports. Comparing reported existing load reductions to total estimated annual pollutant loading values from Table 7-2, Rochester is currently reducing total annual TSS loading from developed areas by 11 percent, and both Rochester and Fairmont are reducing total annual TP loading by about eight percent.

Table 7-3 Reported existing load reduction from select MS4s

MS4	Estimated annual TSS load (lbs/yr)(1)	Estimated annual TP load (lbs/yr)(1)	Estimated annual TN load (lbs/yr)(1)	Reported TSS load reduction (lbs/yr)(2)	Reported TP load reduction (lbs/yr)(2)	Reported TN load reduction (lbs/yr)(2)	Existing TSS load reduction (%)(3)	Existing TP load reduction (%)(3)	Existing TN load reduction (%)(3)
Albert Lea	2,368,000	4,900	24,300	--	--	--	--	--	--
Austin	2,486,000	5,100	25,500	--	--	--	--	--	--
Fairmont	1,406,000	2,900	14,400	--	240	--	--	8%	--
Grand Rapids	1,657,000	3,400	17,000	--	--	--	--	--	--
Hibbing	1,874,000	3,800	19,200	--	--	--	--	--	--
Rochester(4)	10,136,000	20,800	104,000	1,119,000	1,600	--	11.0%	8%	--

(1) Estimated annual pollutant load totals from Table 7-2.
(2) Reported pollutant load reduction totals from 2015 MS4 Annual Reports provided to the MPCA. "--" indicates that the information was not provided within the 2015 MS4 Annual Report.
(3) Calculated by comparing reported pollutant load reductions to estimated annual pollutant loading.
(4) Rochester only provided the annual reduction value for TSS. The TP load reduction presented in this table was calculated using the MPCA Estimator tab provided within the Rochester 2015 MS4 Annual Report and completing the necessary inputs to produce TP removal calculations provided by existing BMPs.

7.2.2 Existing and Anticipated Future TMDL Requirements

Existing TMDL and anticipated future TMDL load reduction requirements were investigated for each of the six MS4s. The anticipated future TMDL requirements applicable to each MS4 were estimated by reviewing existing draft TMDLs, as well as the impairment listings of receiving waterbodies downstream of each MS4. Existing, draft, and anticipated future TMDLs and/or impairment listings applicable to each MS4 are summarized in Table 7-4. Note that existing, draft, and anticipated future SID studies are also included in this table as SIDs can lead to the development of TMDLs.

Table 7-4 Existing, draft, and anticipated TMDL requirements for select MS4s

MS4	Existing TMDLs:(1) Waterbody/ Basin	Existing TMDLs:(1) Pollutant(4)	Draft TMDLs/SIDs:(2) Waterbody/ Basin	Draft TMDLs/SIDs:(2) Pollutant(4)	Anticipated future TMDLs/SIDs:(3) Waterbody/ Basin	Anticipated future TMDLs/SIDs:(3) Pollutant(4)
Albert Lea	Lower Miss. R.	FC	Shell Rock R.	SID(5)	Shell Rock R.	DO, Nut., TSS, pH
Albert Lea	Shell Rock R.	FC	--	--	Albert Lea L.	Nut.
Austin	Lower Miss. R.	FC	Cedar R.	SID(5)	Cedar R.	TSS
Austin	Cedar R.	Hg	--	--	--	--
Fairmont	Blue Earth R.	FC	Blue Earth R.	TSS	Center Creek	NH_4, SID, TSS
Fairmont	Minnesota R.	TP	--	--	Blue Earth R.	SID(5), Nut.
Fairmont	--	--	--	--	Lake Pepin	Nut.
Grand Rapids	Miss. R.	Hg	--	--	Lake Pepin	Nut.
Hibbing	--	--	--	--	East Swan R.	SID(5), Nut., FC
Rochester	Lower Miss. R.	FC	--	--	Zumbro R.	SID(5), Nut.
Rochester	Zumbro R.	TSS	--	--	Lake Zumbro	Nut.

(1) From MPCA master list of approved TMDLs (reference (56)).
(2) From review of existing draft TMDLs and SIDs (reference (56)).
(3) Determined from review of Draft 2016 Impaired Waters List (reference (57)) of receiving downstream waterbodies.
(4) Pollutant abbreviations: DO = dissolved oxygen; FC = fecal coliform; Hg = mercury; NH4 = ammonium; Nut. = nutrients; TP = total phosphorus; TSS = total suspended solids.
(5) Stressor identification studies (SIDs) tracked in this table because SIDs can lead to the development of TMDLs.

7.2.3 Future MS4 Treatment: Expected Treatment Requirements

Existing, draft, and anticipated future TMDLs presented in Table 7-4 were reviewed to determine which TMDLs would establish the future level of stormwater treatment for each MS4 (i.e., the "controlling" TMDL). Table 7-4 indicates that, in addition to existing and draft TMDL requirements, each MS4 investigated can expect additional TMDL requirements in the future based on existing impairments established in the Draft 2016 Impaired Waters List (reference (57)). As water quality standards continue to evolve and, in some cases, become more stringent, it is possible that in the future, TMDLs/SIDs (in addition to those listed on Table 7-4) could be developed for any of the six MS4s. However, based on the recent list of existing, draft, and anticipated future TMDLs, Table 7-5 outlines the likely "controlling" TMDL(s)).

Table 7-5 Controlling TMDL and associated stormwater treatment level

MS4	Controlling TMDLs:(1) Waterbody/ Basin	Controlling TMDLs:(1) Pollutant(2)	Stormwater treatment level
Albert Lea	Albert Lea Lakes	Nutrients	Widespread implementation of structural BMPs(3)
Austin	Cedar R.	TSS	Widespread implementation of structural BMPs
Fairmont	Lake Pepin	Nutrients	Widespread implementation of structural BMPs
Grand Rapids	Lake Pepin	Nutrients	Widespread implementation of structural BMPs
Hibbing	East Swan R.	TSS	Widespread implementation of structural BMPs
Rochester	Zumbro R.	TSS	Widespread implementation of structural BMPs
Rochester	Lake Zumbro	Nutrients	Widespread implementation of structural BMPs

(1) Existing, draft, or anticipated future TMDL(s) which is (are) likely to establish the degree of stormwater treatment the MS4 would need to provide to comply with wasteload allocations.
(2) TSS = total suspended solids.
(3) Widespread implementation of structural BMPs refers to providing enhanced stormwater treatment to developed portions of the MS4.

As shown in Table 7-5, the TMDL identified as controlling the degree of stormwater treatment that would be required by each of the six MS4s is related to either sediment or nutrients in all cases. Nutrient and sediment TMDLs often establish the degree of stormwater treatment required in MS4s because, typically, a majority of excess sediment and nutrient loading originates from stormwater runoff within the developed portions of an MS4. Table 7-5 also outlines that widespread implementation of structural BMPs would be required to meet future TMDL WLAs, based on the identified controlling TMDL. Specifically, the six MS4s would likely need to provide enhanced stormwater treatment to all developed areas within the MS4 municipal boundary. The determination that widespread implementation of structural BMPs would likely be required by all six MS4s analyzed was based on analysis of existing TMDL WLAs and two other factors – analysis of the draft Lake Pepin watershed TMDL project (Section 7.2.3.1) and uncertainty related to expected TMDL requirements for draft TMDLs and/or new water quality impairments (Section 7.2.3.2).

7.2.3.1 Draft Lake Pepin Nutrient TMDL

Table 7-5 shows that the draft Lake Pepin nutrient TMDL would likely establish the degree of stormwater treatment required in at least one (Grand Rapids) of the six MS4s evaluated and could also control treatment requirements for Fairmont. As can be seen in Figure 7-1, the Lake Pepin watershed encompasses a majority of the state. Because the draft TMDL is still under development, WLAs and associated loading reductions for MS4s within the Lake Pepin watershed have not yet been published. For the purposes of this study, it was assumed that the future TMDL TP areal loading rate from developed portions of MS4s within the Lake Pepin watershed would be similar to the MS4 TP areal loading rate published in the Lake St. Croix nutrient TMDL (0.338 lbs TP/ac/yr) (reference (58)) because the Lake St. Croix watershed represents a large area within the Lake Pepin basin and the MS4 TP areal loading rate established in the Lake St. Croix TMDL is expected to be sufficient to meet reductions required by the Lake Pepin TMDL (reference (47)).

Based on the estimated annual loading rates shown in Table 7-2, the existing areal loading rates from developed areas in Fairmont and Grand Rapids are 0.77 and 0.72 lbs TP/ac/yr, respectively. Based on these areal loading values, existing areal loading from developed areas would need to be reduced by just over 50 percent to meet the TMDL requirement. Considering that constructed wet detention ponds can be expected to provide 50 percent TP reduction (reference (59)), this finding indicates that an areal TP TMDL of 0.338 lbs TP/ac/yr would require stormwater treatment equivalent to treating all developed areas within both MS4s using wet detention ponds or equivalent BMPs (i.e., widespread implementation of structural BMPs).

Although the Lake Pepin TMDL project is still under development, the areal TP loading requirement outlined in the Lake St. Croix nutrient TMDL illustrates the potential for waterbody impairments to establish controlling TMDLs for MS4s on a regional basis (e.g., the Lake St. Croix watershed). A similar TP areal loading rate required by the Lake Pepin TMDL would be of statewide significance given the number of MS4s that are present in the Lake Pepin watershed.

7.2.3.2 Future TMDL Requirements and Future Impairments

The determination that widespread implementation of structural BMPs would be needed in MS4s outside of the Lake Pepin watershed (Albert Lea, Austin, Hibbing, and Rochester) was due in large part to the uncertainty of future TMDL requirements, future water quality standards, and related impairment listings. Because the controlling TMDLs shown in Table 7-5 are all based on draft and anticipated future TMDLs, the magnitude of pollutant load reduction which would be required by these TMDLs is inexact, as the TMDL studies have not yet been approved. Additionally, it is possible that based on changing water quality standards, additional impairments requiring TMDLs will be identified in the future. Due to the uncertainty related to future TMDL requirements and future water quality standards, and because there is precedent for nutrient TMDLs to require MS4s to provide widespread implementation of structural BMPs on a regional basis (reference (58)), it was assumed for this analysis that each of the six MS4s would be required to provide widespread implementation of structural BMPs.

7.2.4 Future MS4 Treatment: Pollutant Load Reduction

Widespread implementation of structural BMPs, assumed necessary to meet future TMDL requirements, would require that each of the MS4s upgrade existing stormwater systems to provide treatment to all developed areas within each MS4's municipal boundary. To estimate the pollutant load reduction that could be achieved by providing stormwater treatment to all developed areas within each MS4, it was assumed that all developed areas would be treated using wet detentions ponds. Municipal-scale stormwater treatment is often achieved using a variety of BMPs (rain gardens, dry detention basins, vegetated buffer strips, etc.).To simplify the cost analysis (Section 7.3) and calculate the total pollutant load reduction (Table 7-6), this study assumed that all treatment would be provided using wet detention ponds.

The total pollutant load reduction to meet future TMDL requirements (i.e., the load reduction achieved by widespread implementation of structural BMPs) is shown in Table 7-6. To account for existing stormwater treatment within each MS4, existing pollutant load values from Table 7-2 are compared to the estimated future load reduction values to determine the percentage of the future treatment goal that is provided by existing stormwater treatment systems. As shown in Table 7-6, this analysis can be performed for only the two MS4s that provided estimates of existing pollutant load reduction – Fairmont and Rochester. Based on this analysis shown in Table 7-6, the Cities of Fairmont and Rochester are currently providing 16.4 percent and 15.3 percent of their future required pollutant load reduction, respectively. As shown in Table 7-6, existing pollutant load reduction was not estimated for MS4s not required to report existing load reduction in 2015 MS4 Annual Reports to the MPCA (Albert Lea, Austin, Grand Rapids, and Hibbing). To develop a conservative estimate of cost for these MS4s, it was assumed that stormwater systems in these MS4s currently provide no pollutant load reduction.

Table 7-6 Total pollutant load reduction based on future TMDL requirements

MS4	Existing annual TSS load (metric tons/yr)(1)	Existing annual TP load (metric tons/yr)(1)	Existing annual TN load (metric tons/yr)(1)	Reported existing TSS load reduction (metric tons/yr)(2)	Reported existing TP load reduction (metric tons/yr)(2)	Future TSS load reduction requirement (metric tons/yr)(3)	Future TP load reduction requirement (metric tons/yr)(3)	Future TN load reduction requirement (metric tons/yr)(3)	Percentage of future TP load reduction provided by existing stormwater systems (%)(4)
Albert Lea	1,070	2.2	11	--	--	910	1.1	3.3	--
Austin	1,130	2.3	12	--	--	960	1.2	3.5	--
Fairmont	640	1.3	6.5	--	0.1	540	0.7	2.0	16%
Grand Rapids	750	1.5	7.7	--	--	640	0.8	2.3	--
Hibbing	850	1.7	8.7	--	--	720	0.9	2.6	--
Rochester	4,600	9.4	47	510	0.7	3,910	4.7	14	15%

(1) Existing estimated annual pollutant loading from developed areas from Table 7-2. Values converted from pounds to metric tons.
(2) Reported annual pollutant load reductions from 2015 MS4 Annual Reports provided to the MPCA (Table 7-3).
(3) Future pollutant load reduction calculated by assuming all developed area would be treated using wet detention ponds. These values calculated by applying typical wet detention pond pollutant removal efficiencies to the existing annual pollutant load (wet basin removal efficiencies: TSS = 85%; TP = 50%; and TN = 30%) (reference (59)).
(4) Percent of future treatment already provided by existing stormwater systems calculated by comparing reported existing TP reduction to future TP pollutant load reduction requirements.

7.3 Cost Analysis for MS4s Studied

Based on future TMDL requirements, it is likely that each of the six MS4s studied would need to implement widespread structural BMPs (Section 7.2). The following subsections outline the methods used to estimate the associated upgrades to existing stormwater treatment systems and the related cost for each of the six MS4s.

7.3.1 Cost Estimate Model

To estimate the total cost to upgrade existing stormwater systems, a model must be selected to estimate the cost of wet detention basins. Several wet detention cost estimate models were evaluated (references (60), (61), (62), (63)). The model shown below was ultimately selected (reference (63)) as this model is specific to the state of Minnesota and is the most recently developed of the models evaluated:

$$TPC = \beta_0 (WQV)^{\beta_1} \qquad (63)$$

Where:

TPC = total present cost (2005 dollars)

WQV = water quality volume (m^3)

B_0 = empirical constant (wet basins, average = 4,398)

B_1 = empirical constant (wet basins, average = 0.512)

Water quality volume (WQV) in the model is defined as the volume of runoff that a given stormwater BMP is designed to treat. WQV in the context of total required treatment and individual wet detention basins is discussed in greater detail in Section 7.3.2. Total present cost (TPC) is the total construction cost and equivalent present cost of twenty years of operation and maintenance (O&M) costs in 2005 dollars. Note that TPC from the equation above is converted from 2005 dollars into 2016 dollars in the final MS4 cost estimates (Section 7.3.3).

7.3.2 Total Water Quality Volume Estimate

To estimate the total cost to provide stormwater treatment using wet detention ponds, the total WQV from developed areas within each MS4 was estimated.

The selected cost estimate model (reference (63)) recommends that WQV be calculated as follows:

$$WQV = P_d \times A \times R_v \qquad (63)$$

Where:

WQV = water quality volume

P_d = design rainfall precipitation depth

A = drainage area

R_v = Runoff Coefficient = 0.05 + 0.9 x impervious fraction

Wet detention ponds in the state of Minnesota are commonly designed with dead storage volume equivalent to the runoff volume produced by a 2.5 inch rainfall event (reference (64)). Using a design rainfall precipitation depth of 2.5 inches, the runoff coefficients, and developed MS4 areas show in Table 7-2, the total developed area WQV for each of the six selected MS4s was calculated (Table 7-7).

Table 7-7 Total developed area WQVs for select MS4s

MS4	Developed municipal area (ac)(1)	Developed area impervious fraction(2)	Developed area runoff coefficient, Rv(3)	Design precipitation depth (in)(4)	Total developed area WQV (ac-ft)
Albert Lea	5,708	0.327	0.345	2.5	410
Austin	5,636	0.346	0.361	2.5	420
Fairmont	3,760	0.304	0.323	2.5	250
Grand Rapids	4,727	0.325	0.343	2.5	340
Hibbing	7,932	0.238	0.264	2.5	440
Rochester	22,292	0.365	0.378	2.5	1,760

(1) Developed area based on 2011 NLCD developed land use types. Runoff and pollutant loading calculated from only developed portions of MS4s.
(2) Zonal average impervious fraction of developed area within each MS4, based on 2011 NLCD developed land use types.
(3) Rv = 0.05 + 0.9 x impervious fraction.
(4) Walker method rainfall volume used for design of wet detention ponds is 2.5 inches (reference (64)).

7.3.3 Cost Estimate for Select MS4s

Using the cost estimate model and total developed area WQVs outlined in Sections 7.3.1 and 7.3.2, an estimated cost was developed to upgrade existing stormwater treatment systems in each of the six selected MS4s to meet future TMDL requirements. The process used to develop unique cost estimates for each MS4 is outlined in the following subsections.

7.3.3.1 Existing Treated WQV estimate

The percentage of future pollutant load reduction already provided by existing stormwater systems (Section 7.2.4, Table 7-6) was used to estimate the existing treated WQV (Table 7-8). The cost to upgrade existing stormwater systems was calculated by comparing the total developed area WQV to the WQV treatment already provided by existing stormwater systems. For the four MS4s which did not provide estimates of existing pollutant load reduction in their 2015 MS4 Annual Reports, WQV and related cost estimates were based on the total developed area WQV.

Table 7-8 Total developed area WQVs for select MS4s

MS4	Percentage of future load reduction provided by existing stormwater systems (%)$^{(1)}$	Total developed area WQV (ac-ft)$^{(2)}$	WQV treated by existing stormwater systems (ac-ft)$^{(3)}$	Additional WQV treatment required (ac-ft)$^{(4)}$
Albert Lea	--	410	--	410
Austin	--	420	--	420
Fairmont	16%	250	40	210
Grand Rapids	--	340	--	340
Hibbing	--	440	--	440
Rochester	15%	1,760	270	1,490

(1) Percent of future load reduction provided and total developed area WQV estimate from Table 7-6 and Table 7-7, respectively.
(2) Estimate of WQV treated = (percent future load reduction provided) x (total developed area WQV).
(3) Additional WQV treatment required = (total developed area WQV) - (estimate of WQV already treated).

7.3.3.2 Typical Wet Detention Basin WQV estimate

The selected cost estimate model (Section 7.3.1) estimates cost based on the design WQV of a single wet detention basin. If the total additional WQV treatment required from Table 7-8 was applied to the equation shown in Section 7.3.1, the calculation would provide the cost to treat the total WQV using one extremely large wet detention basin. Because wet detention ponds become more cost effective as WQV increases, calculating the total cost for each MS4 in this manner would underestimate the total cost to meet future TMDL requirements. For this reason, this study estimated the typical size of a designed wet detention basin to more closely approximate realistic implementation and stormwater treatment of developed areas with distinctly separate drainage areas located throughout each municipality.

Based on the results of a district-wide pond prioritization study in the Ramsey-Washington Metro Watershed District RWMWD (reference (65)), the typical size of constructed wet detention ponds was determined to be 7.4 ac-ft, or roughly 9,000 m^3 (average of 273 wet detention ponds included in study). Based on this assumption of typical pond size, the number of wet detention ponds necessary to provide the additional WQV treatment is shown below in Table 7-9.

Table 7-9 Number of wet detention basins required to meet future TMDL requirements

MS4	Additional WQV treatment required (ac-ft)(1)	Number of wet detention ponds to provide additional treatment(2)
Albert Lea	410	56
Austin	420	58
Fairmont	210	29
Grand Rapids	340	46
Hibbing	440	60
Rochester	1,490	204

(1) Additional WQV treatment required from Table 7-8.
(2) Estimate of number of ponds = (additional WQV treatment required) / (typical size of individual wet detention pond, 9000 m^3).

7.3.3.3 Annualized Cost Estimate

Having calculated the additional WQV treatment required (Section 7.3.3.1) and the number of additional wet detention ponds (Section 7.3.3.2), the cost estimate model (Section 7.3.1) was used to calculate the total annualized cost to meet future TMDL requirements (Table 7-10).

Table 7-10 Annualized cost estimate to meet future TMDL requirements

MS4	Wet detention ponds required to meet future TMDL requirements (#)(1)	2005 TPC from cost estimate model ($)(2)	2016 TPC ($)(3)	Annualized cost estimate to meet future TMDL requirements ($/yr)(4)
Albert Lea	56	26,130,000	32,300,000	1,855,000
Austin	58	27,050,000	33,440,000	1,920,000
Fairmont	29	13,500,000	16,690,000	958,000
Grand Rapids	46	21,530,000	26,620,000	1,529,000
Hibbing	60	27,870,000	34,450,000	1,979,000
Rochester	204	94,830,000	117,220,000	6,732,000

(1) Number of additional ponds to meet future TMDL requirements Table 7-9.
(2) 2005 TPC from the selected cost estimate model (reference (63)). TPC is the total construction cost and equivalent present cost of twenty years of O&M.
(3) 2016 TPC calculated by adjusting 2005 TPC by inflation from 2005 to 2016 (I = 23.6%) (reference (66)).
(4) Annualized cost estimate from capital recovery calculation performed on 2016 TPC value. Interest rate assumed to be 3%, 25 year discount period.

It should be noted that the costs shown in Table 7-10 are conservatively high in that they assume that the full cost of implementing the desired level of stormwater treatment would be completely borne by each municipality. Unless compliance schedules for WLAs dictate more rapid implementation, it is anticipated that municipalities would implement the additional stormwater treatment for developed areas as future development and redevelopment occur. As a result, it is anticipated that some of the future costs for stormwater treatment would be incorporated into the future project costs for land development or redevelopment.

As shown in Table 7-10, a discount period of 25 years was selected to represent a typical compliance schedule of 25 years. A compliance period of 25 years was chosen based on a review of nine municipal MS4 compliance periods for recently completed TMDLs, including the Lower Minnesota River DO TMDL, Zumbro River TSS TMDL, and the Bluff Creek TSS TMDL. Because MS4 compliance schedules for TMDL WLAs are established from SWPPP application for reauthorization target dates, the compliance schedule assumed in this report (i.e., 25 years) may or may not be representative of compliance schedules that are ultimately established by the anticipated controlling TMDLs for each of the select MS4s. Limitations of the assumed compliance schedule are discussed further in Section 7.5. Total annualized cost to the select MS4s, existing loading, current and required future treatment, and load reduction are summarized in Figure 7-2.

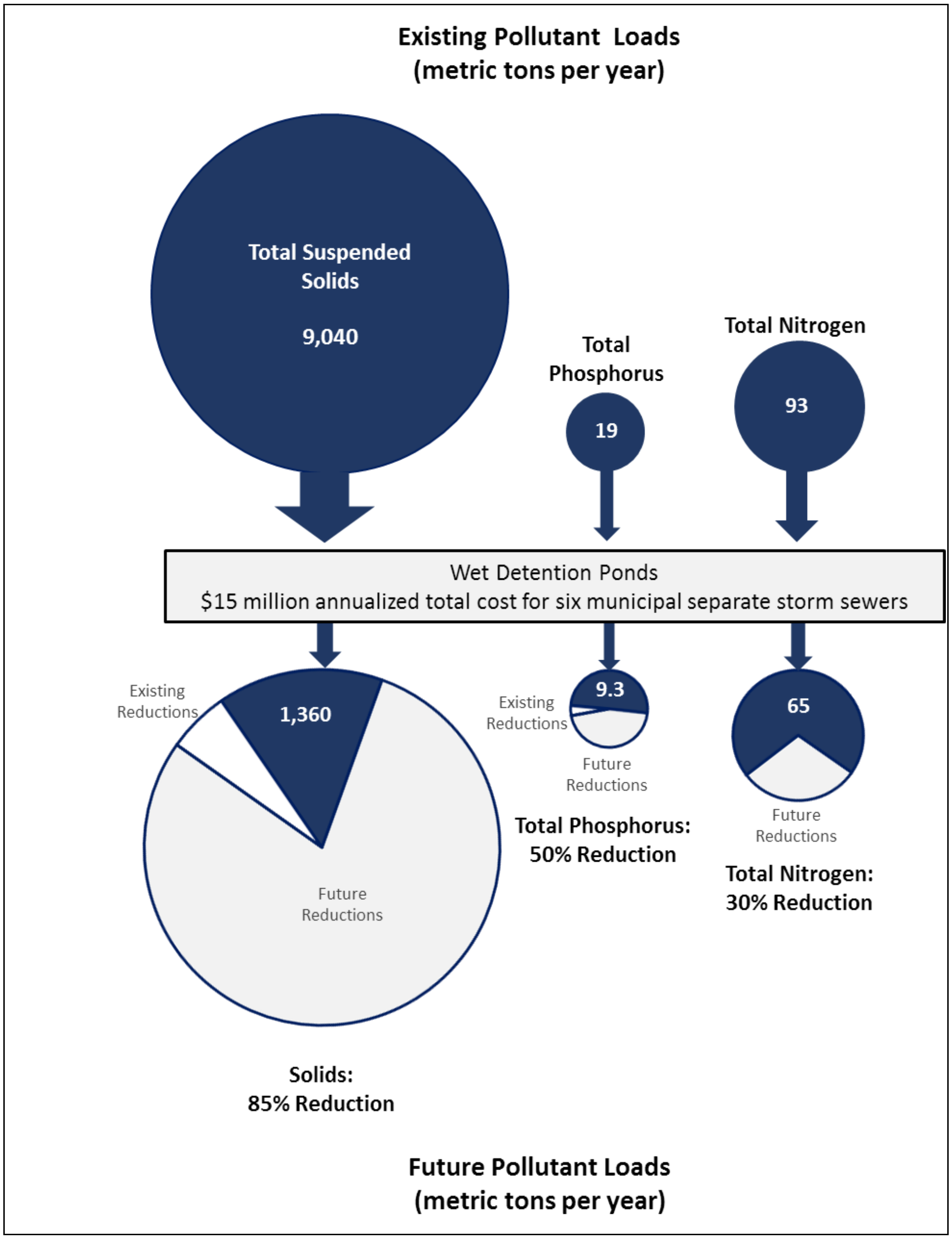


Figure 7-2 Pollutant load reduction by upgrades to six municipal separate storm sewer systems to meet current and future total maximum daily loads (TMDLs)

7.3.3.4 Consideration of Future Growth

Future growth and expansion of the developed area in the six MS4s was evaluated, but ultimately, was not included in the annualized cost-estimate to meet future TMDL requirements. Potential costs of stormwater treatment associated with future growth were not included in the cost analysis because these costs are generally expected to be paid by developers rather than the city. Pursuant to Part III.D.5 of the MPCA's General Permit for small MS4s (reference (67)), MS4s are required to manage stormwater such that development does not result in a net increase in stormwater discharge volume and associated pollutants (TSS and TP). To meet this General Permit condition, MS4s typically require developers to provide post-construction stormwater treatment. Therefore, future growth, development, and/or redevelopment are not expected to result in additional stormwater treatment costs for MS4s to meet future TMDL requirements.

7.4 Statewide Cost Analysis

Existing pollutant loading, expected additional treatment that would be needed to meet existing and future TMDLs, and the associated cost to provide the additional treatment were estimated for every municipal MS4 within the state using the methods outlined in Sections 7.2 and 7.3. Because the in-depth review of existing and expected future TMDL requirements performed for the selected six MS4s could not be performed for all MS4s within the state, basin-wide assumptions related to future TMDL requirements were developed for the major basins shown in Figure 7-1 and Figure 7-3. Assumptions for each basin are outlined in Table 7-11. Additionally, because in-depth review of existing treatment performed for the selected six MS4s could not be performed for all MS4s within the state, existing treatment is not accounted for in the expected future pollutant load reduction shown in Table 7-12 or the cost estimate values shown in Table 7-13.

Table 7-11 Expected major basin stormwater treatment requirements

Major Basin(1)	Expected stormwater treatment requirement	Comment
Lake Pepin	Widespread implementation of structural BMPs2	Based on anticipated Lake Pepin TMDL req.
Lake Winnipeg	No increase	Insufficient evidence to assume increase in stormwater treatment would be required.
Lake Superior	No increase	Insufficient evidence to assume increase in stormwater treatment would be required beyond the TMDL WLA already assigned to Hibbing for the East Swan River.
Lower Mississippi	Site-specific	Individual TMDLs within basin controlling. Widespread implementation of structural BMPs for Albert Lea, Austin, and Rochester.
Missouri	NA	No municipal MS4s in this basin.
Des Moines	Widespread implementation of structural BMPs(2)	Based on Worthington's MS4 wasteload allocation (WLA) for the Heron Lake TMDL

(1) Major basins shown on Figure 7-1 and Figure 7-3.
(2) Widespread implementation of structural BMPs refers to providing enhanced stormwater treatment to developed portions of the MS4.

In addition to the expected treatment requirements for each basin outlined in Table 7-11, it was assumed that any MS4 included in an existing, approved TMDL related primarily to pollutants from non-point stormwater discharges (TSS, TP, TN, and BOD) would require widespread implementation of structural BMPs in the future. Appendix E summarizes the expected load reduction that would be required to meet future TMDL requirements and the associated costs for all MS4s in the state.

Based on basin-wide analysis of existing and expected TMDLs, there was insufficient evidence to assume that MS4s in the Lake Winnipeg and Lake Superior basins would need to provide the same degree of stormwater treatment as other major basins. However, based on future loading requirements related to water quality in Lake Winnipeg, Hypoxia in the Gulf of Mexico, and other ongoing TMDL efforts, it is possible that uniform stormwater treatment reduction goals may ultimately extend to all MS4s within the state.

Based on major basin assumptions outlined in Table 7-11, the existing pollutant load and expected future load reduction for each major basin are shown in Table 7-12; Table 7-13 shows the anticipated annualized cost to provide the level of treatment and the cost-effectiveness of treating for the three pollutants, calculated by comparing the annual expected pollutant reduction to the annualized cost estimate to provide the reduction. Cost-effectiveness values for TSS and TP removal in wet basins typically range from $1-2 per pound of TSS and $1,000-$3,000 per pound of TP removed annually. Cost-effectiveness values shown in Table 7-13 are within a range considered typical for wet detention basins.

Table 7-12 Total pollutant loading and expected future pollutant reduction per major basin

MS4	Existing Annual TSS load (metric tons/yr)(1)	Existing Annual TP load (metric tons/yr)(1)	Existing Annual TN load (metric tons/yr)(1)	Expected future TSS load reduction (metric tons/yr)(2)	Expected future TP load reduction (metric tons/yr)(2)	Expected future TN load reduction (metric tons/yr)(2)
Des Moines	1,660	3.4	17.0	1,409	1.7	5.1
Lake Pepin	157,300	323	1,610	133,700	160	480
Lake Superior	8,570	17.6	87.9	722	0.9	2.6
Lake Winnipeg	8,240	16.9	84.6	0(3)	0(3)	0(3)
Lower Mississippi	13,240	27.2	136	5,780	7.0	20.9
Missouri	900	1.8	9.2	NA(4)	NA(4)	NA(4)

(1) Existing annual pollutant loading from developed areas from methods described in Section 7.2.1.
(2) Expected future pollutant load reduction from major basin assumptions in Table 7-11 and methods outlined in Section 7.2.4.
(3) Not applicable for major basins where future load reduction is not anticipated to exceed existing required load reduction.
(4) NA = not applicable because there are no municipal MS4s in this basin.

Table 7-13 Total cost estimate and cost-effective analysis per major basin

MS4	Annualized cost estimate to meet future TMDL requirements ($/yr)(1)	Cost-effective analysis: TSS ($/lb/yr)(2)	Cost-effective analysis: TP ($/lb/yr)(2)	Cost-effective analysis: TN ($/lb/yr)(2)
Des Moines	$3,320,000	$1.10	$880	$290
Lake Pepin	$300,470,000	$1.00	$840	$280
Lake Superior	$1,980,000	$1.20	$1,030	$340
Lake Winnipeg	NA(3)	NA(3)	NA(3)	NA(3)
Lower Mississippi	$11,730,000	$0.90	$760	$250
Missouri	NA(3)	NA(3)	NA(3)	NA(3)

(1) Annualized cost estimate to meet future TMDL requirements from methods described in Section 7.3.3.
(2) Cost-effective analysis calculated by comparing the expected future load reduction from Table 7-12 to the annualized cost.
(3) NA = not applicable for major basins where future load reduction is not anticipated to exceed existing required load reduction.

It should be noted that the costs shown in Table 7-13 are conservatively high as they assume that the full cost of implementing the desired level of stormwater treatment would be completely borne by each municipality. Unless compliance schedules for WLAs dictate more rapid implementation, it is anticipated that municipalities would implement the additional stormwater treatment for developed areas as future development and redevelopment occur. As a result, it is anticipated that much of the future costs for stormwater treatment would be incorporated into the future project costs for land development or redevelopment.

7.5 Limitations of the Analysis

Specific limitations of the analysis presented in Section 7.0 are highlighted below.

- With the exception of Rochester and Fairmont, the estimated costs to upgrade existing stormwater systems do not account for existing stormwater treatment.
- Existing stormwater treatment was quantified by reviewing 2015 MS4 Permit Annual Reports. Because the other four MS4s were not required to or did not provide TMDL Annual Report Forms within their 2015 MS4 Annual Reports, existing treatment could not be quantified (Section 7.2.1).
- Because in-depth review of existing treatment performed for the selected six MS4s could not be performed for all MS4s within the state, existing treatment is not accounted for in the expected future pollutant load reduction shown in Table 7-12 or the cost estimate values shown in Table 7-13 (Section 7.4).
- It was assumed that MS4s will meet anticipated future TMDL WLAs using large, regional-scale wet detention ponds. The stormwater treatment effectiveness and costs of wet detention ponds were used as surrogate measures for the MS4s that required widespread implementation of structural

BMPs. In practice, MS4s may use a broad spectrum of structural and non-structural (source reduction) BMPs to comply with wasteload reduction goals. Regional-scale wet detention ponds were chosen because they provide high TSS and TP pollutant removal, can be implemented regardless of soil infiltration ability, and are typically highly cost-effective (in terms of dollars per pound of pollutant removed).

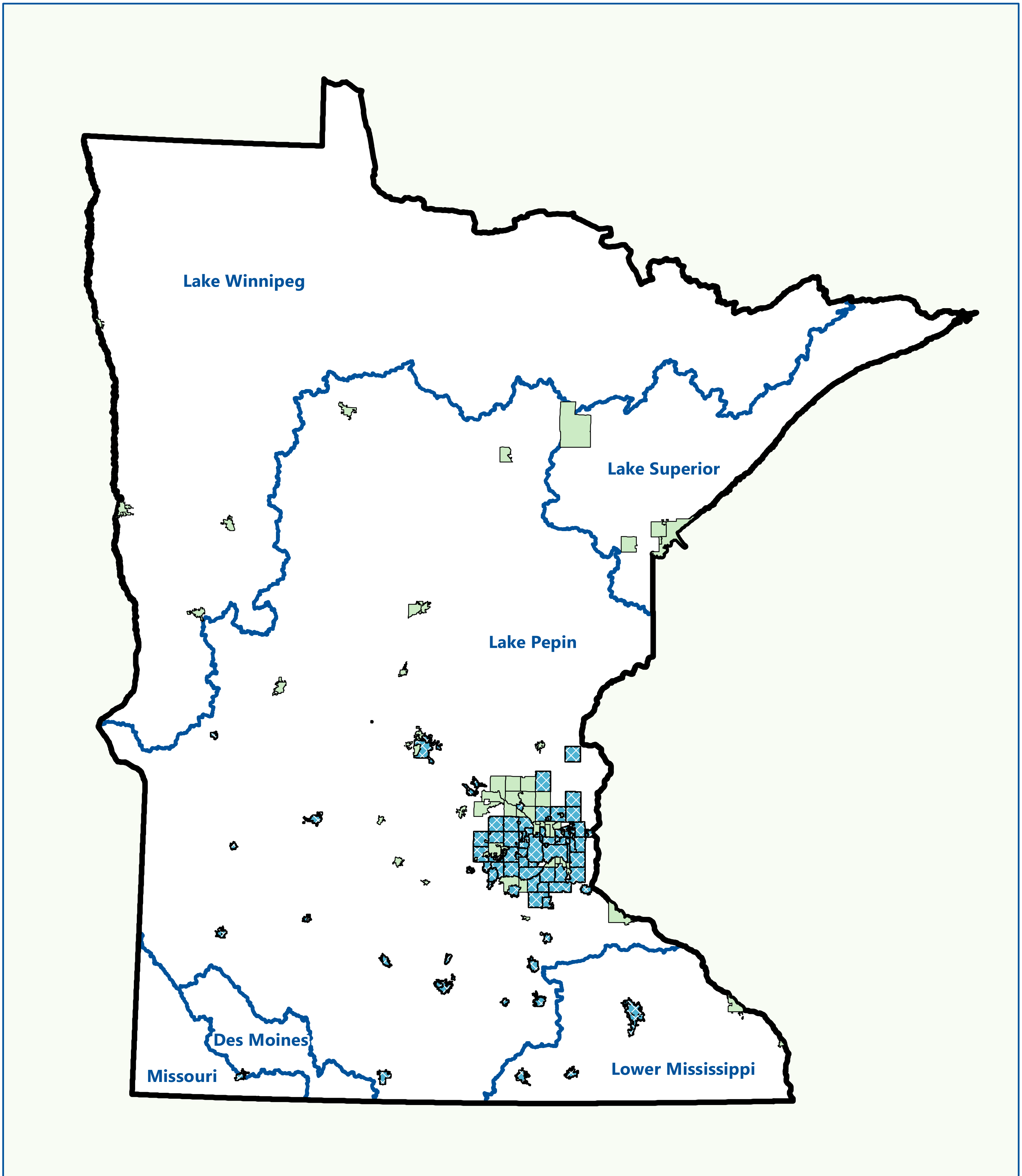
- Estimated costs to meet future TMDL requirements (shown in Table 7-10 and Table 7-13) are based on an assumed compliance period of 25 years (i.e., the discount period used to produce the annualized cost estimate was set to 25 years). A compliance period of 25 years was chosen based on a review of nine municipal MS4 compliance periods for recently completed TMDLs, including the Lower Minnesota River DO TMDL, Zumbro River TSS TMDL, and the Bluff Creek TSS TMDL. Because MS4 compliance schedules for TMDL WLAs are established from SWPPP application for reauthorization target dates, the compliance schedule assumed in this report (i.e., 25 years) may or may not be representative of compliance schedules that are ultimately established for the anticipated controlling TMDLs by each of the select MS4s. Assuming a compliance period of 25 years, the statewide annualized cost to meet future TMDL requirements for all municipal MS4s would exceed $317 million per year. If a compliance period of 50 years is assumed, the statewide annualized cost is reduced to $215 million per year.

- Non-municipal MS4s (e.g., townships, counties, etc.) were not included in the statewide cost analysis in this study. As outlined in the appropriating legislation and our work scope, only municipal MS4s were included in the MS4s selected for detailed cost analysis. Because cost-estimating methodology was developed specifically for municipal MS4s, the statewide cost analysis was performed only for municipal MS4s.

- The TMDL identified as the controlling TMDL for each of the selected MS4s (see Table 7-5) is the TMDL expected to establish the degree of stormwater treatment each MS4 will be required to provide in the future based on the recent list of existing, draft, and anticipated figure TMDLs presented in Table 7-4. As water quality standards continue to evolve and become more stringent in some cases, it is possible that in the future, TMDLs/SIDs (in addition to those listed on Table 7-4) could be developed for any of the MS4s.

- Estimated costs to meet future TMDL requirements shown in Table 7-10 and Table 7-13 are conservatively high as they assume that the full cost of implementing the desired level of stormwater treatment would be completely borne by municipalities. Unless compliance schedules for WLAs dictate more rapid implementation, it is anticipated that municipalities would implement the additional stormwater treatment for developed areas as future development and redevelopment occur. As a result, it is anticipated that some of the future costs for stormwater treatment would be incorporated into the future project costs for land development or redevelopment.

The limitations of analysis discussed above provide information on areas of uncertainty in specific assumptions. They do not change the overall conclusions of the report or application for its intended purpose.



MS4
MS4 w/ active TMDL
Minnesota State Boundary
Major Basins
*MS4 - Municipal Seperate Stormwater System

BARR

N

0 25 50 75
Miles

MUNICIPAL MS4s
IN MINNESOTA
Water Quality Standards
Cost Analysis
Minnesota Management & Budget

FIGURE 7-3

8.0 Cost-Effectiveness Summary

Results of the wastewater and stormwater analyses were combined to estimate the overall costs and water quality changes resulting from municipal wastewater and storm system upgrades to meet current and future WQS.

8.1 Summary of the State-Wide Water Quality Changes Due to Current and Future WQS

Annual load reductions due to upgrades to municipal WWTFs to meet current and future effluent limit requirements (outlined in Section 6.0), combined with removal estimates to meet existing and future stormwater TMDLs (outlined in Section 7.0) provide an estimated total water quality benefit to the state. Table 8-1 summarizes the pollutant load reductions in metric tons per year to each of the six basins, including a total reduction for the Mississippi River major basin. Figure 8-1 summarizes the pollutant load reductions in Minnesota's three major river basins as a result of upgrading wastewater and stormwater treatment systems to meet current and future effluent limits and TMDLs.

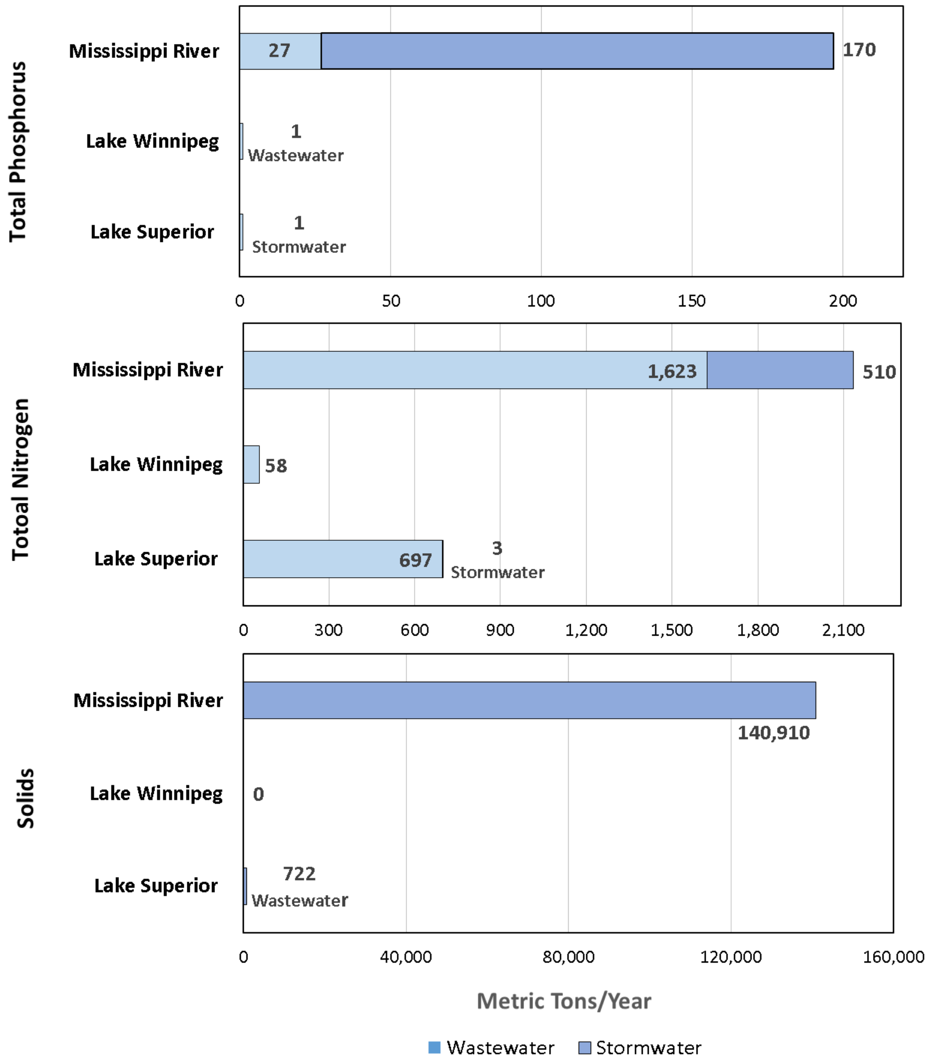


Figure 8-1 Total Pollutant load reductions by major river basin

Table 8-1 Annual basin-wide load reductions due to upgrades to municipal wastewater and stormwater treatment systems to meet current and future water quality standards

Basin	Load Reductions to Meet Municipal WWTF Effluent Limits	Load Reductions to Meet Municipal WWTF Effluent Limits	Load Reductions to Meet Stormwater TMDLs	Load Reductions to Meet Stormwater TMDLs	Total Load Reductions to Meet WQS	Total Load Reductions to Meet WQS
	Under Current WQS (MTs/yr)	Under Future WQS (MTs/yr)	Under Existing TMDL[1] (MTs/yr)	Under Future TMDL (MTs/yr)	Under Current Standards (MTs/yr)	Under Future Standards (MTs/yr)
Phosphorus						
Lake Pepin	11	0	0	161	11	161
Lake Superior	0	0	0	1	0	1
Lake Winnipeg	1	0	0	0	1	0
Lower Mississippi	14	0	0	7	14	7
Des Moines[2]	1	0	0	2	1	2
Missouri[2]	1	0	0	0	1	0
Mississippi River[3]	27	0	0	170	27	170
Total Nitrogen						
Lake Pepin	112	956	0	484	112	1,440
Lake Superior	0	697	0	3	0	700
Lake Winnipeg	45	58	0	0	45	58
Lower Mississippi	7	625	0	21	7	646
Des Moines[2]	2	29	0	5	2	34
Missouri[2]	1	14	0	0	1	14
Mississippi River[3]	122	1,623	0	510	122	2,133
Total Suspended Solids						
Lake Pepin	0	0	0	133,722	0	133,722

Basin	Load Reductions to Meet Municipal WWTF Effluent Limits	Load Reductions to Meet Municipal WWTF Effluent Limits	Load Reductions to Meet Stormwater TMDLs	Load Reductions to Meet Stormwater TMDLs	Total Load Reductions to Meet WQS	Total Load Reductions to Meet WQS
	Under Current WQS (MTs/yr)	Under Future WQS (MTs/yr)	Under Existing TMDL(1) (MTs/yr)	Under Future TMDL (MTs/yr)	Under Current Standards (MTs/yr)	Under Future Standards (MTs/yr)
Lake Superior	0	0	0	722	0	722
Lake Winnipeg	0	0	0	0	0	0
Lower Mississippi	0	0	0	5,779	0	5,779
Des Moines(2)	0	0	0	1,409	0	1,409
Missouri(2)	0	0	0	0	0	0
Mississippi River(3)	0	0	0	140,910	0	140,910

(1) No TMDLs associated with current standards were calculated for this study. Water quality benefits from upgrades to municipal stormwater treatment systems are due exclusively to future TMDLs.

(2) No facilities within the Des Moines or Missouri River basins were evaluated. Nitrogen percent reductions were estimated from reductions similar to neighboring Watonwan and Blue Earth River watersheds. The phosphorus loading reduction for the Des Moines basin was calculated from the required 80% reduction to meet Heron Lake and Talcot Lake eutrophication standards outlined in Table 2-4 of the 2014 Minnesota Nutrient Reduction Strategy report (reference (2)).

(3) Pollutant reductions in Minnesota's contribution to the Mississippi River may be subject to change depending on facility limits within the Des Moines and Missouri basins. Percent phosphorus reductions for the entire Mississippi River major basin were calculated from annual load reductions generated from the data provided in Table 6-9.

8.2 State-wide Cost Effectiveness Due to Current and Future WQS

The associated cost to meet existing and future TMDLs determined in Section 7.4 were outlined at a basin level in Table 7-13. Section 5.9 includes the costs associated with meeting current and future effluent limits as outlined in Table 5-19 and Table 5-20. The cost for wastewater and stormwater treatment system upgrades are shown in Figure 8-2 for the six cities where both were estimated. The values shown in Figure 8-2 can be used by other Minnesota municipalities to estimate the total costs associated with similar wastewater and stormwater treatment upgrades.

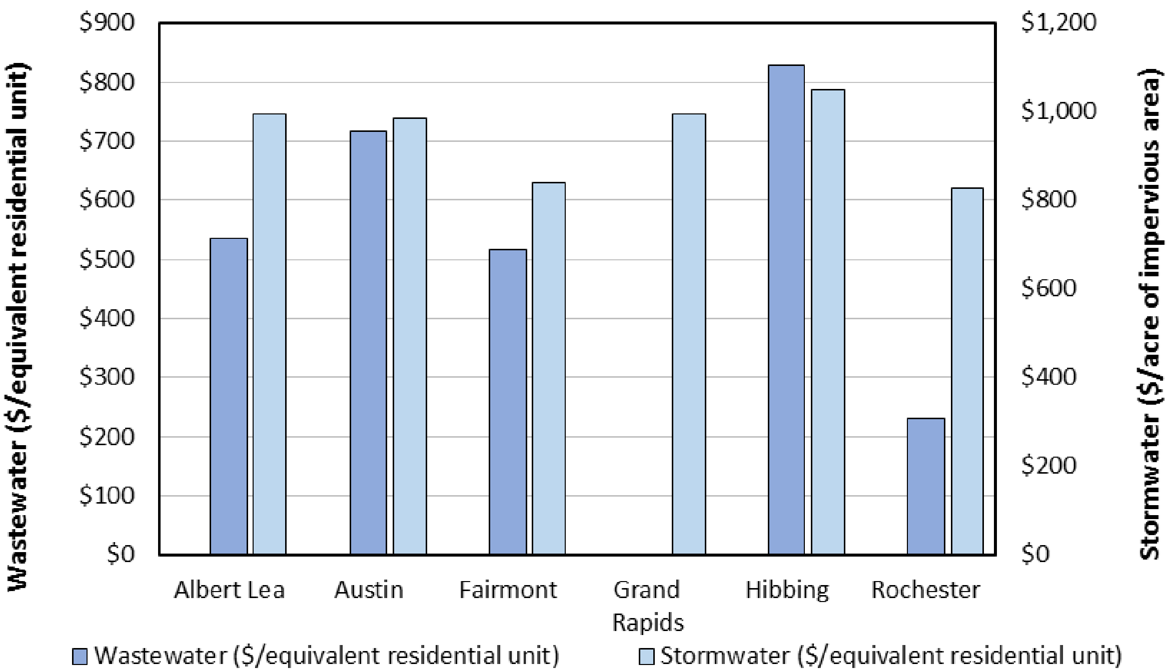


Figure 8-2 Cost of wastewater and stormwater treatment system upgrades to meet current and future water quality standards

The implications of reducing pollutant loading to Minnesota waters by implementing wastewater and stormwater treatment upgrades expand further than simply decreasing nutrient concentrations in surface waters. All Minnesota surface waters have designated beneficial uses, which include categories such as domestic consumption, aquatic life and recreation, industrial consumption, agricultural and wildlife, aesthetic enjoyment and navigation, other uses and protection of border waters, and limited resource value waters. Implementing wastewater and stormwater standards have the potential to impact each beneficial use providing benefit to aquatic environments, human health, and recreation and tourism industries.

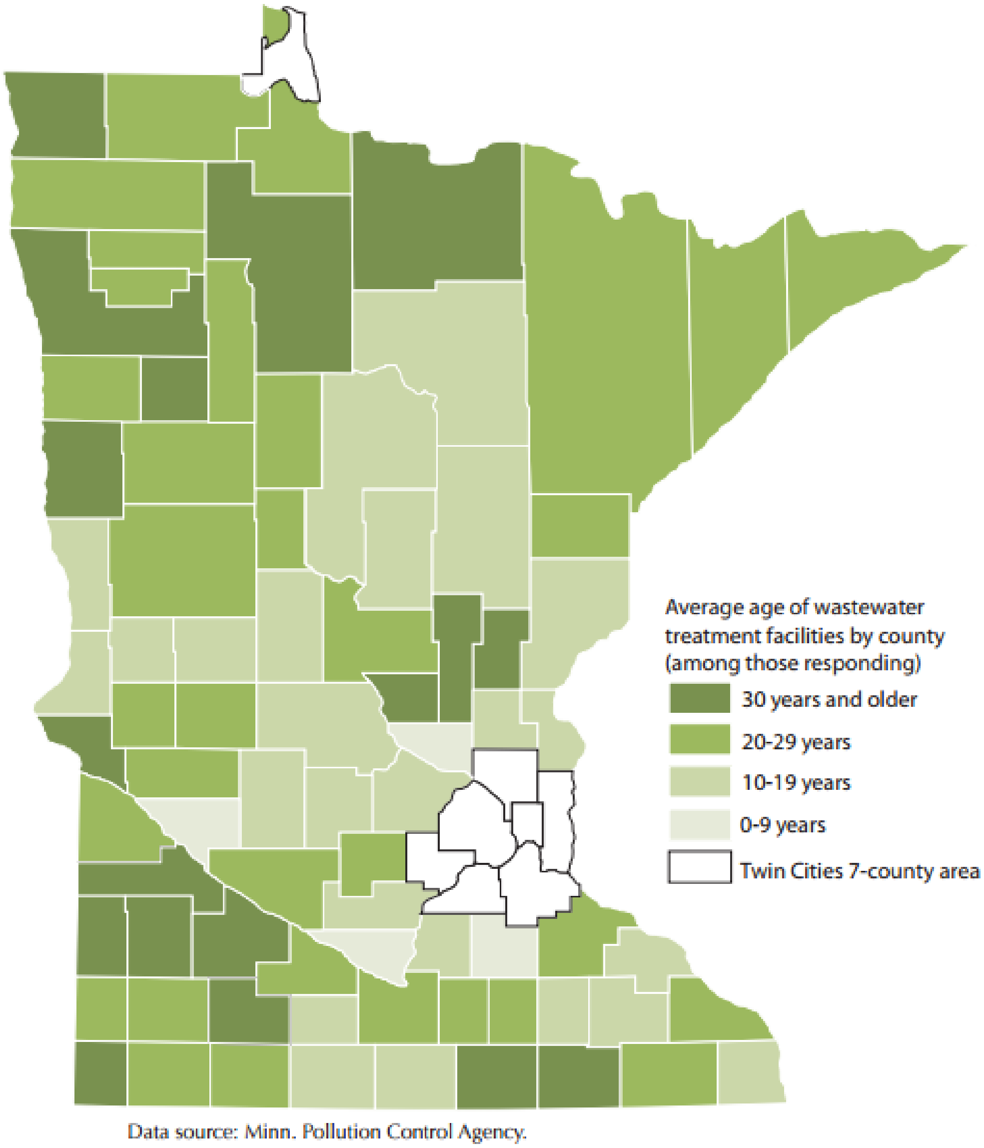
9.0 Available Funding Programs

Cost estimates for upgrades presented in Sections 5.0 and 7.0 represent a significant financial burden for the affected cities. This section outlines programs that can be used to help finance upgrades.

Section 9.1 provides a brief summary of the state's water infrastructure. Section 9.2 outlines funding programs available in Minnesota for wastewater and stormwater infrastructure upgrades. Section 9.2.5 identifies the impact of these programs and the effect of future needs on user affordability.

9.1 State of Water Infrastructure in Minnesota

Major structural components of WWTFs typically have a design life of 40 years; after this time, replacement and repairs are required to maintain the existing level of treatment. Mechanical equipment, such as pumps, has shorter design lives of 15-20 years. Sixteen percent of existing wastewater treatment systems in Minnesota are greater than 40 years old, and 30 percent are greater than 30 years old (reference (68)). In addition, older treatment systems are commonly located in rural areas with higher sewer bills and limited municipal funding for upgrades, as illustrated in Figure 9-1.



Source: Reference (69)

Figure 9-1 Geographical distribution reflecting age of wastewater treatment facilities

Most existing WWTFs were built with the assistance of federal and state funding. Federal funds for Minnesota water infrastructure has tapered off significantly since the 1990s (reference (70)).

9.2 Funding Programs for Wastewater and Stormwater Upgrades

There are several ways to finance wastewater and stormwater improvement projects in Minnesota. This section describes funding programs that can be used to pay for projects or supplement other funding. These funding programs are competitive, and communities not receiving financial assistance are likely to rely on municipal bonds to recover costs of upgrades and operation.

Funding programs either provide loans or grants. If awarded a loan, the awardee must pay back the funding agency according to the loans terms. Loan programs discussed here have more favorable loan terms than municipal bonds, which would decrease the annual loan repayment cost to the permittee and also reduce the impact on user rates. Loan repayment is typically made from hook-up fees collected for new connections to the sewer system and fixed monthly fees for sewer access.

Grant awardees do not need to pay back the funding agency. If grants do not cover the entire project cost, they can reduce the total loan amount needed to fund a project, which reduces the impact on user rates.

9.2.1 Public Facilities Authority Loans and Grants (Multiple Programs)

The PFA provides state funding for water infrastructure sourced from the Clean Water Revolving Fund, the Wastewater Infrastructure Fund (WIF), and the Clean Water Legacy Fund. PFA also administers Small Community Grants for small communities to improve subsurface sanitary treatment systems and soil treatment systems and Point Source Implementation Grants to meet TMDL or WQBELs, especially for phosphorus and nitrogen limits (reference (71)). PFA funding accounts for about 75 percent of public wastewater funding in Minnesota (reference (70)). Wastewater and stormwater projects must be on the MPCA's Project Priority List (PPL) to be eligible for PFA funds.

Clean Water Revolving Fund loans are typically used to fund wastewater improvement projects. They can also now be used to fund drinking water projects that are needed to help WWTF meet permit requirements such as reduced chloride effluent limits.

The PFA outlines an Intended Use Plan (IUP) each year, which includes projects on the PPL prepared by the MPCA. Projects must have a facilities plan approved by the MPCA to request placement on the IUP. The 2017 PPL includes 290 projects with a total estimated cost of $1.5 billion and an additional 17 projects without cost estimates. The projects include stormwater collection and treatment, wastewater collection system improvements, wastewater treatment, and water treatment to remove chlorides. The 2017 IUP lists 84 projects totaling $347 million but only expects to finance 36 projects totaling $107 million in 2017. The projects that the PFA plans to finance only account for seven percent of the estimated costs included in the MPCA 2017 PPL (reference (72)).

The WIF provides supplemental grants to cities, counties, townships, or other governmental subdivisions responsible for wastewater treatment. Projects must be listed on the PPL and certified by the MPCA. When available, grants may not exceed the lesser of $4 million or $15,000 per sewer connection.

9.2.2 Minnesota Board of Water and Soil Resources (BWSR)

The Minnesota Board of Water and Soil Resources (BWSR) administers a Clean Water Fund (CWF) to support projects that protect or improve water quality in surface or groundwater. This includes some stormwater treatment projects, although stormwater conveyances, maintenance activities, and repair of capital equipment are ineligible. In order to be eligible, cities in the seven-county metropolitan area must have adopted a relevant water plan, such as a watershed management plan or metropolitan groundwater plan that has been approved by the state and locally adopted (reference (73)). Cities, including those outside of the seven-county metropolitan area, without such plans are encouraged to work with another eligible local government if interested in receiving grant funds (e.g., watershed districts, watershed management organizations, and soil and water conservation districts).

BWSR publishes a list of CWF-competitive grant applicants/recipients each year. For FY2017, 171 applicants totaling $34.41 million requested funds, but BWSR only expects to fully fund 77 applications totaling $13.66 million. Of the $13.66 million in FY2017 funding, $12.67 million is being provided in grant categories that municipalities could be eligible to use to improve surface water quality. A significant portion of the available grant funding each year is spent to address nonpoint source runoff of pollutants from rural areas.

9.2.3 US Department of Agriculture (Water and Waste Disposal Program)

The US Department of Agriculture (USDA) administers loans to small communities in order to reduce user costs of drinking water, wastewater, and stormwater treatment upgrades via the federally funded Water and Waste Disposal Program. Cities, towns, and rural areas with populations less than 10,000 are eligible (reference (74)).

9.2.4 Minnesota Department of Employment and Economic Development (Small Community Development Grant Program)

Minnesota's Department of Employment and Economic Development (MDEED) oversees federal funds for Small Community Development Grants. These grants are designed to reduce the financial burden of wastewater treatment for low to medium income households. Cities and towns with populations less than 50,000 and unincorporated townships with populations less than 200,000 are eligible (reference (71)). Grants are provided for a maximum of $600,000 for single purpose projects.

9.2.5 Summary of Funding Programs and Impact on Cost to City

Funding programs that may be used to finance wastewater upgrades are summarized in Table 9-1.

Table 9-1 Summary of wastewater and stormwater infrastructure funding programs for Minnesota communities

Funding program	Funding Type	Administered by	Funding Source	Comments and Key Limitations	Type of Infrastructure
Clean Water Revolving Fund	Loan	PFA	State	Must be listed on MPCA's PPL	WW, SW, DW
Clean Water Legacy Fund	Loan	PFA	State	Focused on phosphorus reduction. Must be listed on MPCA's PPL	WW
Wastewater Infrastructure Funds	Deferred Loans and Grants	PFA	State	Priority to high cost, high priority wastewater projects. Must be listed on MPCA's PPL	WW
Small Communities – Construction and Technical Assistance	Loans and Grants	PFA	State	For small communities, but no population cap specified. For subsurface and soil treatment systems. Must be listed on MPCA's PPL	WW
Point Source Implementation Grants	Grants	PFA	State	Focused on nutrient TMBLs and WQBELs. Must be listed on MPCA's PPL	WW, SW
Clean Water Fund	Grant	BWSR	State	Must have relevant water management plan or partner with another eligible local government organization	SW
Water and Waste Disposal	Loans and Grants	USDA	Federal	Cities with population <10,000	WW
Small Communities Development Grants	Grants	MDEED	Federal	Cities with population <50,000 or unincorporated townships with population <200,000	WW, SW

Type of Infrastructure: WW = wastewater, SW = stormwater, and DW = drinking water

9.3 Funding Conclusions and Outlook

Wastewater and stormwater improvement projects in Minnesota can be financed by loans or grants from a variety of public funding programs. Program loans typically provide more favorable repayment conditions than municipal bonds. Grants (when available) can be used to decrease the required loan amount making repayment of capital costs more affordable.

In recent years, based upon the difference between the requested funding and the available funding, it could be inferred that current funding is limited. Existing wastewater infrastructure in many Minnesota cities is approaching the end of its useful design life, so many funding requests in recent years have been for rehabilitation projects of existing wastewater collection and treatment systems to maintain performance rather than meet new standards.

Existing sewer use fees are typically near recognized limits for affordability. For the 15 municipalities in this study, the current sewer rates range from 0.6 percent to 2.5 percent of median household income. New water quality standards requiring upgrade of existing facilities would add to the operating city's financial burden. The WWTF upgrades and operation for the 15 municipalities in this study are expected to result in sewer fees ranging from 1.1 percent to 5.2 percent of household median income which will increase the gap between funding requested and available funding. This will increase pressure on the affordability of wastewater infrastructure.

For the six regulated MS4s included in this study, future stormwater treatment requirements have the potential to add significant cost to the city's financial burden of approximately $15 million combined cost (capital and operating) per year. While a significant portion of the capital costs will likely be borne by future land development or redevelopment projects, the remaining capital and operational costs will be borne by the respective cities, further adding costs to the new wastewater costs discussed above. Given the significant gap that currently exists between requested and available Clean Water Funding for stormwater projects and given that other non-municipal stormwater projects are also competing for funding, it is expected that future stormwater treatment requirements for all 164 cities with MS4s permits will significantly exceed current funding levels.

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Appendices

Appendix A

Current water quality standards by associated use class

Table A-1 Current water quality standards by associated use class

Parameter	Unit	Fraction	EPA Maximum Contaminant Levels	EPA Secondary Drinking Water Regulations	MN SW 2A Chronic 7050 - 100 Hardness	MN SW 2A Maximum 7050 - 100 Hardness	MN SW 2A Final Acute Value 7050 - 100 Hardness	MN SW 2B Chronic 7050 - 100 Hardness	MN SW 2B Maximum 7050 - 100 Hardness	MN SW 2B Final Acute Value 7050 - 100 Hardness	MN SW 3A Industrial Consumption 7050	MN SW 3B State Waters 7050	MN SW 3C State Waters 7050	MN SW 4A State Waters 7050	MN SW 4B Livestock Wildlife 7050	MN SW 5 Aesthetic Navigation Non Wetlands 7050
Alkalinity, bicarbonate, as HCO3	mg/l													250		
Arsenic	µg/l		10		2.0	360	720	53	360	720						
Bacteria, coliform fecal	%		5.0(EPA-1)(EPA – 2)		(2A/2B – 2)	(2A/2B – 2)	(2A/2B – 2)	(2A/2B – 2)	(2A/2B – 2)	(2A/2B – 2)						
Bacteria, total coliforms	%		5.0(EPA-1)(EPA – 2)													
Cadmium	µg/l	Dissolved	5		1.0(HD)(CF)	3.7(HD)(CF)	7.4(HD)(CF)	1.0(HD)(CF)	31(HD)(CF)	63(HD)(CF)						
Cadmium	µg/l	Total	5		1.1(HD)	3.9(HD)	7.8(HD)	1.1(HD)	33(HD)	67(HD)						
Chloride	mg/l			250	230	860	1720	230	860	1720	50	100	250			
Chlorine, total residual	µg/l		4000		11	19	38	11	19	38						
Chromium	µg/l	Dissolved	100		11(CF)(CR6)	16(CF)(CR6)	31(CF)(CR6)	11(CF)(CR6)	16(CF)(CR6)	31(CF)(CR6)						
Chromium	µg/l	Total	100		11(CR6)	16(CR6)	32(CR6)	11(CR6)	16(CR6)	32(CR6)						
Copper	µg/l	Dissolved	1300(TT)	1000	9.4(HD)(CF)	17(HD)(CF)	34(HD)(CF)	9.4(HD)(CF)	17(HD)(CF)	34(HD)(CF)						
Copper	µg/l	Total	1300(TT)	1000	9.8(HD)	18(HD)	35(HD)	9.8(HD)	18(HD)	35(HD)						
Dissolved oxygen	mg/l				(2A/2B – 6)	(2A/2B – 6)	(2A/2B – 6)	(2A/2B – 6)	(2A/2B – 6)	(2A/2B – 6)						
Hardness, as CaCO3	mg/l											250	500			
Mercury	µg/l	Dissolved	2		0.0069(CF)	2.0(CF)(2A/2B – 1)	4.2(CF)(2A/2B – 1)	0.0069(CF)	2.0 (CF)(2A/2B – 1)	4.2 (CF)(2A/2B – 1)						
Mercury	µg/l	Total	2		0.0069	2.4(2A/2B – 1)	4.9(2A/2B – 1)	0.0069	2.4(2A/2B – 1)	4.9(2A/2B – 1)						
Nickel	µg/l	Dissolved			158(HD)(CF)	1415(HD)(CF)	2830(HD)(CF)	158(HD)(CF)	1415(HD)(CF)	2830(HD)(CF)						
Nickel	µg/l	Total			158(HD)	1418(HD)	2836(HD)	158(HD)	1418 (HD)	2836(HD)						
Nitrogen, ammonia, as N	µg/l				16(2A/2B – 3)			40(2A/2B – 3)								
Nitrogen, Nitrate + Nitrite, as N	mg/l		1(N)													
Nitrogen, Nitrate, as N	mg/l		10													
Nitrogen, Nitrite, as N	mg/l		1													
pH	pH units			8.5	6.5-8.5			6.5-9.0			6.5-8.5	6.0-9.0	6.0-9.0	6.0-8.5	6.0-9.0	6.0-9.0
Phosphorus, total, as P	µg/l				(2A/2B – 4)	(2A/2B – 4)	(2A/2B – 4)	(2A/2B – 8)	(2A/2B – 4)	(2A/2B – 4)						
Salinity	mg/l														1000	

Parameter	Unit	Fraction	EPA Maximum Contaminant Levels	EPA Secondary Drinking Water Regulations	MN SW 2A Chronic 7050 - 100 Hardness	MN SW 2A Maximum 7050 - 100 Hardness	MN SW 2A Final Acute Value 7050 - 100 Hardness	MN SW 2B Chronic 7050 - 100 Hardness	MN SW 2B Maximum 7050 - 100 Hardness	MN SW 2B Final Acute Value 7050 - 100 Hardness	MN SW 3A Industrial Consumption 7050	MN SW 3B State Waters 7050	MN SW 3C State Waters 7050	MN SW 4A State Waters 7050	MN SW 4B Livestock Wildlife 7050	MN SW 5 Aesthetic Navigation Non Wetlands 7050
Selenium	µg/l		50		5.0	20	40	5.0	20	40						
Sodium	µg/l													[4A – 1]		
Solids, total dissolved	mg/l			500										700[4A – 2]	1000[S]	
Solids, total suspended	mg/l				10[2A/2B – 7]			15[2A/2B – 8]								
Specific Conductance @ 25 °C	µmhos /cm													1000		
Sulfate, as SO4	mg/l			250										10[Wild Rice]		
Zinc	µg/l	Dissolved		5000	105[HD][CF]	114[HD][CF]	229[HD][CF]	105[HD][CF]	114[HD][CF]	229[HD][CF]						
Zinc	µg/l	Total		5000	106[HD]	117[HD]	234[HD]	106[HD]	117[HD]	234[HD]						

Notes for EPA Maximum Contaminant Levels:

- (EPA – 1): No more than 5.0% samples total coliform-positive (TC-positive) in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli if two consecutive TC-positive samples, and one is also positive for E.coli fecal coliforms, system has an acute MCL violation.
- (EPA – 2): Fecal coliform and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.
- (TT): Treatment Technique - A required process intended to reduce the level of a contaminant in drinking water. Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/l, and for lead is 0.015 mg/l.
- (N): Based on the criteria for Nitrogen, Nitrite as N.

Notes for all MN SW 2A and MN SW 2B classes (chronic, maximum, and final acute value):

- (2A/2B – 1): The provisions of this item apply to maximum standards (MS), final acute values (FAV), and double dashes in this part and part 7050.0220 are marked with an asterisk. For carcinogenic or highly bioaccumulative chemicals with BCFs greater than 5000 or log K values greater than 5.19, the human health-based chronic standard (CS) may be two or more orders of magnitude smaller than the acute toxicity-based MS. If the commissioner finds that a very large MS and FAV, relative to the CS for such pollutants, is not protective of the public health, the MS and FAV shall be reduced according to the following guidelines: If the ration of the MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS, and the CS times 200 should be substituted for the applicable FAV. Any effluent limit derived using the procedures of this item shall only be required after the discharger has been given notice of the specific proposed effluent limits and an opportunity to request a hearing as provided in part 7000.1800.
- (2A/2B – 2): Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.
- (2A/2B – 3): Value represents the criteria for Ammonia, unionized as N.
- (2A/2B – 4): See 7050 rules for guidance on criteria applicable to certain areas.
- (2A/2B – 5): Based on the criteria for cyanide, free.
- (2A/2B – 6): 5.0 mg/l as a daily minimum. This dissolved oxygen standard may be modified on a site-specific basis according to part 7050.0220, subpart 7, except that no site-specific standard shall be less than 5 mg/l as a daily average and 4 mg/l as a daily minimum. Compliance with this standard is required 50 percent of the days at which the flow of the receiving water is equal to the 7Q. This standard applies to all Class 2B waters except for those portions of the Mississippi River from the outlet of the Metro Wastewater Treatment Works in Saint Paul (River Mile 835) to Lock and Dam No. 2 at Hastings (River Mile 815). For this reach of the Mississippi River, the standard is not less than 5 mg/l as a daily average from April 1 through November 30, and not less than 4 mg/l at other times.
- (2A/2B – 7): TSS standards for Class 2A may be exceeded for no more than ten percent of the time. This standard applies April 1 through September 30.
- (2A/2B – 8): Value for North River Nutrient Region. Other regions' TSS standards are less restrictive than the existing technology based effluent limits, and were not considered. See 7050 rules for guidance on criteria applicable to certain areas.
- (CF): Conversion Factor.
- (CR6): Value represents the criteria for Hexavalent Chromium.
- (HD): Hardness Dependent.

Notes for MN SW 4A State Waters 7050:

- (4A – 1): 60% of total cations as milliequivalents per liter.
- (4A – 2): Value represents the criteria for Total Dissolved Salts.
- (Wild Rice): Wild Rice Applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.

Notes for MN SW 4B Livestock Wildlife 7050

- (S): Value represents the criteria for Total Salinity.

Appendix B

Effluent Limit Tables for 25 Municipalities—Current and Future (for existing and potential future WQSs) Effluent Limits

Ada Effluent Limit Summary - Current and Proposed Standards
Facility Name: Ada
Permit Number: MN-580095
Receiving Water: Unnamed Ditch to Marsh River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Modified: October 20, 2010
Permit Expires: August 31, 2015
SD 001: Main Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
BOD, Carbonaceous 05 Day (20 Deg C)	216	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	345	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrogen, Ammonia, Total (as N)[2]	NA	mg/L	NA	Mar-Jun	2.1	1.1			1.6	0.8		
Nitrogen, Ammonia, Total (as N)	NA	mg/L	NA	Sep-Dec								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[3]	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Phosphorus, Total (as P)[3]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec			1,150	573				
Solids, Total Suspended (TSS)	388	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	560	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Values represent the calculated limits for ammonia, unionized as N.
[3] Marsh River Phosphorus memo determined that no phosphorus control is necessary at this time for small facilities, but larger one may need to reduce to meet Lake Winnipeg requirements

Albert Lea Effluent Limit Summary - Current and Proposed Standards
Facility Name: Albert Lea Wastewater Treatment Facility
Permit Number: MN0041092
Receiving Water: Shell Rock River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: December 16, 2009
Permit Expires: November 30, 2014
SD-001: 001 Total Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Maximum Calendar Week Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	308	217	336	236	308	217	336	236
Copper, Total (as Cu)	Monitor Only	kg/day	Calendar Quarter Average	Jan-Dec								
Copper, Total (as Cu)	Monitor Only	µg/L	Calendar Quarter Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Hardness, Calcium & Magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Quarter Maximum	Jan-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					8.3	4.0		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	4	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[3]	Monitor Only	kg/day	Calendar Month Average	Jan-Dec (Mar-Nov Proposed)		29.7						
Phosphorus, Total (as P)[3]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec (Mar-Nov Proposed)		1.74						

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Salinity, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			135	76				
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec			911	662				
Solids, Total Suspended (TSS)	2084	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	3126	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Week Average	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1,195	971				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Toxicity, Whole Effluent (Chronic)	1.15	TUc	Calendar Month Average	Dec								
SD-001: 001 Total Facility Discharge *Period: Limits Applicable in the Final Period, Variability of Operation - Tertiary*												
BOD, Carbonaceous 05 Day (20 Deg C)	347	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	5	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	695	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	10	mg/L	Maximum Calendar Week Average	Jan-Dec								
Nitrogen, Ammonia, Total (as N)	486	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)[4]	7	mg/L	Calendar Month Average	Dec-Mar	14.0	7.8			4.7	2.6		
Nitrogen, Ammonia, Total (as N)	208	kg/day	Calendar Month Average	Apr-May, Oct-Nov								
Nitrogen, Ammonia, Total (as N)[4]	3	mg/L	Calendar Month Average	Apr-May, Oct-Nov	0.48	0.33			0.47	0.32		
Nitrogen, Ammonia, Total (as N)	69	kg/day	Calendar Month Average	Jun-Sep								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Nitrogen, Ammonia, Total (as N)[4]	1	mg/L	Calendar Month Average	Jun-Sep	0.25	0.17			0.25	0.17		

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrate + nitrite data.
[3] Limit is based on MPCA memo 'Phosphorus Effluent Limit Review for the Lower Shell Rock River Watershed' dated 6/1/2015.
[4] Values represent the calculated limits for ammonia, unionized as N.

Austin Effluent Limit Summary - Current and Proposed Standards
Facility Name: Austin
Permit Number: MN0022683
Receiving Water: Cedar River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Modified: February 07, 2013
Permit Expires: June 30, 2015
SD-002: Combined Industrial & Domestic Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates (HCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	641	kg/day	Calendar Month Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	20	mg/L	Calendar Month Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	1121	kg/day	Maximum Calendar Week Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	35	mg/L	Maximum Calendar Week Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	801	kg/day	Calendar Month Average	Apr-May, Oct-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Apr-May, Oct-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	1281	kg/day	Maximum Calendar Week Average	Apr-May, Oct-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Apr-May, Oct-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	481	kg/day	Calendar Month Average	Jun-Sep								
BOD, Carbonaceous 05 Day (20 Deg C)	15	mg/L	Calendar Month Average	Jun-Sep								
BOD, Carbonaceous 05 Day (20 Deg C)	961	kg/day	Maximum Calendar Week Average	Jun-Sep								
BOD, Carbonaceous 05 Day (20 Deg C)	30	mg/L	Maximum Calendar Week Average	Jun-Sep								
BOD, Carbonaceous 05 Day (20 Deg C), Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	455	355	497	387	455	355	497	387
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Fecal Coliform, MPN or Membrane filter 44.5C	200	#100m1	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium, Calculated (as CaCo3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Quarter Maximum	Jan-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					6.7	5.0		
Nitrogen, Ammonia, Total (as N)	1313	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)	41	mg/L	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)	929	kg/day	Calendar Month Average	Apr								
Nitrogen, Ammonia, Total (as N)	29	mg/L	Calendar Month Average	Apr								
Nitrogen, Ammonia, Total (as N)	384	kg/day	Calendar Month Average	May								
Nitrogen, Ammonia, Total (as N)	12	mg/L	Calendar Month Average	May								
Nitrogen, Ammonia, Total (as N)	250	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)	7.8	mg/L	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)	352	kg/day	Calendar Month Average	Oct								
Nitrogen, Ammonia, Total (as N)	11	mg/L	Calendar Month Average	Oct								
Nitrogen, Ammonia, Total (as N)	705	kg/day	Calendar Month Average	Nov								
Nitrogen, Ammonia, Total (as N)	22	mg/L	Calendar Month Average	Nov								
Nitrogen, Ammonia, Total (as N)[3]		mg/L		Nov-Mar	12.9	5.9			6.8	3.1		
Nitrogen, Ammonia, Total (as N)[3]		mg/L		Apr-Oct	3.3	1.6			3.1	1.5		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	5.5	mg/L	Calendar Month Minimum	Dec-Mar								
Oxygen, Dissolved	5.0	mg/L	Calendar Month Minimum	Apr-May, Oct-Nov								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Oxygen, Dissolved	6.0	mg/L	Calendar Month Minimum	Jun-Sep								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]	Monitor Only	kg/day	Calendar Month Average	Jun-Sep		8.9						
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jun-Sep								
Phosphorus, Total (as P)[4]	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			1,382	777				
Solids, Total Suspended (TSS)	961	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	1442	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS), Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1,642	1,309				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrate + nitrite data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Assume RPE=Yes, so use equation for Continuous 1.0-20.0 mgd AWWDF (0.7*AWWDF*0.53 mg/L). Divide by 2 for AML.

Butterfield Effluent Limit Summary - Current and Proposed Standards
Facility Name: Butterfield
Permit Number: MN-0022977
Receiving Water: Butterfield Creek
Beneficial Use Classification: 2C, 3C, 4A, 5, 6
Permit Modified: March 31, 2010
Permit Expires: February 28, 2015
SD 001: Total Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	261.7	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	419	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jun-Sep								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-May, Oct-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-May, Oct-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	Mar-Jun, Sep-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec					8.4	2.7		
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Nitrogen, Ammonia, Total (as N)[3]		mg/L		Mar-Jun	2.5	1.1			1.7	0.8		
Nitrogen, Ammonia, Total (as N)[3]		mg/L		Sep-Dec	1.8	0.9			1.5	0.7		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]	Monitor Only	mg/L	Calendar Month Average	June-Sept		4.2						

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Phosphorus, Total (as P)	Monitor Only	kg/mo	Calendar Month Total	Jan-Dec								
Phosphorus, Total (as P)[4]	372	kg/yr	Calendar Year To Date Total	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec			846	673				
Solids, Total Suspended (TSS)	0.518	tons/day	Blue Earth River Turbidity TMDL WLA									
Solids, Total Suspended (TSS)	471.1	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	681	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Limit based on MPCA memo 'Blue Earth and Watonwan River Watershed Phosphorus Reviews' dated 10/23/15. The limit is proposed based on an anticipated facility expansion.

Campbell Effluent Limit Summary - Current and Proposed Standards
Facility Name: Campbell Wastewater Treatment Facility
Permit Number: MN0020915
Receiving Water: Rabbit River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: February 23, 2010
Permit Expires: January 31, 2015
SD 001: Surface Water Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	26.9	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	43.1	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Mar, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Apr-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Apr-Jun, Sep-Dec Measurement								
Nitrate, Total (as N) [2]		mg/L		Jan-Dec					8.0	4.0		
Nitrogen, Ammonia, Total (as N) [2] [3]		mg/L		Apr-Jun					1.8	0.9		
Nitrogen, Ammonia, Total (as N) [2] [3]		mg/L		Sep-Dec					2.0	1.0		
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]	Monitor Only	kg/day	Calendar Month Average	Jun-Sep		3.15						
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	48.5	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
					MDL	AML	MDL	AML	MDL	AML	MDL	AML
Solids, Total Suspended (TSS)	70.0	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Limits were estimated for purposes of the study with the assumption that data would be collected within the study period.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Limit is based on MPCA phosphorus memo 'The Mustinka and Bois de Sioux Watershed Phosphorus Effluent Limit Analysis' dated 6/10/2015.

Cold Spring Effluent Limit Summary - Current and Proposed Standards
Facility Name: Cold Spring
Permit Number: MN0023094
Receiving Water: Sauk River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Modified: June 13, 2014
Permit Expires: August 31, 2015
SD 001: Main Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates (HCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg deg C)	101.6	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg deg C)	15	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg deg C)	169.4	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg deg C)	25	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg deg C), Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	647	491	708	538	647	491	708	538
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			1,135	792				
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Quarter Maximum	Jan-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					16.9	8.6		

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Nitrogen, Ammonia, Total (as N)	33.9	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)[3]	5.0	mg/L	Calendar Month Average	Dec-Mar	17.42	6.92			3.10	1.23		
Nitrogen, Ammonia, Total (as N)	20.3	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)[3]	3.0	mg/L	Calendar Month Average	Jun-Sep	1.73	0.84			1.45	0.70		
Nitrogen, Ammonia, Total (as N)	94.9	kg/day	Calendar Month Average	Oct-Nov								
Nitrogen, Ammonia, Total (as N)[3]	14.0	mg/L	Calendar Month Average	Oct-Nov	11.22	5.80			4.60	2.38		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved[3]	6.0	mg/L	Calendar Month Minimum	Jun-Mar								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Apr-May								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)	1.0	mg/L	12 Month Moving Average	Jan-Dec								
Phosphorus, Total (as P)[4]	2472.9	kg/yr	12 Month Moving Total	Jan-Dec		1,978						
Phosphorus, Total (as P)[5]		kg/day	Calendar Month Average	Jun-Sep		4.1						
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)	Monitor Only	kg/mo	Calendar Month Total	Jan-Dec								
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			3,129	1,583				
Solids, Total Suspended (TSS)	81.7	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	122.5	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1,985	1,680				

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec							12	9
Toxicity, Whole Effluent (Chronic)	7	TUc	Calendar Quarter Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] 12 month moving total TP mass limit Lake Pepin from memo.
[5] Seasonal average monthly TP mass limit from memo.

Cook Effluent Limit Summary - Current and Proposed Standards
Facility Name: Cook
Permit Number: MNG580179
Receiving Water: Little Fork River
Beneficial Use Classification: 2C, 3C, 4A, 4B, 5, 6
Permit Issued: November 19, 2010
Permit Expires: August 31, 2015
SD 002: Total Facility Discharge (Applicable only during discharge)

					Current Standard Calculated Limit	Current Standard Calculated Limit	Current Standard Calculated Limit	Current Standard Calculated Limit	Proposed Standard Calculated Limit	Proposed Standard Calculated Limit	Proposed Standard Calculated Limit	Proposed Standard Calculated Limit
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	135.4	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	216.0	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Apr-Sep								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Oct-Mar								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[2]	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[2][3]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								

					Current Standard Calculated Limit	Current Standard Calculated Limit	Current Standard Calculated Limit	Current Standard Calculated Limit	Proposed Standard Calculated Limit	Proposed Standard Calculated Limit	Proposed Standard Calculated Limit	Proposed Standard Calculated Limit
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Solids, Total Suspended (TSS)	243.8	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	352.2	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] No phosphorus memo provided by MPCA, limit analysis based on RES standard of 50 µg/L because stream is dominated by facility flow.
[3] MN Rules 7050.222 RES for phosphorus in the North River Nutrient Region indicate a 0.05 mg/L phosphorus limit. The practical treatment limit is 0.1 mg/L. Additionally, the Cook WWTP is 75 miles from the nearest water body subject to the RES. Therefore no phosphorus limit was suggested.

Fairmont Effluent Limit Summary - Current and Proposed Standards
Facility Name: Fairmont
Permit Number: MN-0030112
Receiving Water: Center Creek
Beneficial Use Classification: 2B, 3C, 4A, 4B,5, 6
Permit Modified: October 10, 2011
Permit Expires: April 30, 2015
SD001 Total Facility Discharge

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Bicarbonates	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	221	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	15	mg/l	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	369	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Week Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	308	209			308	209		
Chronic Toxicity Testing	1	TUc	Annual WET Testing	Jan-Dec, effective July 01, 2010								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			841	402				
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Total (as Hg)	10.0	ng/L	Calendar Month Average	Jan-Dec								
Mercury, Total (as Hg)	17	ng/L	Daily Maximum	Jan-Dec								

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					7.24	4.26		
Nitrogen, Ammonia, Total (as N)	74	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)	5.0	mg/L	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)	78	kg/day	Calendar Month Average	Apr-May								
Nitrogen, Ammonia, Total (as N)[3]	5.3	mg/L	Calendar Month Average	Apr-May	1.29	0.55			1.68	0.72		
Nitrogen, Ammonia, Total (as N)	15	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)[3]	1.0	mg/l	Calendar Month Average	Jun-Sep	1.39	0.55			1.02	0.40		
Nitrogen, Ammonia, Total (as N)	40	kg/day	Calendar Month Average	Oct-Nov								
Nitrogen, Ammonia, Total (as N)[3]	2.7	mg/L	Calendar Month Average	Oct-Nov	1.96	0.77			1.72	0.67		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	5.0	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]		kg/year	Calendar Month Average	Jan-Dec		4310.4						
Phosphorus, Total (as P)	14.8	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[4]		kg/day	Calendar Month Average	Jun-Sep		11.5						
Phosphorus, Total (as P)	1.0	mg/L	Calendar Month Average	Jan-Dec								
Potassium, Dissolved (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			236	121				
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			804	671				
Solids, Total Suspended (TSS)	443	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	664	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Week Average	Jan-Dec								

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1206	943				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Limit based on MPCA memo 'Blue Earth and Watonwan River Watershed Phosphorus Reviews' dated 10/23/15.

Gilbert Effluent Limit Summary - Current and Proposed Standards
Facility Name: Gilbert
Permit Number: MN0020125
Receiving Water: Unnamed Ditch
Beneficial Use Classification: 2B[2], 3C, 4A, 4B, 5, 6, 7
Permit Modified: March 3, 2010
Permit Expires: June 30, 2014
SD 002: Main Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates (HCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	39.2	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	15	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	78.4	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	30	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	292	213	250	183	292	213	250	183
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Dissolved (as Hg)	Monitor Only	ng/l	Calendar Month Average	May, Sep								
Mercury, Dissolved (as Hg)	Monitor Only	ng/l	Daily Maximum	May, Sep								

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Mercury, Total (as Hg)	1.8	ng/l	Calendar Month Average	May, Sep								
Mercury, Total (as Hg)	3.2	ng/l	Daily Maximum	May, Sep								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Quarter Average	Jan-Dec					8	4		
Nitrogen, Ammonia, Total (as N)[3]	Monitor Only	mg/L	Calendar Month Maximum	Apr-Sep	10	5			3	2		
Nitrogen, Ammonia, Total (as N)[3]	Monitor Only	mg/L	Calendar Month Maximum	Oct-Mar					5	2		
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Mar, Sep								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Quarter Average	Jan-Dec								
Nitrogen, Total (as N)	Monitor Only	mg/L	Calendar Quarter Average	Jan-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]	2.6	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[4]	1.0	mg/L	Calendar Month Average	Jan-Dec								
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			44	30				
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			700	520				
Solids, Total Suspended (TSS)	56.7	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	85	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS), grab (Mercury)	Monitor Only	mg/L	Calendar Month Average	May, Sep								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Solids, Total Suspended (TSS), grab (Mercury)	Monitor Only	mg/L	Daily Maximum	May, Sep								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1000	783				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec							10	8

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] No phosphorus memo provided by MPCA.

Grand Rapids Effluent Limit Summary - Current and Proposed Standards
Facility Name: Grand Rapids
Permit Number: MN0022080
Receiving Water: Mississippi River
Beneficial Use Classification: 2B, 3C, 4A, 5, 6
Permit Modified: November 19, 2014
Permit Expires: May 31, 2018
SD 004: Main Facility Discharge

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
BOD, Carbonaceous 05 Day (20 Deg C)	1438	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	2301	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Mercury, Dissolved (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	May, Sep								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	May, Sep								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Nitrogen, Ammonia, Total (as N)[2]		mg/L		Jan-May	9.7	4.9			3.1	1.6		
Nitrogen, Ammonia, Total (as N)[2][3]	8.0	mg/L	Calendar Month Average	Jun-Sep	4.0	2.3			2.4	1.4		
Nitrogen, Ammonia, Total (as N)[2]		mg/L		Oct-Dec	7.1	3.3			3.1	1.4		
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-May, Oct-Dec								
Nitrogen, Ammonia, Total (as N)	460	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Phosphorus, Total (as P)[4]	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[4]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep			2116	1055				
Solids, Total Suspended (TSS)	1726	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	2589	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS), grab (Mercury)	Monitor Only	mg/L	Calendar Month Maximum	May, Sep								
Zinc. Total (as Zn)	Monitor Only	ug/L	Calendar Month Average	Jan-Dec								
Zinc, Total (as Zn)	418	ug/L	Calendar Month Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Values represent the calculated limits for ammonia, unionized as N.
[3] Warm season limit assumed to apply due to cold season RPE.
[4] No RPE for phosphorus as determined in memo provided by MPCA.

Halstad Effluent Limit Summary - Current and Proposed Standards
Facility Name: Halstad
Permit Number: MN0020770
Receiving Water: Red River of the North
Beneficial Use Classification: 1C, 2Bd, 3C, 4A, 4B, 5, 6
Permit Issued: March 8, 2012
Permit Expires: February 28, 2017
SD 002: Main Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
BOD, Carbonaceous 05 Day (20 Deg C)	10.8	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	17.3	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C), Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Apr-Sep								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Oct-Mar								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Phosphorus, Total (as P)[2]	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[2]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Solids, Total Suspended (TSS)	12.9	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	19.4	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Not included - per Total phosphorus effluent limit review: Marsh River Watershed memo, TP effluent limits are not applicable at this time for any WWTF that discharges within the Marsh Watershed.

Hancock Effluent Limit Summary - Current and Proposed Standards
Facility Name: Hancock
Permit Number: MN0023582
Receiving Water: Unnamed Ditch
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: March 4, 2011
Permit Expires: February 29, 2016
SD 005: Surface Water Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
BOD, Carbonaceous 05 Day (20 Deg C)	129.6	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	207.4	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	May-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb. Jun-Sep								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-May, Oct-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-May, Oct-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec					9.1	3.3		
Nitrogen, ammonia, as N (Apr-Sep)[3]		mg/L		Apr-Sep	0.8	0.3			0.8	0.2		
Nitrogen, ammonia, as N (Oct-Mar)[3]		mg/L		Oct-Mar								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]		kg/year	Calendar Month Average	Jan-Dec		884						
Phosphorus, Total (as P)[4]	Monitor Only	kg/day	12 Month Moving Total	Jan-Dec		2.5						

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec			934	636				
Solids, Total Suspended (TSS)	233.3	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	337.0	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] From Chippewa River Watershed Phosphorus Memo dated 9/16/2015.

Hanska Effluent Limit Summary - Current and Proposed Standards
Facility Name: Hanska
Permit Number: MN0052663
Receiving Water: County Ditch #63
Beneficial Use Classification: 3C, 4A, 4B, 5, 6, 7
Permit Issued: March 1, 2016
Permit Expires: February 28, 2021
SD 001 Total Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	35.5	kg/day	Calendar Month Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	56.7	kg/day	Maximum Calendar Week Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	45	mg/L	Maximum Calendar Week Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	May-Oct								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	mgd	Calendar Month Average Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Maximum Intervention Limit	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Maximum	Mar-Jun, Sep-Dec								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Jun, Jul- Dec (Jun, Dec)								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Jun, Jul- Dec (Jun, Dec)								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Jan-Jun, Jul- Dec (Jun, Dec)								
Nitrogen, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Jun, Jul- Dec (Jun, Dec)								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec, (Sep-Aug), (Oct-Sep)								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec, (Sep-Aug), (Oct-Sep)								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Phosphorus, Total (as P)	Monitor Only	kg/day	Calendar Month Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Phosphorus, Total (as P)	138	kg/year	12-Month Moving Total	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Phosphorus, Total (as P)	Monitor Only	kg/month	Calendar Month Total	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Solids, Total Suspended (TSS)	63.8	kg/day	Calendar Month Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Solids, Total Suspended (TSS)	92.2	kg/day	Maximum Calendar Week Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec, (Sep-Aug), (Oct-Sep)								

Notes

[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.

Hawley Effluent Limit Summary - Current and Proposed Standards
Facility Name: Hawley
Permit Number: MN0020338
Receiving Water: Buffalo River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: April 21, 2011
Permit Expires: March 31, 2016
SD 002

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
BOD, Carbonaceous 05 Day (20 Deg C)	202.7	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	324.4	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	Mar-Jun, Sep-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Nitrogen, Ammonia, Total (as N)[3]	Monitor Only	mg/L	Calendar Month Average	Apr-Sep	1.8	0.7			1.5	0.6		
Nitrogen, Ammonia, Total (as N)[3]	Monitor Only	mg/L	Calendar Month Average	Oct-Mar	2.9	1.4			2.0	1.0		
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Oxygen, Dissolved[4]	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec					5			
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum									

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Phosphorus, Total (as P)[5]		kg/year	12 Month Rolling Total	Jan-Dec		926						
Phosphorus, Total (as P)	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec			2,083	1,659				
Solids, Total Suspended (TSS)	364.9	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	527.1	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] SID shows DO impairment so limit set at WQS.
[5] Recommended/proposed limit provided in Phosphorus Effluent Limit Review for the Buffalo River Watershed Version 1.1 and based on Lake Winnipeg.

Hibbing Effluent Limit Summary - Current and Proposed Standards
Facility Name: Hibbing
Permit Number: MN0030643
Receiving Water: East Swan Creek
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: August 20, 2012
Permit Expires: July 31, 2017
SD 001: 001 Main Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Alkalinity, bicarbonate, as HCO3	DMR data provided - no permit limit or monitoring requirement	mg/l	Calendar Month Maximum				257	190				
Bicarbonates	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	131	kg/day	Calendar Month Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	7.7	mg/L	Calendar Month Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	204	kg/day	Maximum Calendar Week Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	12	mg/L	Maximum Calendar Week Average	Dec-Mar								
BOD, Carbonaceous 05 Day (20 Deg C)	160	kg/day	Calendar Month Average	Apr-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	9.4	mg/L	Calendar Month Average	Apr-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	255	kg/day	Maximum Calendar Week Average	Apr-Nov								
BOD, Carbonaceous 05 Day (20 Deg C)	15	mg/L	Maximum Calendar Week Average	Apr-Nov								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dee.								
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								
Chronic Toxicity Testing	1.1	TUc	Annual WET Testing	Jan-Dec, effective January 01, 2013								
Chronic Toxicity Testing	1.1	TUc	Quarterly WET Testing	Jan-Dec, effective October 01, 2012								
Copper, Total (as Cu)[3]	Monitor Only	ug/L	Calendar Quarter Maximum	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Dissolved (as Hg)	Monitor Only	ng/L	Calendar Quarter Maximum	Jan-Dec								
Mercury, Total (as Hg)	30.6	mg/day	Calendar Month Average	Jan-Dec								
Mercury, Total (as Hg)	1.8	ng/L	Calendar Month Average	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Mercury, Total (as Hg)	54.4	mg/day	Daily Maximum	Jan-Dec								
Mercury, Total (as Hg)	3.2	ng/L	Daily Maximum	Jan-Dec								
Nitrite Plus Nitrate, Total (as N) [2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					6.6	4.5		
Nitrogen, Ammonia, Total (as N)	114	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)[3]	6.7	mg/L	Calendar Month Average	Dec-Mar	19.2	6.2			4.7	1.5		
Nitrogen, Ammonia, Total (as N)	150	kg/day	Calendar Month Average	Apr-May								
Nitrogen, Ammonia, Total (as N) [3]	8.8	mg/L	Calendar Month Average	Apr-May	7.1	2.2			3.3	1.0		
Nitrogen, Ammonia, Total (as N)	22	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)[3]	1.3	mg/L	Calendar Month Average	Jun-Sep	4.2	1.4			2.3	0.8		
Nitrogen, Ammonia, Total (as N)	83	kg/day	Calendar Month Average	Oct-Nov								
Nitrogen, Ammonia, Total (as N)[3]	4.9	mg/L	Calendar Month Average	Oct-Nov	4.1	1.6			2.9	1.1		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	12.5	mg/L	Calendar Month Minimum	Dec-Mar								
Oxygen, Dissolved	7.8	mg/L	Calendar Month Minimum	Apr-Nov								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[4]	17.0	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[4]	1.0	mg/L	Calendar Month Average	Jan-Dec								
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			68	52				
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			708	583				
Solids, Total Suspended (TSS)	510	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	766	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS), grab (Mercury)	Monitor Only	mg/L	Calendar Quarter Maximum	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec								
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec							10.0	6.8

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] No phosphorus memo provided by MPCA.

Lake Crystal Effluent Limit Summary - Current and Proposed Standards
Facility Name: Lake Crystal Wastewater Treatment Facility
Permit Number: MN0055981
Receiving Water: Minneopa Creek
Beneficial Use Classification: 3C, 4A, 4B, 5, 6, 7
Permit Issued: December 22, 2010
Permit Expires: November 30, 2015
SD 002: 001 Main Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	33	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	15	ng/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	56	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	May-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	Jan, July								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Nitrogen, Ammonia, Total (as N)[2][3]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Nitrogen, Ammonia, Total (as N)[2][3]				Apr-Oct					1.2	0.6		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)	1.0	mg/L	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[4]		kd/day		Jan-Dec		3						
Phosphorus, Total (as P)	Monitor Only	kg/mo	Calendar Month Total	Oct-Apr								
Phosphorus, Total (as P)	358	kg/yr	Season To Date Total	Oct-Apr								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep			853	658				
Solids, Total Suspended (TSS)	67	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	100	kg/day	Maximum Calendar Week Average	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Sulfate		mg/L										

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Values represent the calculated limits for ammonia, unionized as N.
[3] Downstream waters have Class 2B protections, so ammonia limits are shown for illustrative purposes; however the receiving stream segment does not have Class 2B protections.
[4] Limit based on MPCA memo 'Phosphorus Effluent Limit Review: Minnesota River Basin' dated 2/18/2016.

Lewisville Effluent Limit Summary - Current and Proposed Standards
Facility Name: Lewisville Wastewater Treatment Facility
Permit Number: MN0065722
Receiving Water: Unnamed Ditch
Beneficial Use Classification: 3C, 4A, 4B, 5, 6, 7
Permit Issued: December 22, 2010
Permit Expires: November 30, 2015
SD 001: Total Facility Discharge (Applicable only during discharge)

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
BOD, Carbonaceous 05 Day (20 Deg C)	44	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	70	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Average	May-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[2]	Monitor Only	mg/L	Calendar Month Average	Jun-Sep		4.2						
Phosphorus, Total (as P)	166	kg/yr	Calendar Month Year to Date Total	Jan-Dec								
Solids, Total Suspended (TSS)	79	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	120	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Proposed River Eutrophication Standard (RES) June-September, based on MPCA memo titled Blue Earth and Watonwan River Watershed Phosphorus Reviews (10/23/2015)

Madelia Effluent Limit Summary - Current and Proposed Standards
Facility Name: Madelia WWTP
Permit Number: MN0024040
Receiving Water: Watonwan River
Beneficial Use Classification: 2B, 3A, 3C, 4A, 4B, 5, 6
Permit Issued: April 20, 2016
Permit Expires: March 31, 2021
SD 003: Main Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Bicarbonates (HCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	50	kg/day	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	75	kg/day	Maximum Calendar Week Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	10	mg/L	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C)	15	mg/L	Maximum Calendar Week Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)	490	346	69	49	490	346	537	379
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec (Sep-Aug) (Oct-Sep)								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
Hardness, Calcium & magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)			863	507				
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
Mercury, Dissolved (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	May, Sep								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	May, Sep								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)					8.1	2.5		

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Nitrogen, Ammonia, Total (as N)	11	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)[3]	2.3	mg/L	Calendar Month Average	Jun-Sep	3	1.1			2.3	0.9		
Nitrogen, Ammonia, Total (as N)	104	kg/day	Calendar Month Average	Apr-May								
Nitrogen, Ammonia, Total (as N)[3]	21	mg/L	Calendar Month Average	Apr-May	4	1.3			3.7	1.1		
Nitrogen, Ammonia, Total (as N)	Monitor Only	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)[3]	Monitor Only	mg/L	Calendar Month Average	Dec-Mar	18	5.7			5.6	1.7		
Nitrogen, Ammonia, Total (as N)	35	kg/day	Calendar Month Average	Oct-Nov								
Nitrogen, Ammonia, Total (as N)[3]	7.1	mg/L	Calendar Month Average	Oct-Nov	5	1.7			3.1	1.0		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Nitrogen, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec (Sep-Aug) (Oct-Sep)								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec (Sep-Aug) (Oct-Sep)								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
Phosphorus, Total (as P)	1.0	mg/L	12-Month Moving Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Phosphorus, Total (as P)	Monitor Only	kg/day	Calendar Month Average	Oct-May								
Phosphorus, Total (as P)[4]		kg/day	Calendar Month Average	Jun-Sep								
Phosphorus, Total (as P)	Monitor Only	kg/mo	Calendar Month Total	Jan-Dec (Sep-Aug) (Oct-Sep)								
Phosphorus, Total (as P)	1448	kg/yr	12-Month Moving Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
Silver, Total (as Ag)	Monitor Only	mg/L	Calendar Month Maximum	May, Oct								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)			1,397	661				
Solids, Total Suspended (TSS)	149	kg/day	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Solids, Total Suspended (TSS)	224	kg/day	Maximum Calendar Week Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Solids, Total Suspended (TSS) Percent Removal	85	%	Calendar Month Average	Jan-Dec (Sep-Aug) (Oct-Sep)								
Solids, Total Suspended (TSS), grab (Mercury)	Monitor Only	mg/L	Calendar Month Maximum	May, Sep								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)			1,276	1,030				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec (Sep-Aug) (Oct-Sep)								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Limit based on MPCA memo 'Blue Earth and Watonwan River Watershed Phosphorus Reviews' dated 10/23/15.

Nashwauk Effluent Limit Summary - Current and Proposed Standards
Facility Name: Nashwauk
Permit Number: MNG580184
Receiving Water: Hanna Reservoir #2
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: November 19, 2010
Permit Expires: August 31, 2015
SD 002: Total Facility Discharge (Applicable only during discharge)

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	292	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	468	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Feb, Jul								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrite Plus Nitrate, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Nitrogen, Ammonia, Total (as N) [2]	Monitor Only	mg/L	Calendar Month Maximum	Apr-Sep	1.7	0.8			1.3	0.7		
Nitrogen, Ammonia, Total (as N) [2]	Monitor Only	mg/L	Calendar Month Maximum	Oct-Mar	5.2	2.6			3.4	1.7		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P) [3]	11.7	kg/day	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)	1.0	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Jun, Jul-Dec								
Solids, Total Suspended (TSS)	526	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	760	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Values represent the calculated limits for ammonia, unionized as N.
[3] MPCA determined existing limit is protective for RES per memo 'Total phosphorus effluent limit review: Stabilization pond general permittees in the Mississippi River - Grand Rapids Watershed' dated 3/24/15.

Northrup Effluent Limit Summary - Current and Proposed Standards
Facility Name: Northrup
Permit Number: MN0024384
Receiving Water: Judicial Ditch No. 8
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Modified: September 10, 2013
Permit Expires: February 29, 2016
SD-002: Combined Industrial & Domestic Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
BOD, Carbonaceous 05 Day (20 Deg C)	74.7	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	119.4	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or membrane Filter 44.5C	200	#100ml	Calendar Month Geometrc Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun, Sep-Dec								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[2]	138	kg/yr	12 Month Moving Total	Jan-Dec		138.2						
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[2]	Monitor Only	mg/L	Calendar Month Average	Jun-Sep		4.2						
Phosphorus, Total (as P)	Monitor Only	kg/mo	Calendar Month Total	Jan-Dec								
Solids, Total Suspended (TSS)	134.4	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	194	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Limit based on MPCA memo 'Blue Earth and Watonwan River Watershed Phosphorus Reviews' dated 10/23/15. The limit is proposed based on an anticipated facility expansion.

Rochester Effluent Limit Summary - Current and Proposed Standards
Facility Name: Rochester
Permit Number: MN0024619
Receiving Water: South Fork of Zumbro River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: May 26, 2010
Permit Expires: April 30, 2015
SD 001: Main Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	1352	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	15	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	2254	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Cadmium, Total (as Cd)	Monitor Only	ug/L	Single Value	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	292	252	319	274	292	252	319	274
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								
Chromium, Total (as Cr)	Monitor Only	ug/L	Single Value	Jan-Dec								
Chronic Toxicity Testing	1.7	TUc	Annual WET Testing	Jan-Dec, effective July 01, 2010								
Copper, Total (as Cu)	Monitor Only	ug/L	Single Value	Jan-Dec								
Fecal Coliform, MPB or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium, Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Lead, Total (as Pb)	Monitor Only	ug/L	Single Value	Jan-Dec								
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Mercury, Total (as Hg)	10	ng/L	Calendar Month Average	Mar, Jun, Sep, Dec								
Mercury, Total (as Hg)	17	ng/L	Daily Maximum	Mar, Jun, Sep, Dec								
Nickel, Total (as Ni)	Monitor Only	ug/L	Single Value	Jan-Dec								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					8.3	3.9		
Nitrogen, Ammonia, Total (as N)	451	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N) [3][4]	5	mg/L	Calendar Month Average	Dec-Mar	10.2	8.5			4.0	3.4		
Nitrogen, Ammonia, Total (as N)	902	kg/day	Calendar Month Average	Apr-May								
Nitrogen, Ammonia, Total (as N) [3][4]	10	mg/L	Calendar Month Average	Apr-May	4.0	3.2			2.2	1.8		
Nitrogen, Ammonia, Total (as N)	270	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N) [3]	3	mg/L	Calendar Month Average	Jun-Sep	2.7	1.5			1.7	1.0		
Nitrogen, Ammonia, Total (as N)	1172	kg/day	Calendar Month Average	Oct-Nov								
Nitrogen, Ammonia, Total (as N)[3]	13	mg/L	Calendar Month Average	Oct-Nov	5.7	2.9			3.5	1.8		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	5.0	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[5]	72.2	kg/day	12 Month Moving Average	Jun-Sep		6.76						
Phosphorus, Total (as P)[5]	1.0	mg/L	Calendar Month Average	Jun-Sep		0.11						
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			825	747				
Solids, Total Suspended (TSS)	2705	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	4057	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1,313	997				

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	Existing Limit	Units	Limit Type	Effective Period	MDL	AML	MDL	AML	MDL	AML	MDL	AML
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Zinc, Total (as Zn)	Monitor Only	ug/L	Single Value	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Cold season limits assumed to apply due to warm season RPE.
[5] Phosphorus limits were calculated based on the assumption that a WLA would be developed for Rochester. Limits were calculated using a RES of 0.1 mg/L..

Serpent Lake Effluent Limit Summary - Current and Proposed Standards
Facility Name: Serpent Lake
Permit Number: MNG580215
Receiving Water: Rabbit River
Beneficial Use Classification: 2C, 3C, 4A, 4B, 5, 6
Permit Issued: July 8, 2008
Permit Expires: April 30, 2013
SD 002: Total Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
BOD, Carbonaceous 05 Day (20 Deg C)	591	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	946	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Mar, Jul, Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Apr-Jun, Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Apr-Jun, Sep-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Maximum	May, Oct								
Nitrite Plus Nitrate, Total (as N)[2][4]		mg/L	Calendar Month Maximum									
Nitrogen, ammonia, as N (Apr-Sep)[3][4]		mg/L	Calendar Month Maximum	Apr-Sep	2.2	1.1			1.6	0.8		
Nitrogen, ammonia, as N (Oct-Mar)[3][4]		mg/L	Calendar Month Maximum	Oct-Mar								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[5]	1.0	mg/L	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[5]	23.6	kg/day	Calendar Month Average Intervention	Jan-Dec								
Phosphorus, Total (as P)[6]		kg/year	Calendar Month Average	Jan-Dec		928						
Solids, Total Dissolved (TDS)		mg/L	Calendar Month Maximum				700	349				
Solids, Total Suspended (TSS)	1064	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	1537	kg/day	Maximum Calendar Week Average	Jan-Dec								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								
Sulfate, Total (as SO4)[7]	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Not currently listed in permit limits but DMR data collected.
[5] Limit based on Table 6 of Mississippi River – Brainerd Watershed Phosphorus Memo.
[6] Limit based on Table 6 of Mississippi River – Brainerd Watershed Phosphorus Memo, under Lake Eutrophication Standards.
[7] Not currently listed in permit limits but facility is upstream of a wild rice water (Mahnomen Lake). Including a monitor only limit. (No DMR data to complete calculation; additional data needed to determine RPE.)

Starbuck Effluent Limit Summary - Current and Proposed Standards
Facility Name: Starbuck
Permit Number: MN-0021415
Receiving Water: Outlet Creek
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Modified: June 15, 2011
Permit Expires: May 31, 2016
SD 003: Effluent to Surface Water

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			275	247				
BOD, Carbonaceous 05 Day (20 Deg C)	33.1	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	52.9	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	347	267	379	292	347	267	379	292
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Apr-Oct								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Calcium & Magnesium Calculated (as CaCO3)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			881	439				
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Average	Jan, July								
Nitrite Plus Nitrate, Total (as N)[2]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					9.9	5.0		
Nitrogen, Ammonia, Total (as N)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Nitrogen, Ammonia, Total (as N)[3][4]		mg/L		Apr, Sep	1.0	0.5			0.9	0.4		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)	Monitor Only	kg/day	Calendar Month Average	Jan-Dec								

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
Phosphorus, Total (as P)	1.0	mg/L	Calendar Month Average	Jan-Dec								
Phosphorus, Total (as P)[5]		kg/day	Calendar Month Average	June-Sept		1.8						
Phosphorus, Total (as P)	414	kg/yr	12 month rolling total	Jan-Dec								
Phosphorus, Total (as P)	Monitor Only	mg/L	Calendar Year to Date Total	Jan-Dec								
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			331	237				
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			881	720				
Solids, Total Suspended (TSS)	39.7	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	59.5	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removal	85	%	Minimum Calendar Week Average	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1,377	1,036				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] No cold season data available to calculate ammonia limits for Oct-Mar.
[5] Limit based on MPCA memo 'Total phosphorus effluent limit review: Mississippi River – Brainerd Watershed' dated 11/4/2015.

Watertown Effluent Limit Summary - Current and Proposed Standards
Facility Name: Watertown
Permit Number: MN0020940
Receiving Water: South Fork of Crow River
Beneficial Use Classification: 2B, 3B, 4A, 4B, 5, 6
Permit Issued: October 30, 2009
Permit Expires: September 30, 2014
SD 001: Total Facility Discharge

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Bicarbonates	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			250	208				
BOD, Carbonaceous 05 Day (20 Deg C)	23.9	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	5	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	47.7	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	10	mg/L	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C) Percent Removal	85	%	Minimum Calendar Month Average	Jan-Dec								
Calcium, Total (as Ca)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Chloride, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec	270	219	100	81	270	219	100	81
Chlorine, Total Residual	0.038	mg/L	Daily Maximum	Jan-Dec								
Fecal Coliform, MPN or Membrane Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	Monitor Only	mgd	Calendar Month Average	Jan-Dec								
Flow	Monitor Only	mgd	Calendar Month Maximum	Jan-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Jan-Dec								
Hardness, Carbonate (as CaCo3)[2]	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			250	201				
Magnesium, Total (as Mg)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Mercury, Total (as Hg)	Monitor Only	ng/L	Calendar Month Average	Jan, July								
Nitrite Plus Nitrate, Total (as N)[3]	Monitor Only	mg/L	Calendar Month Average	Apr, Sep					6.0	4.6		
Nitrogen, Ammonia, Total (as N)	36.7	kg/day	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)[4]	7.7	mg/L	Calendar Month Average	Dec-Mar								
Nitrogen, Ammonia, Total (as N)	114.5	kg/day	Calendar Month Average	Apr-May								
Nitrogen, Ammonia, Total (as N)[4]	24	mg/L	Calendar Month Average	Apr-May								
Nitrogen, Ammonia, Total (as N)	6.7	kg/day	Calendar Month Average	Jun-Sep								
Nitrogen, Ammonia, Total (as N)[4]	1.4	mg/L	Calendar Month Average	Jun-Sep					2.4	1.2		
Nitrogen, Ammonia, Total (as N)	24.3	kg/day	Calendar Month Average	Oct-Nov								

					Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Current WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS	Estimated Effluent Limit Future WQS
					CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]	CLASS 2	CLASS 2	CLASS 3/4[1]	CLASS 3/4[1]
Parameter	**Existing Limit**	**Units**	**Limit Type**	**Effective Period**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**	**MDL**	**AML**
Nitrogen, Ammonia, Total (as N)[4]	5.1	mg/L	Calendar Month Average	Oct-Nov	11.6	4.3			3.8	1.4		
Nitrogen, Kjeldahl, Total	Monitor Only	mg/L	Calendar Month Average	Apr, Sep								
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[5]	Monitor Only	mg/L	Calendar Month Average	Jun-Sep		0.53						
Phosphorus, Total (as P)[5]	Monitor Only	kg/year	Calendar Month Average	Jan-Dec		1394.8						
Potassium, Total (as K)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								
Salinity, Total	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			1,000	624				
Sodium, Total (as Na)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec			121	86				
Solids, Total Dissolved (TDS)	Monitor Only	mg/L	Calendar Month Average	Apr, Sep			700	615				
Solids, Total Suspended (TSS)	143	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	30	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	214	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS) Percent Removed	85	%	Minimum Calendar Month Average	Jan-Dec								
Specific Conductance	Monitor Only	umh/cm	Calendar Month Maximum	Jan-Dec			1,000	860				
Sulfate, Total (as SO4)	Monitor Only	mg/L	Calendar Month Maximum	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Limit is based on 3B listing in permit, toxics review says 3C and not listed on MN Rules 7050.0470.
[3] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[4] Values represent the calculated limits for ammonia, unionized as N.
[5] Recommended/proposed limit provided in South Fork Crow River Watershed Phosphorus Effluent Limit Analysis.

Wendell Effluent Limit Summary - Current and Proposed Standards
Facility Name: Wendell Wastewater Treatment Facility
Permit Number: MN0051501
Receiving Water: Mustinka River
Beneficial Use Classification: 2B, 3C, 4A, 4B, 5, 6
Permit Issued: January 11, 2011
Permit Expires: December 31, 2015
SD 001: Surface Water Discharge

Parameter	Existing Limit	Units	Limit Type	Effective Period	Estimated Effluent Limit Current WQS CLASS 2 MDL	Estimated Effluent Limit Current WQS CLASS 2 AML	Estimated Effluent Limit Current WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Current WQS CLASS 3/4[1] AML	Estimated Effluent Limit Future WQS CLASS 2 MDL	Estimated Effluent Limit Future WQS CLASS 2 AML	Estimated Effluent Limit Future WQS CLASS 3/4[1] MDL	Estimated Effluent Limit Future WQS CLASS 3/4[1] AML
BOD, Carbonaceous 05 Day (20 Deg C)	15.4	kg/day	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	25	mg/L	Calendar Month Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	24.6	kg/day	Maximum Calendar Week Average	Jan-Dec								
BOD, Carbonaceous 05 Day (20 Deg C)	40	mg/L	Maximum Calendar Week Average	Jan-Dec								
Fecal Coliform, MPN or membrance Filter 44.5C	200	#100ml	Calendar Month Geometric Mean	Apr-Oct								
Flow	0	MG	Calendar Month Total Intervention	Jan-Feb, Jul,Aug								
Flow	Monitor Only	mgd	Calendar Month Average	Mar-Jun,Sep-Dec								
Flow	Monitor Only	MG	Calendar Month Total	Mar-Jun,Sep-Dec								
Nitrite Plus Nitrate, Total (as N)[2][4]	NA	mg/L	NA	Jan-Dec					8.0	4.0		
Nitrogen, Ammonia, Total (as N)[3][4]	NA	mg/L	NA	Mar-Jun					1.5	0.7		
Nitrogen, Ammonia, Total (as N)[3][4]	NA	mg/L	NA	Sep-Dec					1.2	0.6		
Oxygen, Dissolved	Monitor Only	mg/L	Calendar Month Minimum	Jan-Dec								
pH	9.0	SU	Calendar Month Maximum	Jan-Dec								
pH	6.0	SU	Calendar Month Minimum	Jan-Dec								
Phosphorus, Total (as P)[5]	1.0	mg/L	Calendar Month Average	Jan-Dec		1.0						
Phosphorus, Total (as P)[5]	27	kg/yr	Calendar Year To Date Total	Jan-Dec		27						
Solids, Total Suspended (TSS)	27.7	kg/day	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	45	mg/L	Calendar Month Average	Jan-Dec								
Solids, Total Suspended (TSS)	40.0	kg/day	Maximum Calendar Week Average	Jan-Dec								
Solids, Total Suspended (TSS)	65	mg/L	Maximum Calendar Week Average	Jan-Dec								

Notes
[1] Class 3 and 4 standards are included for illustrative purposes, but are not to be used for facility designs.
[2] Calculated limits are based on available DMR data. Limit is shown as total nitrogen as nitrate but was developed from nitrite + nitrate data.
[3] Values represent the calculated limits for ammonia, unionized as N.
[4] Receiving stream concentrations used to set future limits as no DMR data was available.
[5] Limit based on MPCA memo 'The Mustinka and Bois de Sioux Watershed Phosphorus Effluent Limit Analysis' dated 6/10/15.

Appendix C

Membrane Costs

Memorandum

To: Paul Saffert and Seth Peterson, Bolton and Menk
From: Barr Engineering Co.
Subject: MMB cost analysis for RO, NF, and evaporator/crystallizer systems
Date: December 2, 2016
Project: 23621125.00 WWCE
c: Bryan Oakley, Jon Minne, Jeff Ubl, Tim Reid, Alison Ling, Dale Finnesgaard, Hal Runke

C1.0 Rationale for Cost Estimate

Barr compiled estimated costs to upgrade 15 Minnesota wastewater treatment facilities to meet current and future water quality standards. Some of the 15 wastewater facilities analyzed in this study may require reverse osmosis (RO) and/or nanofiltration (NF) treatment to meet anticipated future Minnesota Pollution Control Agency (MPCA) standards for chloride and sulfate. The majority of costs were estimated using CapdetWorks™, a software program that models treatment costs for a wide variety of wastewater processes. However, reverse osmosis (RO) and associated brine treatment are expensive methods that produce cleaner water than typically required for wastewater treatment, and these processes are not included in the model.

This memo describes Barr's cost estimation for RO or NF membrane filtration and brine treatment by evaporation/crystallization for Minnesota wastewater treatment facilities. Cost estimates were normalized to July 2014 dollars using Engineering News Record (ENR) cost indices for construction costs. July 2014 was chosen as the basis to match the cost output from CapdetWorks™.

C2.0 Membrane Costs

Both RO and NF capital costs were based on budgetary proposals from GE Water and Process Solutions for a confidential Barr project for hollow fiber membrane modules mounted on 8' x 20' skids.

C2.1 Flow Apportioning

Because RO and NF remove over 90% of target salts fed to the membranes and treatment is expensive, WWTFs requiring RO or NF treatment are expected to treat only a portion of the plant flow with RO or NF membranes. This cost analysis assumes that flow would be apportioned to treat the minimum volume required to meet chloride and sulfate targets. The method used to calculate these flows for RO and NF is outlined below.

Design conditions for chloride and sulfate removal were determined based on historical DMR flow and concentration data. For example, Figure C-1 shows the relationship between flow and chloride concentration for Watertown. Generally, concentrations of sulfate and chloride decrease with increasing plant flow, which allows a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates. The amount of flow requiring RO treatment was evaluated for two different conditions. The first condition evaluated was the average monthly flow with the highest recorded average monthly influent chloride concentration. In the case of Watertown, this was 755 mg/L at 0.418 MGD, as shown on Figure C-1. The second condition evaluated was the average monthly chloride concentration at the highest recorded flow which was then assumed for the design average wet weather flow. In the case of Watertown, this was 364 mg/L at 0.80 MGD, as shown on Figure C-1.

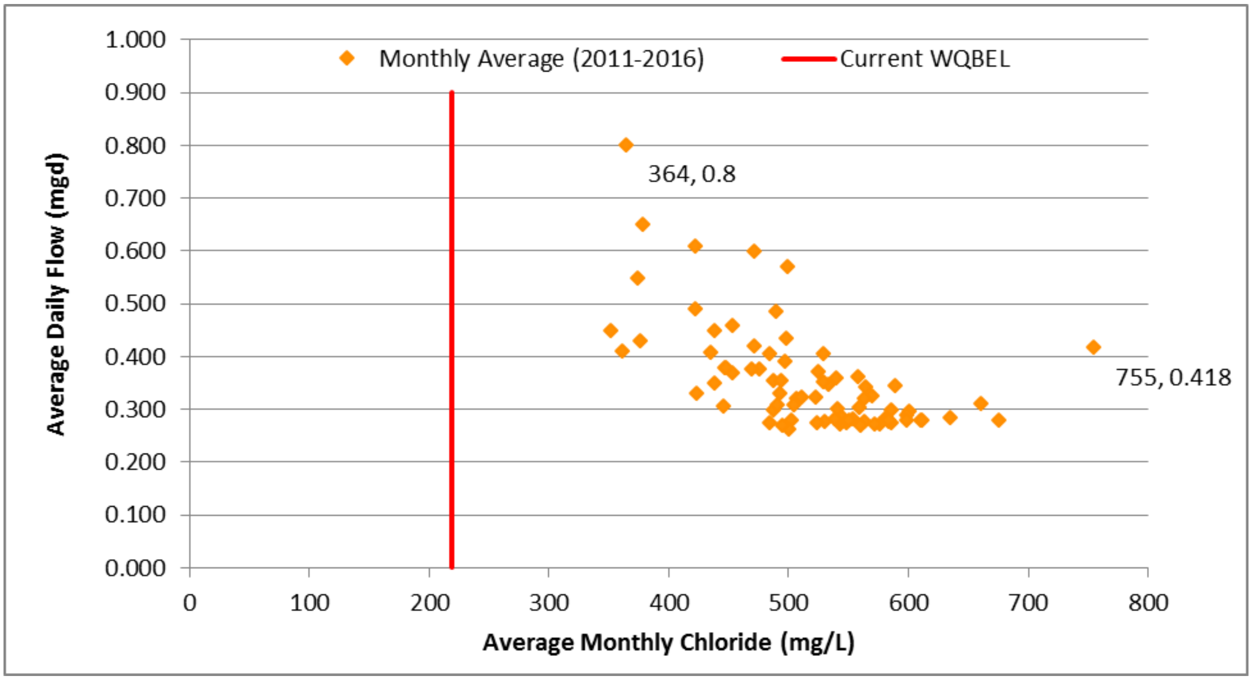

Figure C-1 Effluent Flow and Chloride Concentration Relationship, Watertown

The amount of flow to be routed to RO treatment for each condition was calculated based on the chloride removal requirements. The anticipated chloride limit was compared to the design chloride concentration and flow selected as described in Section 0 and the RO chloride rejection and used to calculate the minimum RO treatment flow required to meet the chloride limit. The condition which resulted in the highest flow to the RO system was selected for the RO cost model. For Watertown, the low flow/high concentration condition required 208 gpm of RO treatment, while the high flow/low concentration condition required 224 gpm of RO treatment, so the average wet weather flow was used with the chloride concentration at the high flow to determine the required RO capacity. In this example, the design condition required 352 gpm of RO capacity.

The remainder of the flow was assumed to be bypassed unless the facility is anticipated to have a sulfate limit. The design influent sulfate concentration and flow condition were determined using the same condition used for determining RO flow for chloride – either the average monthly flow with highest recorded monthly sulfate concentration or highest recorded flow with average monthly sulfate concentration applied to the average wet-weather flow.

If sulfate removal is required to meet a sulfate limit, the fraction of RO bypass flow requiring NF to meet the sulfate limit was calculated based on the design influent sulfate concentration, the RO sulfate rejection, and the NF sulfate rejection. In all cases, one stage of membrane treatment was sufficient to meet anticipated future chloride and sulfate limits.

C2.2 RO Equipment Capital Cost Basis

Assumptions for RO capital equipment are based on GE proposals for a previous project and are outlined in Table C-1. The cost estimated for one 8′ x 20′ membrane skid with 180 membrane elements, including chemical dosing and cleaning skids, was $1 million.

Table C-1 RO treatment capital cost assumptions

Parameter	Value	Basis
RO recovery	75%	GE Proposal
RO chloride rejection	99%	GE Proposal
RO sulfate rejection	99%	GE Proposal
RO flux	12 gal/sf/day	Bartels, 2005[(1)]
Percent of membranes in forward flow	90%	GE Proposal

(1) Reference (1)

C2.3 NF Equipment Capital Cost Basis

Assumptions for NF capital equipment are based on GE proposals for a previous project and are outlined in Table C-2. The same membrane skid and auxiliary systems costs used for RO capital costs were also used for NF capital costs.

Table C-2 NF treatment capital cost assumptions

Parameter	Value	Basis
NF recovery	80%	GE Proposal
NF chloride rejection	10%	GE Proposal
NF sulfate rejection	95%	GE Proposal
NF flux	14 gal/sf/day	Slightly higher than RO
Percent of membranes in forward flow	90%	GE Proposal

C2.4 Other Membrane Capital Costs Basis

Electrical and instrumentation and controls costs were assumed to be 15% of the delivered equipment costs. Inside process piping was also assumed to be 15% of the delivered equipment costs. Building costs were assumed to be $110 per square foot plus $500 for earthwork per 200 square feet. An additional scaling factor was applied to total building and equipment costs, as described in Section 0. A minimum building size of four times the basis skid size was assumed, and for increasing flows, additional building space of twice the skid area was assumed. Start-up and commissioning costs of $40,000 for an RO system and $30,000 for an NF system were included and assumed to be constant and independent of system flow.

C2.5 Membrane O&M Cost Basis

Chemical costs were based on quotes Barr received for another project in April 2016. Membrane cleaning and replacement frequency and power use were based on the same GE proposal used as basis for the capital costs. Required labor was assumed to be 2 hours per day for operation and 0.5 hours per day for maintenance. Chemical costs for RO and NF systems were estimated based on RO and NF O&M estimates from GE and scaled according to flow. Replacement costs for major equipment were not included in this analysis. O&M assumptions for RO and NF membrane treatment are presented in Table C-3.

Table C-3 RO or NF treatment O&M cost assumptions

Parameter	Value	Basis
Power cost	$0.08/kW-hr	Xcel (1) and Minnesota Power (2) Rate Books
RO power use	145 kW/MGD to RO	GE Proposal
NF power use	70 kW/MGD to NF	GE Proposal
Number of CIP cleanings per year	6/year	GE Proposal
Membrane replacement frequency	3 years	GE Proposal
Operations labor	2 hours/day, 365 days/year	Engineering judgement
Maintenance labor	0.5 hours/day, 365 days/year	Engineering judgement
Cost of labor	$51.50/hr	CapDetWorks

(1) Reference (2)
(2) Reference (3)

C3.0 Evaporator/Crystallizer Costs

C3.1 Equipment and Building Cost Basis

In this document, the term evaporator is used to refer to equipment such as brine concentrator and falling film evaporator. This estimate assumes that all NF and RO brine solution is treated with evaporation and/or crystallization.

Costs for evaporator and crystallizer equipment are based on a budget proposal for a 65 gpm crystallizer for a different Barr project and on provided approximate costs from a Veolia representative for a 250 gpm system with both evaporator and crystallizer (reference (4)). The quoted costs for the 65 gpm and 250 gpm systems were $6 million and $15 million, respectively. Additional assumptions based on input from Veolia include:

- For systems smaller than 100 gpm, evaporator is not cost-effective – only use crystallizer
- For systems larger than 100 gpm, use both evaporator and crystallizer

Building costs were assumed to be $110 per square foot plus $500 for earthwork per 200 square feet. An additional scaling factor was applied to total building and equipment costs, as described in Section 0. A minimum building size of four times the basis equipment was assumed, and for increasing flows, additional building space of twice the skid area was assumed.

C3.2 O&M Cost Basis

Evaporator and crystallizer O&M assumptions are summarized in Table C-4. Power costs were based on a proposal for a previous project to concentrate from 25% solids to 85% solids using a crystallizer and were scaled according to flow. These power estimates were consistent with a Bureau of Reclamation report on crystallizers (reference (5)).

The Veolia representative stated that maintenance costs are typically 2% of the equipment cost. Barr assumed that labor accounts for 25% of maintenance costs and material and supply account for the remaining 75%. Veolia also advised that operation of the evaporator and crystallizer would take a full-time staff person, regardless of the system capacity (reference (4)). Replacement costs for major equipment were not included in this analysis.

Chemical costs were based on a US Bureau of Reclamation Report that lists costs for a 1 MGD forced circulation crystallizer system and were scaled according to flow. Costs for hauling salt sludge to a non-hazardous landfill were estimated based on a CapdetWorks™ module that uses five 22-cubic-yard trucks and assumes a 1.75-hour, 20 mile round trip, including loading time.

Table C-4 Evaporator/crystallizer O&M cost assumptions

Parameter	Value	Basis
Power cost	$0.08/kW-hr	Xcel (1) and Minnesota Power (2) Rate Books
Power usage	9600 kW/MGD	Veolia proposal
Operations labor	8 hours/day, 365 days/year	Veolia conversation
Maintenance labor	25% of maintenance cost	Veolia conversation
Materials and supply	75% of maintenance cost	Veolia conversation
Chemical cost	$282,000/year/MGD	US Bureau of Reclamation Study
Solids concentration to membranes	2,000 mg/L	Conservative based on groundwater
Final moisture content of salts	35%	Assume need 65% solids to pass paint filter test for landfill suitability
Depth of salts in storage shed	4 feet	Engineering experience
Landfill disposal cost	$40 per ton	Typical for non-hazardous landfills
Hauling costs	$4.69 per cubic yard	CapDetWorks™ (see text for assumptions)

(1) Reference (2)
(2) Reference (3)

C4.0 Capital Cost Scaling

C4.1 Procedure for Scaling Equipment Costs

The 0.6-rule for process equipment was used to scale capital costs. This rule suggests that if capital costs for a given treatment process are known, these costs can be scaled to smaller and larger systems by multiplying the known treatment cost by the ratio of the unknown to known system capacities raised to the power of 0.6 (reference (6)). This was applied to RO, NF, and evaporator/crystallizer cost estimates.

For evaporator/crystallizer systems, the 65 gpm crystallizer system was used as basis for scaling costs to systems treating less than 100 gpm, and the 250 gpm evaporator/crystallizer system was used as basis for scaling costs to systems treating more than 100 gpm.

Building sizes for both membrane and evaporator/crystallizer systems were assumed to be four times the size of equipment used for the cost basis. This provides enough footprint for the equipment as well as chemical dosing skids and cleaning modules. Any increase in flow beyond the base equipment (495 gpm for RO, 990 gpm for NF, and 65 gpm for evaporator/crystallizer) was assumed to require additional footprint space equal to the twice the base equipment footprint multiplied by the ratio of the flow to the base equipment flow.

C4.2 Procedure for Estimating Total Capital Costs

Additional capital costs for equipment installation and facility construction was scaled based on estimated equipment and building costs. For a given process, the required ancillary capital cost items including piping, electrical, and building are expected to be consistent, regardless of flow. At higher flows, the size and complexity of the ancillary systems would increase, but the added cost is not expected to scale with flow. At moderate flows (assumed to be 2 MGD for RO and NF treatment and 65 gpm for evaporator/crystallizer treatment), we assumed a scaling factor of 1,0, which means that construction and installation costs are assumed to be the same as equipment and building costs. Scaling factors for other flows were developed using the 0.6-rule. This study assumed that the minimum scaling factor is 0.3, which means that at very high flows, construction and installation costs are assumed to be 30% of estimated equipment and building costs. This scaling cost includes equipment installation contingencies and contractor profit. Additional contingencies and contractor profit for the project as a whole is included elsewhere. Capital cost estimates did not include engineering fees in order to be consistent with other estimated costs.

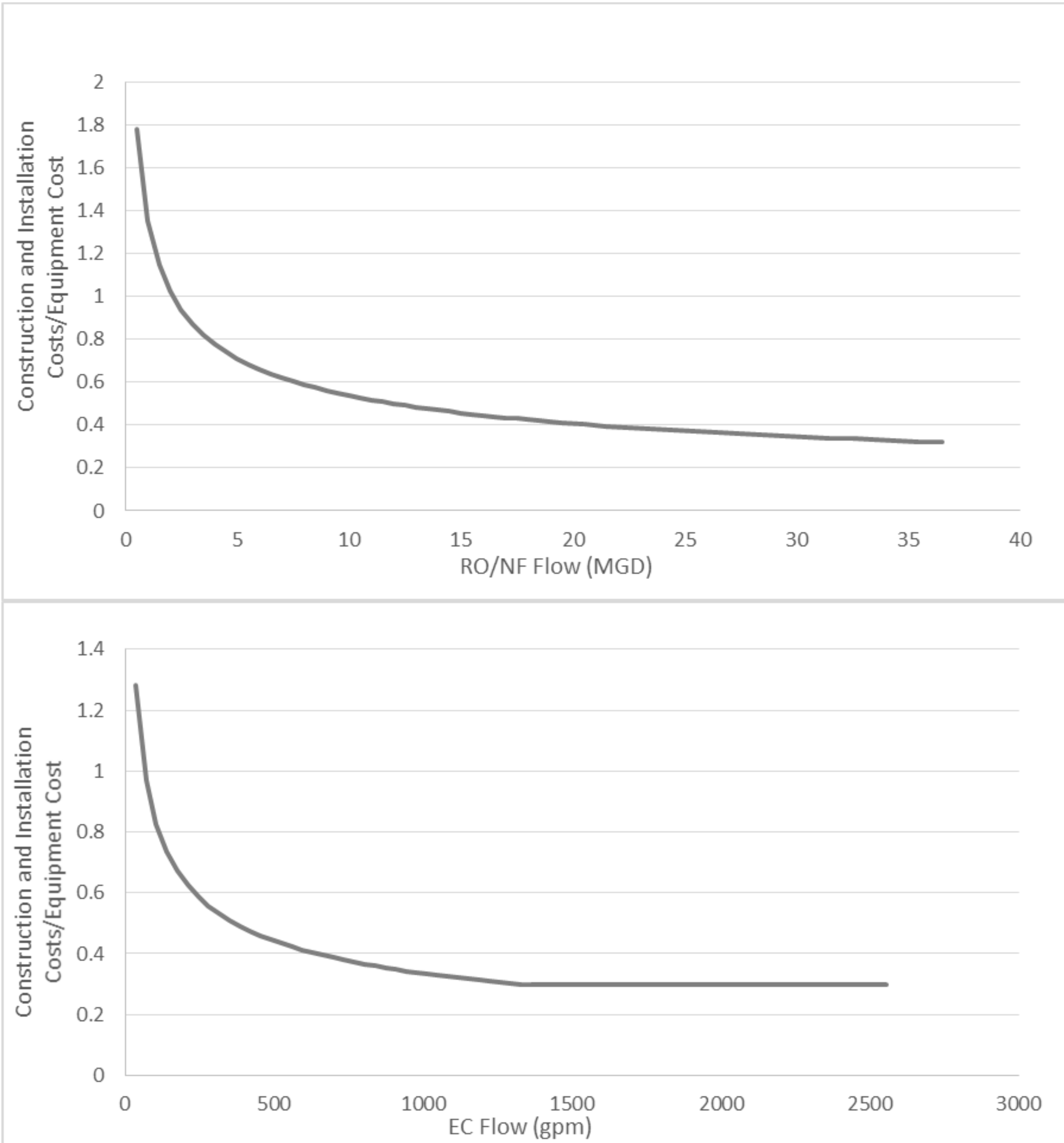

Figure C-2 Construction and installation factor used for a range of equipment flow rates - Top: for RO and NF costs. Bottom: for evaporator and crystallizer costs

C4.3 Comparison to Literature Values

The total estimated capital costs, including estimated construction and installation costs and contingency and contractor profits were compared to Water Environment Federation study by Mackey and colleagues (reference (7)). Costs from the Mackey paper were converted to 2014 dollars using ENR indices prior to comparison.

Estimated capital costs and costs from the Mackey study for RO are illustrated in Figure C-3. RO costs are similar up to 2 MGD, which is the range for which Mackey estimates exist. At higher flow rates, estimated costs are lower than the Mackey trend. This is consistent with improvements in RO technology since 2005 that would decrease the cost of capital equipment.

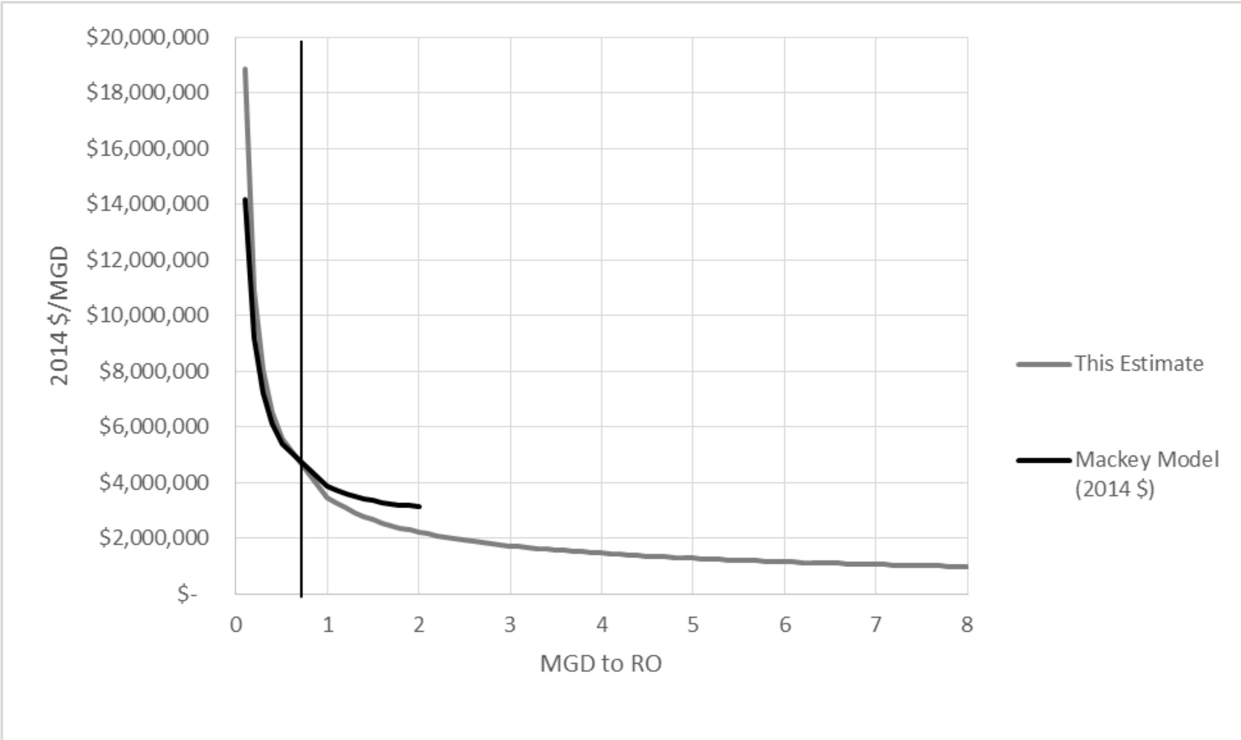

Figure C-3 Comparison of estimated costs to literature costs for RO treatment. Vertical lines reflect the equipment size used as basis for cost estimate

Figure C-4 illustrates costs estimated using the methods described here compared to estimates from the Mackey paper for evaporator treatment, which only estimates costs up to 600 gpm of flow (reference (7)). The Mackey estimate for brine disposal costs includes only evaporation, while this estimate includes both evaporation and crystallization for plants treating more than 100 gpm of brine and crystallization only for plants treating less than 100 gpm of brine. Estimated evaporator costs are about twice the costs of the Mackey estimate. At low flow rates, this trend is expected, because this estimate uses only a crystallizer, which is more expensive than only an evaporator. At higher flow rates, this estimate for evaporator approaches cost of the Mackey model.

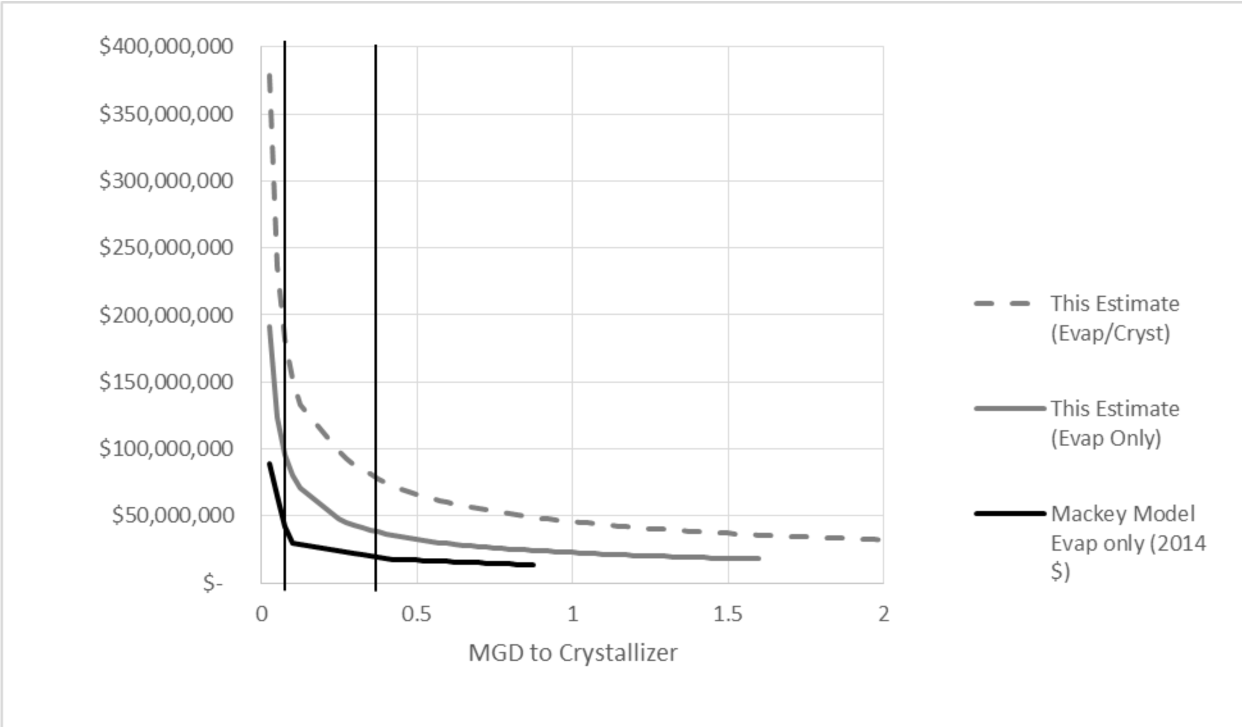

Figure C-4 Comparison of estimated costs to literature costs for evaporator and crystallizer treatment. Vertical lines reflect the equipment sizes used as basis for cost estimate

C5.0 References

1. **Bartels, C. R., et al.** Design considerations for wastewater treatment by reverse osmosis. Water Science & Technology. 2005, Vol. 51, 6-7, pp. 473-482.

2. **Xcel Energy**. Minnesota Commercial and Industrial Electric Prices. November 1, 2015.

3. **Minnesota Power**. Electric Rate Book. July 29, 2014.

4. **Ling, Ali, Barr Engineering Co.** Documented phone conversation with Rob Lawson-Veolia (ZLD) re: MMB Cost Estimates. November 16, 2016.

5. **U.S. Department of the Interior, Bureau of Reclamation**. Zero Liquid Discharge. Brine-Concentrate Treatment and Disposal Options Report: Southern California Regional Brine-Concentrate Management Study – Phase I Lower Colorado Region. s.l. : U.S. Department of the Interior, Bureau of Reclamation, 2009.

6. **Tribe, Michael and Alpine, R. L.W.** Scale economies and the "0.6 rule". Engineering Costs and Production Economics. February 1986, Vol. 10, 4, pp. 271-278.

7. **Mackey, Erin D., et al.** Salinity Removal Cost Curves for Small to Medium Size Water Wells and Wastewater Effluents. Technology. 2005, pp. 539-557.

Appendix D

WWTP Cost Evaluation Summary Memoranda for 15 Municipalities

Memorandum

To: MMB
From: Bryan Oakley, Tim Reid, Jon Minne, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Ada to meet Anticipated Water Quality Standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Ada would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0 – Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Ada operates a WWTF which includes two primary and one secondary stabilization ponds.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MNG580095 (expired August 31, 2015)
- Preliminary Engineering Report, dated January 2004
- Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of existing Ada WWTF

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	0.448
Average Flow (mgd)(1)	0.232
Year Built	1972, with lift station upgrade in 2011
Watershed	Red River
Discharge Location	Unnamed Ditch (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Two primary stabilization ponds, one secondary stabilization pond
Facility Class	D
Service Population(2)	1696
Estimated Equivalent Residential Units (ERU)	1059
Median Household Income(3)	$37,143
Typical Residential Sewer Rate(4)	$421

(1) City of Ada discharge monitoring report influent flow data, November 2010-June 2016
(2) Minnesota State Demographer 2015 estimate (source: http://www.mn.gov/admin/demography/data-by-topic/population-data/our-estimates/
(3) 2014 American Community Survey ((source www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 12, 2016. The process flow diagram developed for the model is shown in Figure D-1.

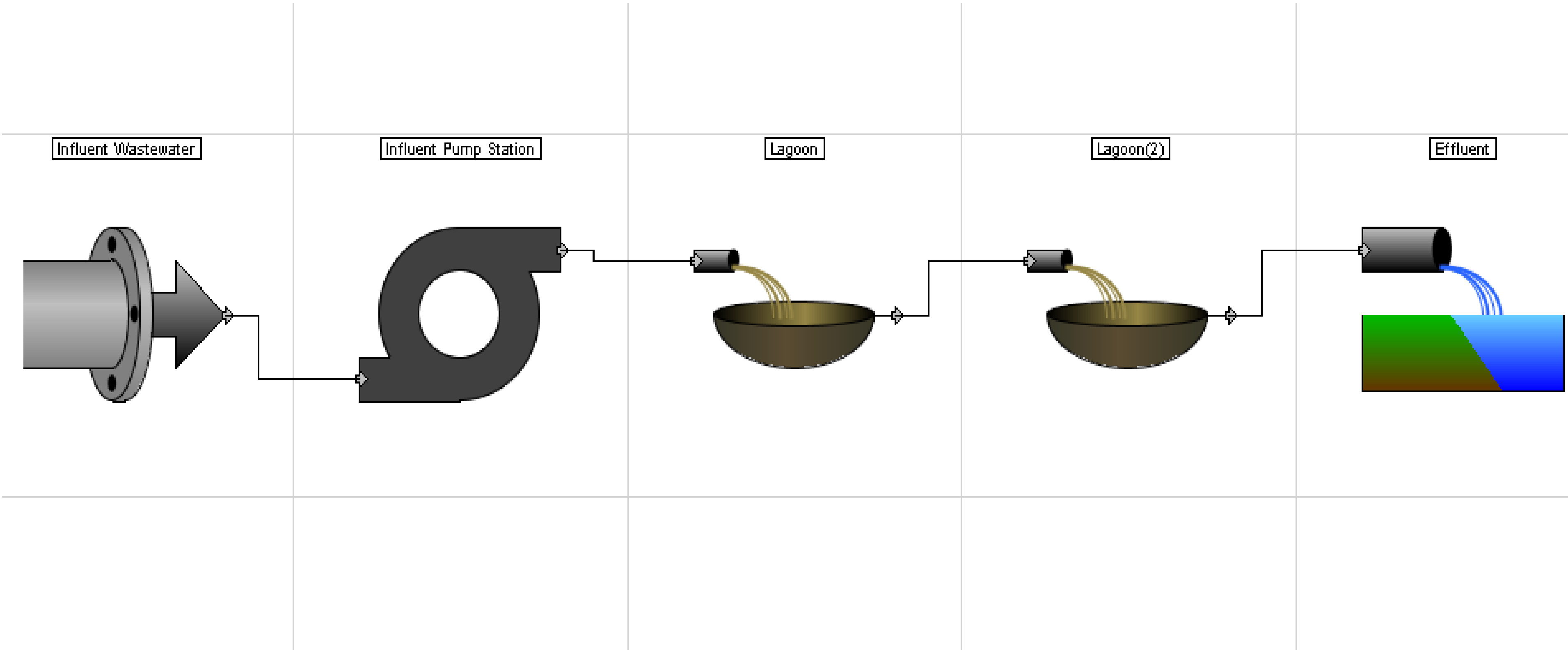

Figure D-1 Process flow diagram of existing Ada WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-2 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-2 Summary of existing and estimated effluent limits: Ada WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia-N (mg/L)	Cal Mo Max	Mar-Jun	2.99	Monitor	2.1 MDL	1.6 MDL
Ammonia-N (mg/L)	Cal Mo Avg	Mar-Jun	1.12-2.99	Monitor	1.1 AML	0.8 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	0.66	Monitor	No change	No change
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.47-1.60	Monitor	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	3.0-62.0	45	No change	No change

Cal Mo Avg—calendar month average
Cal Mo Max – calendar month maximum
MDL—maximum daily limit
AML—average day of the AWW month
AAF—average annual flow
NA—not applicable
(1) From data reported on monthly discharge monitoring reports June 2011 through May 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

For ammonia, there are only two data points available for analysis. The tests exceed both current and future WQBEL. It is unlikely the existing pond system can reliably meet either the current or future WQBEL for ammonia.

New WQBELs for chloride, nitrate, sulfate, total suspended solids (TSS), and phosphorus are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

Upgrades are needed to meet current ammonia WQBELs. The current WQBELs could be met by adding an aerated pond prior to the stabilization ponds and an aerated rock filter following the secondary pond for ammonia polishing; however, these improvements would likely be inadequate to meet future ammonia WQBELs and would be difficult to upgrade.

To meet current and future ammonia WQBELs, an activated sludge system would be necessary. Additional equipment would require:

- An activated sludge system with a minimum of 10 days hydraulic detention time.
- An aeration system capable of maintaining 2 mg/L of dissolved oxygen under all loading conditions.
- Transfer structures to facilitate transfer from the aerated pond to the stabilization ponds.
- Secondary clarifiers capable of handling 1.46 mgd. This would allow discharge of 6 months accumulated wastewater in 8 weeks.
- Recirculation pump and piping from the secondary clarifiers to the secondary pond.

D4.1 Upgrades to Meet Nutrient Requirements

Treatment for ammonia to meet the current WQBEL would require an aerated pond prior to the primary treatment ponds and an aerated rock filter on the effluent of the secondary pond.

D4.2 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet current WQBELs. Section 0 provides more detail on costs of the recommended upgrades.

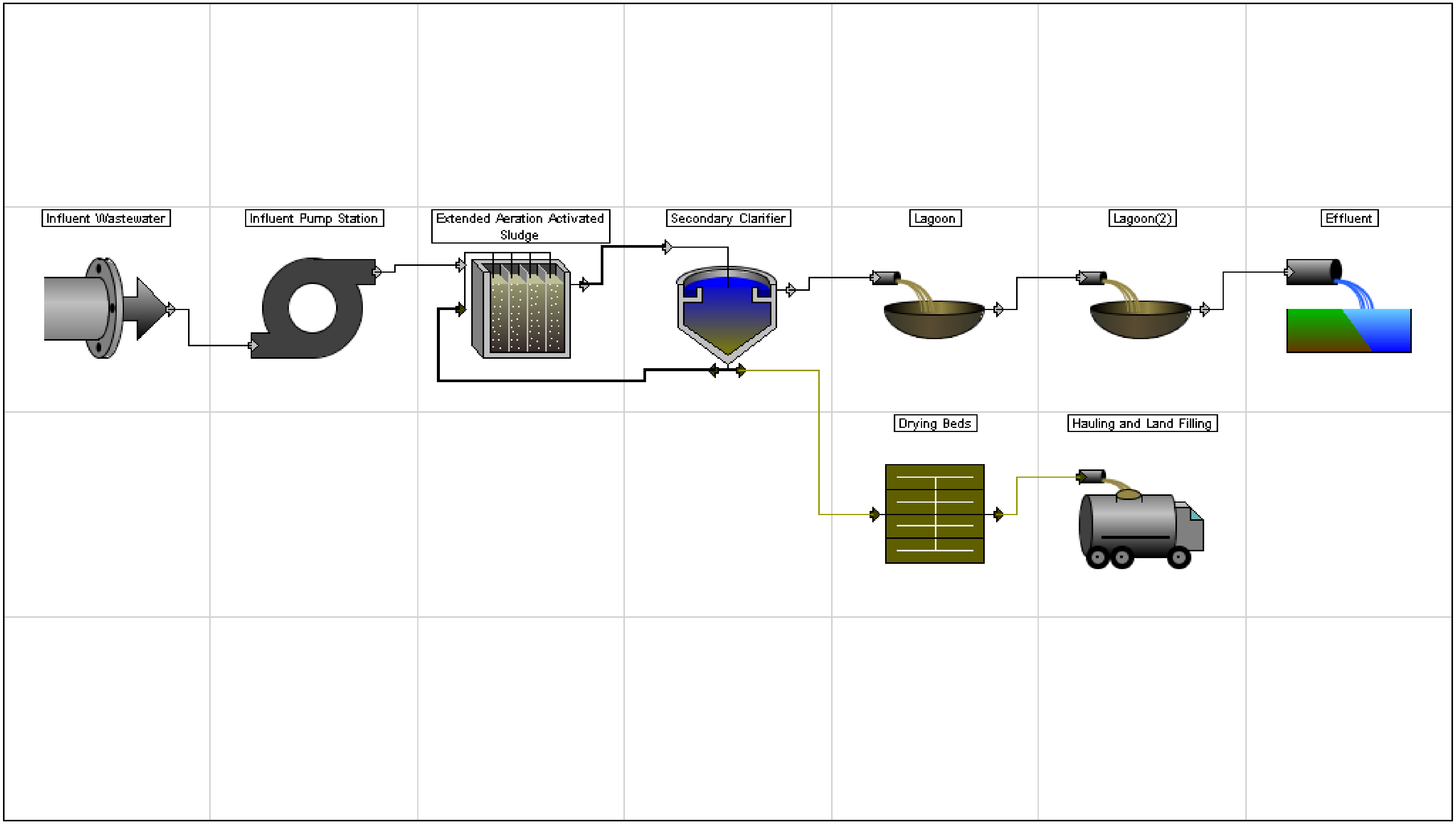

Figure D-2 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Ada

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Cost

Capital costs are shown in Table D-3. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-3, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-3 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
Extended Aeration Activated Sludge	$547,000
Secondary Clarifier	$335,000
Drying Beds	$255,000
Hauling and Land Filling	$336,000
Blower System	$274,000
Direct Costs	$975,000
Contingencies	$409,000
Construction Total	**$3,131,000**
Engineering, Legal, Admin Total	$627,000
Totals	**$3,758,000**

Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com,)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $254,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's Recommended Practice No. 17R-97: Cost Estimate Classification System. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.

- Extended aeration activated sludge costs include:
  - Concrete basins with handrail
  - Return activated sludge pumps
  - Pump building space
  - Fine-bubble diffusers
  - Air piping
- Secondary clarifier costs include:
  - Two 20-foot diameter concrete basins with handrails
  - Clarifier internal equipment
  - Effluent launder weirs
- Drying bed costs include
  - 12,000 sf earthen basin
  - Sand and gravel drainage media
  - Drainage pipe
  - Membrane liner
- Sludge Hauling costs include:
  - Vehicle cost
- Blower System costs include:
  - Air blowers required for activated sludge
  - Blower building space

The following costs are evaluated separately from unit processes:

- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space
- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-4 reflect the projected change in costs incurred from adding the activated sludge system.

Table D-4 Annual costs for improvements to meet the current WQBEL for Ada

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Extended Aeration Activated Sludge	$61,300	$25,400	$19,800	$0	$18,500	$125,000
Secondary Clarifier	$29,200	$13,500	$1,700	$0	$800	$45,200
Drying Beds	$24,000	$7,900	$1,700	$0	$0	$33,600
Hauling and Land Filling	$400	$0	$22,900	$0	$0	$23,300
Totals	**$114,900**	**$46,800**	**$46,100**	**$0**	**$19,300**	**$227,100**

Annual cost clarifications:

- Operation costs for the existing ponds are assumed to be unchanged and are not used to offset new costs.
- Power and maintenance costs for the blower system are included in the activated sludge process line items.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated by dividing the average daily flow (232,000) by the existing population, dividing by 100 (typical domestic wastewater generation rate in gallons per person per day) and multiplying by the number of residential households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $454/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate to $875/year per ERU, which is 2.4% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

Improvements proposed to meet the current WQBELS would be capable of meeting future WQBELs.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

Improvements proposed to meet the current WQBELS would be capable of meeting future WQBELs.

Memorandum

To: MMB
From: Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Albert Lea to meet Anticipated Water Quality Standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jon Minne, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet current and anticipated future water quality standards, the City of Albert Lea would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0 – Estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Albert Lea operates a WWTF which includes secondary treatment of domestic strength wastewater and land application of residual sludge.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0041092 (expired November 30, 2014)
- NPDES permit application dated May 30, 2014
- Wastewater Treatment Plant Construction Plans "Issued for Bidding", dated March 21, 1980
- Facilities Plan for Wastewater Treatment, dated December 11, 1975

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	18.38
Design Average Dry Weather Flow (mgd)	9.125
Average Flow (mgd)(1)	3.86
Year Built	1983
Watershed	Cedar River
Discharge Location	Shell Rock River (Class 2B)
Major Treatment Units	Pre-aeration tanks, primary clarifiers, activated sludge, nitrification activated sludge, tertiary filtration, UV disinfection, anaerobic sludge digestion, sludge thickening, sludge storage
Facility Class	A
Service Population(2)	17,899
Estimated Equivalent Residential Units (ERU)	16,873
Median Household Income(3)	$37,576
Typical Residential Sewer Rate(4)	$547

(1) City of Albert Lea discharge monitoring report data, January 2010 – July 2016
(2) Minnesota State Demographer 2015 estimate (source: http://www.mn.gov/admin/demography/data-by-topic/population-data/our-estimates/)
(3) 2014 American Community Survey (source www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 10, 2016. The process flow diagram developed for the model is shown in Figure D-1.

To: MMB
From: Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Albert Lea to meet Anticipated Water Quality Standards
Date: January 26, 2017
Page: 3

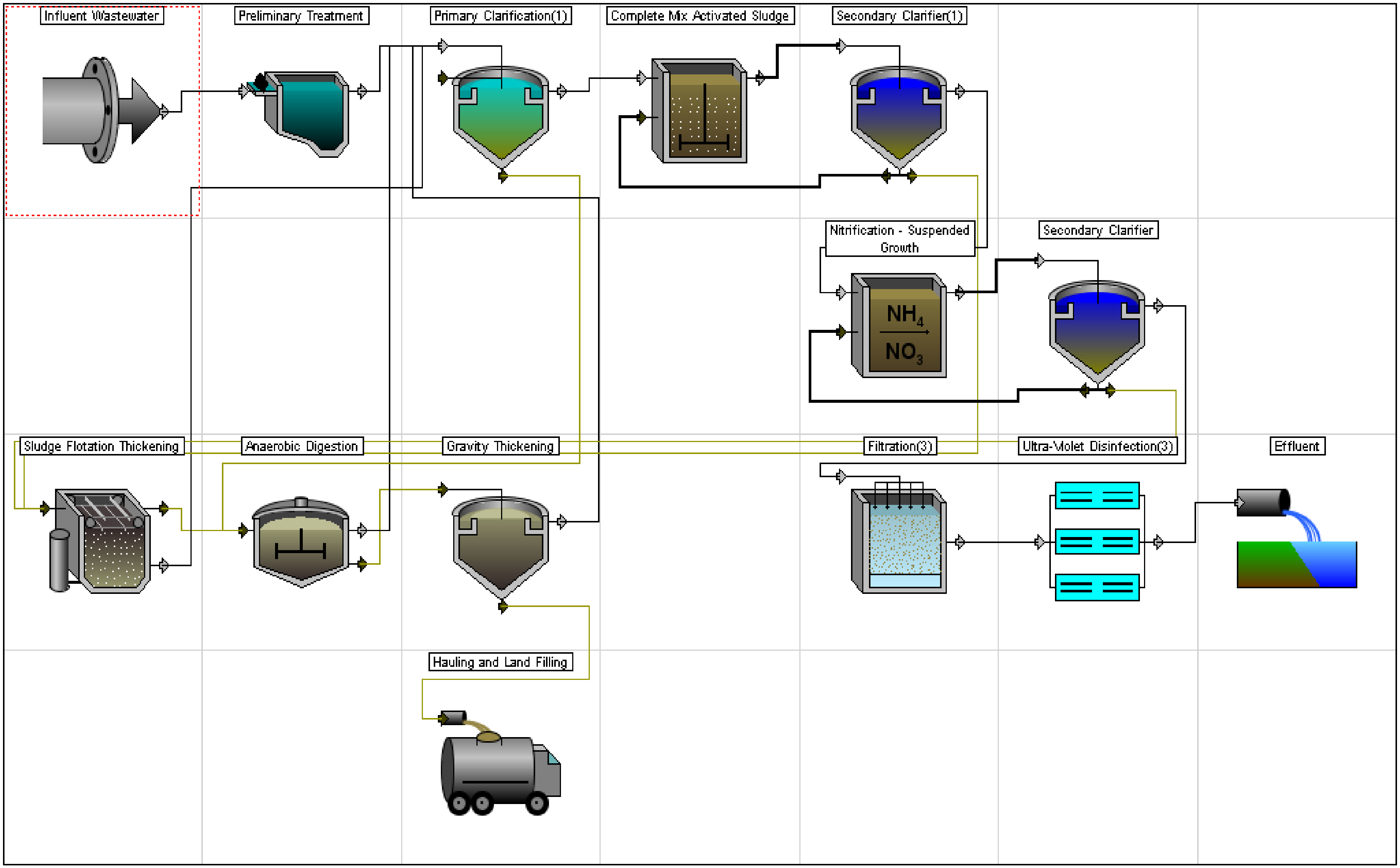

Figure D-1 Process flow diagram of existing Albert Lea WWTF

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WWTF

Actual Feature	Model Difference from Actual	Impact on Analysis
The facility includes a pre-aeration tank prior to primary treatment.	This unit is not included in the model.	None. The upgrades would keep this unit in service as it currently functions.
Filter backwash flows to the pre-aeration tank.	Filter backwash flow is tracked to preliminary treatment, but not shown in the model.	Minimal. The model assumes the filter backwash is equalized.
Digested sludge is stored onsite.	The model does not offer sludge storage as an option.	None. This is a site-specific requirement and is evaluated independently of the model.

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-3 Summary of Existing and Estimated Effluent Limits: Albert Lea WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Dec-Mar	0.05-0.42	7.0	14.0 MDL 7.8 AML	4.7 MDL 2.6 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Apr-May Oct-Nov	0.1-0.23	3.0	0.48 MDL 0.33 AML	0.47 MDL 0.32 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jun-Sep	0.07-0.24	1.0	0.25 MDL 0.17 AML	0.25 MDL 0.17 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	110-446	monitor	217	No change
Chloride (mg/L)	Daily Max	Jan-Dec	110-446	monitor	308	No change
Nitrate (mg/L as N)	Cal Mo Avg	Apr, Sep	4.4-25.5	monitor	NA	8.3 MDL 4.0 AML
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	44.7-112	monitor	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	2.84-11.4	monitor	1.74	No change
Total Phosphorus (kg/day)	Cal Mo Avg	Jan-Dec	55.0-157.1	monitor	29.7	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	0.48-3.00	30	No change	No change

Cal Mo Avg—calendar month average
MDL—maximum daily limit
AML—average monthly limit
NA—not applicable
(1) From data reported on monthly discharge monitoring reports January 2010 through July 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The exceedance of the future WQBEL for ammonia noted above occurred on two consecutive months in 2014. Excluding that period, the ammonia in Jun-Sep has not exceeded 0.17 mg/L. No additional treatment is required to meet the current or future WQBEL. Winter, spring, and fall ammonia concentrations have been consistently been lower than the future WQBEL for the past 6 years of monitoring.

The current and future WQBELs for chloride would require additional treatment. The facility has never reported a monthly average effluent chloride concentration below the WQBEL value.

The future WQBEL for nitrate would require additional treatment.

The current and future WQBELs for total phosphorus would require additional treatment. The effluent is consistently above the annual mass loading future WQBEL. The existing concentration is also consistently above the current WQBEL concentration limit. At the design average wet weather flow, the current WQBEL mass limit would limit the concentration to an effective concentration limit of 0.44 mg/L.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Limits

Treatment for phosphorus to meet the current WQBEL would require ferric chloride addition prior to the existing secondary clarifier and tertiary filtration at the highest flows. The tertiary filter could likely be eliminated if the monthly flow is less than 15.6 mgd. This is less than the facility's AWW; however, the maximum monthly flow recorded in the past 6 years was 7.16 mgd. For this reason, tertiary filtration is not included in this analysis for phosphorus removal.

Additional equipment required would include the following:

- Chemical metering pumps
- Chemical storage tank
- Secondary containment
- Building enclosure
- Truck access

The facility is capable of meeting the current ammonia WQBEL without modification.

D4.2 Upgrades to Meet the Chloride Limit

D4.2.1 Chloride

The 6-year average chloride concentration is more than forty percent greater than the estimated current WQBEL. More than 90% of effluent chloride samples are greater than the current WQBEL. Additional treatment for chloride would be required.

Figure D-2 shows the relationship between flow and chloride concentration. As flow increases, the chloride concentration decreases. This would allow a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates.

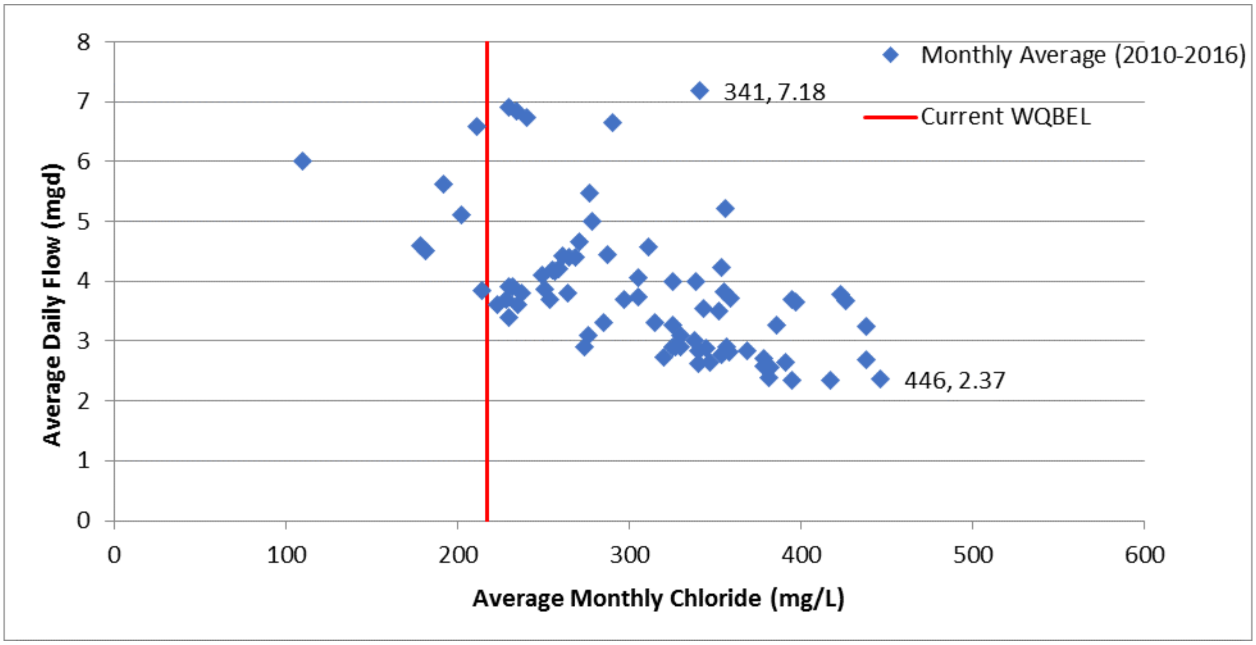

Figure D-2 Effluent Flow and Chloride Concentration Relationship, Albert Lea

Chloride can be removed using reverse osmosis (RO) filtration. Water reaching the RO system would require pretreatment to remove solids with a deep-bed, granular-media filter, or an ultrafilter.

Assuming 99% removal of chloride, a reverse osmosis system can be sized to treat a portion of the flow adequate to bring the blended flow below the monthly average requirement of 217 mg/L.

The extreme conditions recorded in the past 6 years include a high chloride concentration of 446 mg/L at a flow of 2.37 mgd and a chloride concentration of 341 mg/L at a high flow of 7.18 mgd.

At the low flow, high concentration condition, the RO system would be required to treat 52% of the flow, or 854 gpm.

At the high flow, low concentration condition, the RO system would be required to treat 37% of the flow, or 1,831 gpm.

D4.2.1 Chloride Treatment System

RO treatment produces a significant brine waste stream. The most viable method of disposal for wastewater treatment in Minnesota is evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required for RO treatment:

- The high chloride mass observed in the past 6 years is the design criteria.

- The RO would generate 25% of its feed flow as brine
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent without further treatment.

RO treatment of a side stream from the secondary effluent to meet the current WQBEL for chloride would require the following new treatment units:

- Deep bed granular filtration of the RO influent
- RO system capable of treating 1,831 gpm
- Evaporator/Crystallizer capable of treating 458 gpm at AWW
- Salt storage (7,200 cf required for weekly disposal)
- Truck access

Because a new filtration system would be required to pretreat the RO influent, and the existing tertiary filter would not be required to meet the current phosphorus WQBEL, it is assumed that the existing tertiary filter will be abandoned.

D4.3 Summary of Proposed Upgrades to Meet Current Standards

Figure D-3 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades.

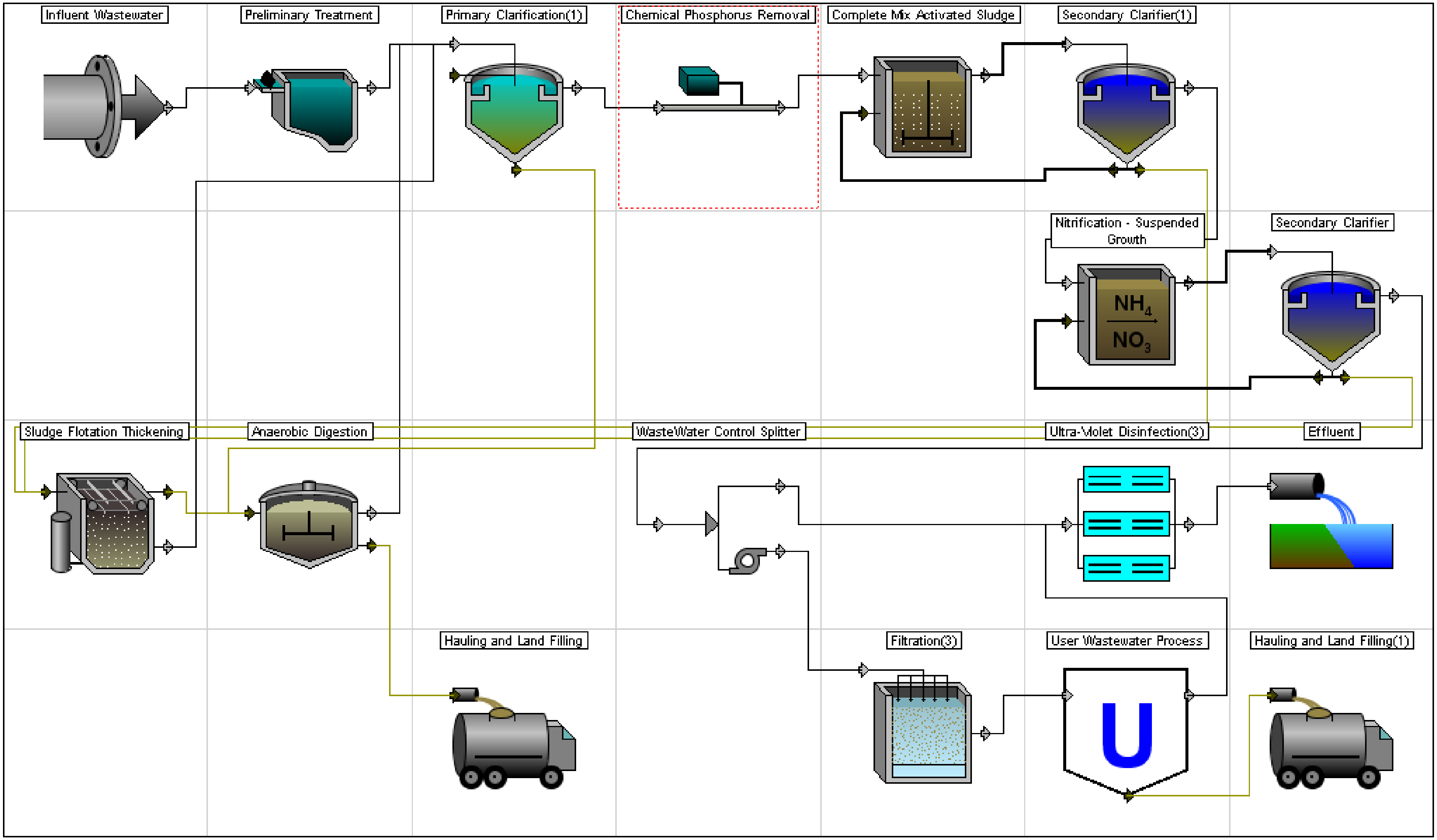

Figure D-3 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Albert Lea

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
WasteWater Control Splitter	$129,000
Filtration(3)	$2,958,000
RO Filtration	$4,954,000
Evaporator/Crystallizer	$30,791,000
Hauling and Land Filling(1)	$591,000
Iron Feed System	$324,000
Direct Costs	$4,983,000
Contingencies	$6,710,000
Construction Total	**$51,440,000**
Engineering, Legal, Admin	$10,288,000
Totals	**$61,728,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $4,167,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Wastewater Control Splitter costs include:
    - Concrete splitter box
    - Duplex pumping for RO side stream
    - Gravity flow to existing chlorine contact tank
- Filtration(3) costs include:
    - Deep-bed, dual media gravity filtration
    - Concrete basins with handrail
    - Automatic valves
    - Backwash tank and pumps
- RO Filtration costs include:
    - Booster pumps
    - Process piping and valves
    - RO membrane skids with 8" membrane modules
    - Clean-in-place equipment
    - Process equipment building space
- Evaporator/Crystallizer costs include:
    - Booster pumps
    - Process piping and valves
    - Evaporator
    - Crystallizer
    - Process equipment building space
- Hauling and Land Filling(1) costs include:
    - Salt storage shed
    - Loading equipment
    - Truck access
- Iron Feed System costs include:

- Chemical storage
- Chemical metering pumps
- Secondary containment
- Truck access

- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from adding RO treatment of the side stream.

Table D-5 Annual costs for improvements to meet the current WQBEL for Albert Lea

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Chemical Phosphorus Removal	$0	$0	$0	$962,000	$0	$962,000
Complete Mix Activated Sludge	$0	$0	$10,700	$0	$0	$10,700
Nitrification - Suspended Growth	$0	$0	$20,000	$0	$0	$20,000
Secondary Clarifier	$3,100	$2,300	$200	$0	$0	$5,600
WasteWater Control Splitter	$24,500	$17,200	$800	$0	$6,200	$48,700
Filtration(3)	$5,900	$3,400	$23,300	$0	$1,500	$34,100
Ultra-Violet Disinfection(3)	$0	$1,600	$1,200	$500	$3,500	$6,800
RO Filtration	$37,600	$14,200	$15,900	$206,700	$65,400	$339,800
Evaporator/Crystallizer	$150,400	$13,500	$53,800	$94,400	$1,885,400	$2,197,500
Hauling and Land Filling(1)	$9,100	$0	$401,000	$0	$0	$410,100
Sludge Flotation Thickening	$104,000	$15,000	$10,000	$3,000	$34,000	$166,000
Anaerobic Digestion	$9,000	$4,700	$0	$0	$1,600	$15,300
Hauling and Land Filling	$52,000	$0	$0	$0	$0	$52,000
Iron Feed System	$105,000	$0	$5,300	$0	$0	$110,300
Totals	**$500,600**	**$71,790**	**$542,200**	**$1,266,600**	**$1,997,600**	**$4,378,900**

Annual cost clarifications:

- Some existing unit processes would incur additional costs due to additional solids from the chemical phosphorus removal process.
- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- Wastewater control splitter includes the cost of pumping to the new filtration train.
- RO filtration and evaporator/crystallizer would include costs for additional staffing, process testing, membrane replacement, cleaning chemicals, and energy.
- Hauling and land filling(1) would include the cost of hauling salt waste to a landfill. The salt waste is assumed to be non-hazardous.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1 was estimated using typical flows.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $507/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate more than two times to $1,054/year per ERU, which is 2.8% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Requirements

The existing activated sludge process should be capable of meeting the ammonia future WQBELs, but does not have the capacity to remove nitrate to the future WQBELs, so the secondary treatment system would need to be modified to include denitrification.

An activated sludge system capable of meeting the nitrate WQBEL would include the following:

- 5-stage biological nutrient removal activated sludge process
    - New mixed anaerobic tank
    - 2 new mixed anoxic tanks
    - Reuse existing aeration tanks
    - Reuse existing aeration diffusers
    - Reuse existing blower system
    - Reuse existing return activated sludge pumps and pipes
    - New recirculation pumps
    - Reuse existing waste sludge pumps
    - Existing secondary clarifiers can be reused
- Sludge processing
    - Additional sludge hauling facilities are required

The existing facility is capable of meeting the phosphorus limits with the addition of chemical phosphorus removal; however, there would be a reduction in chemical use if the new activated sludge system is designed to incorporate biological nutrient removal (BNR) and supplemented with chemical phosphorus removal. This estimate assumes that in addition to nitrate, the activated sludge system would remove phosphorus to less than 1 mg/L. Chemical addition for removal of phosphorus would continue, but at a lower chemical usage applied primarily to recycle streams high in phosphorus. Tertiary filtration is not required to meet the future WQBEL phosphorus limit.

D6.2 Upgrades to Meet Chloride Requirements

Improvements detailed in the previous sections for chloride removal to meet current standards would also be used to meet future standards.

D6.3 Summary of Proposed Upgrades to Meet Future Standards

Figure D-4 shows the CapDetWorks^{TM} process flow diagram for the WWTF upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

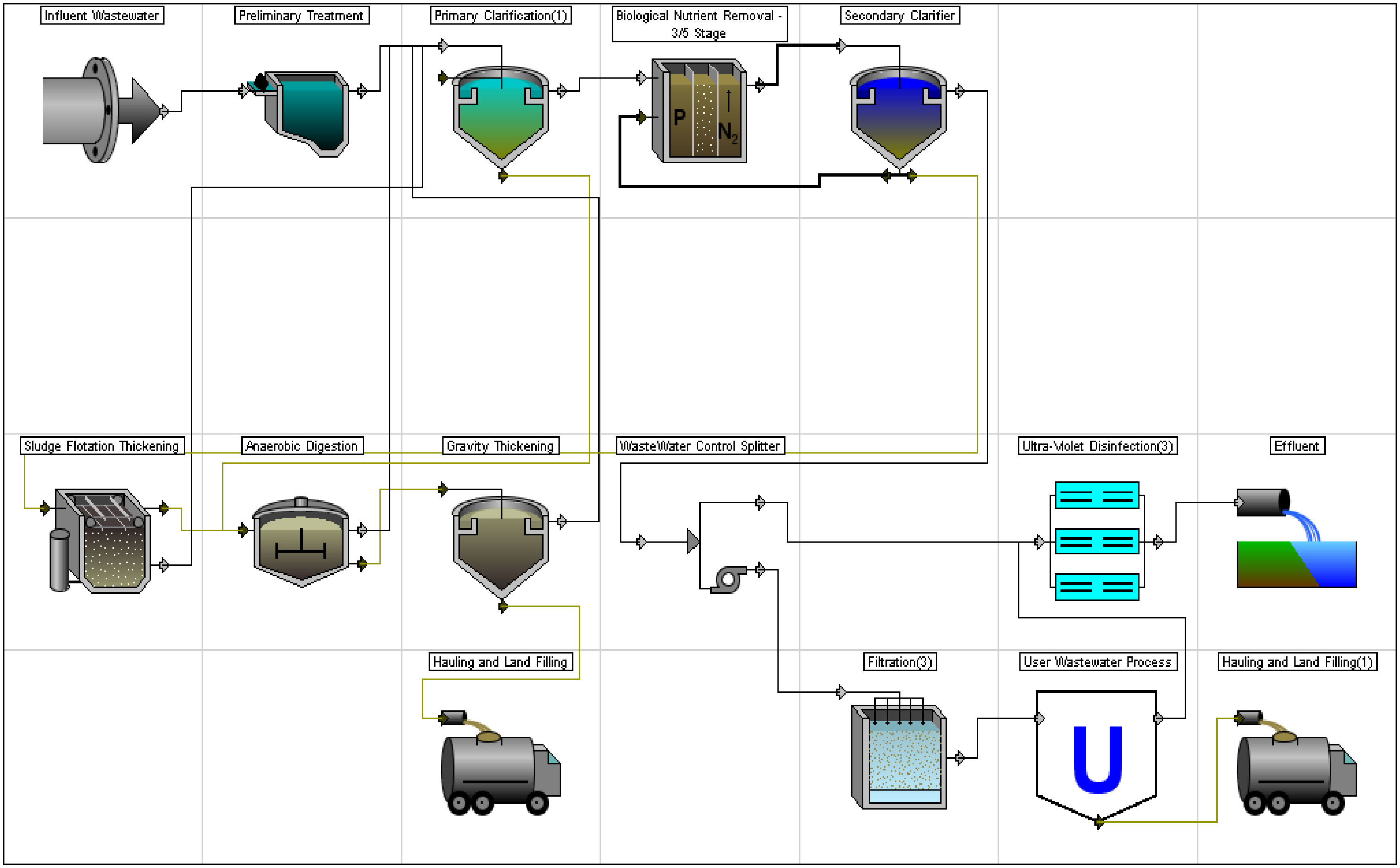

Figure D-4 **Process flow diagram of potential WWTF upgrades to meet future WQBELs for Albert Lea**

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-6. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-6, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-6 Capital Costs for Improvements to Meet Future WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3/5 Stage	$8,028,000
WasteWater Control Splitter	$129,000
Filtration(3)	$2,958,000
RO Filtration	$4,954,000
Evaporator/Crystallizer	$30,791,000
Hauling and Land Filling(1)	$591,000
Iron Feed System	$324,000
Direct Costs	$4,778,000
Contingencies	$7,883,000
Construction Total	**$60,436,000**
Engineering, Legal, Admin	$12,088,000
Totals	**$72,524,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $4,896,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes required to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the potential new WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Biological Nutrient Removal costs include:
    - 5-stage Bardenpho activate sludge process
    - Concrete anaerobic basin with handrail
    - Two concrete anoxic basins per train with handrail
    - Recirculation pumps
    - Pump building
    - Fine-bubble diffusers
    - Anaerobic basin mixers
    - Anoxic basin mixers
    - Air piping
    - Reuse of existing concrete aeration basins
    - Reuse of secondary clarifiers
    - Reuse of return activated sludge pumps
- Other costs are described in Section D5.1

D7.2 Annual Costs

Annual costs shown in Table D-7 reflect the projected change in costs incurred from changing the secondary treatment process and adding membrane filtration.

Table D-7 Annual costs for improvements to meet the future WQBEL for Albert Lea

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Chemical Phosphorus Removal	$0	$0	$0	$460,000	$0	$460,000
Biological Nutrient Removal - 3/5 Stage	$137,000	$77,800	$126,600	$0	$253,000	$594,400
WasteWater Control Splitter	$24,500	$17,100	$800	$0	$6,200	$48,600
Filtration(3)	$5,900	$3,400	$23,300	$0	$1,500	$34,100
Ultra-Violet Disinfection(3)	$0	$9,400	$6,600	$2,800	$21,400	$40,200
RO Filtration	$37,600	$14,200	$15,900	$206,700	$65,400	$339,800
Evaporator/Crystallizer	$150,400	$13,500	$53,800	$94,400	$1,885,400	$2,197,500
Hauling and Land Filling(1)	$9,100	$0	$401,000	$0	$0	$410,100
Iron Feed System	$0	$0	$5,300	$0	$0	$5,300
Totals	**$364,500**	**$135,400**	**$633,300**	**$763,900**	**$2,232,900**	**$4,130,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source www.enr.com, dated July 2014)

Annual cost clarifications:

- The BNR system annual costs would be partially offset by existing annual costs associated with the activated sludge process. The BNR process would have increased costs for operation and maintenance due to a more complex process flow.
- Power costs for the blower system are included in the BNR process line item.
- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item. Note that chemical costs would be less than chemical costs for phosphorus removal without BNR.

D7.3 User Costs

User costs were evaluated as described in Section D5.3.

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $535/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by more than two times to $1,082/year per ERU, which is 2.9% of the median household income.

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Memorandum

To: MMB
From: Katie Wolohan, Jeff Ubl, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Austin to meet current and future water quality standards
Date: January 27, 2016
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jon Minne, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Austin would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0– Estimated effluent limits under current and future water quality standards
Section D4.0– Proposed upgrades to meet current standards
Section D5.0– Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Austin operates a WWTF which includes two separate facilities (one industrial and one municipal). The industrial facility consists of a lift station, two equalization/primary anaerobic digesters, two secondary anaerobic digesters, a degasification tank, four settling tanks, and six concrete biosolids storage tanks. The municipal facility is a typical trickling filter treatment system. The system consists of an equalization tank, a grit tank, three primary clarifiers, four high-rate trickling filters, and two circular intermediate clarifiers. The two facilities share a nitrification trickling filter pump station, a six cell nitrification trickling filter, a splitter box, four final clarifiers, a chlorine contact tank and four decommissioned storage lagoons.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0022683 (expired June 30, 2015)
- NPDES permit application dated December 24, 2014
- Sewage Treatment Project Drawings, dated November, 1938
- Sewage Treatment Plant Drawings, dated March 1958
- Facility Plan for Austin, Minnesota Wastewater Treatment Plants, dated September 1997

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	8.475 (combined facilities) 6.375 (municipal facility only)
Design Average Dry Weather Flow (mgd)	6.35
Average Flow (mgd)(1)	5.46
Year Built	1939
Watershed	Cedar River
Discharge Location	Cedar River (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Flow equalization, anaerobic digesters, nitrification trickling filter, chlorine contact tank, final clarifiers
Facility Class	A
Service Population(2)	25,111
Estimated Equivalent Residential Units (ERU)	14,840
Median Household Income(3)	$39,890
Typical Residential Sewer Rate(4)	$393/year

(1) City of Austin discharge monitoring report data, August 2010 – June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 21, 2016. The process flow diagram developed for the model is shown in Figure D-1.

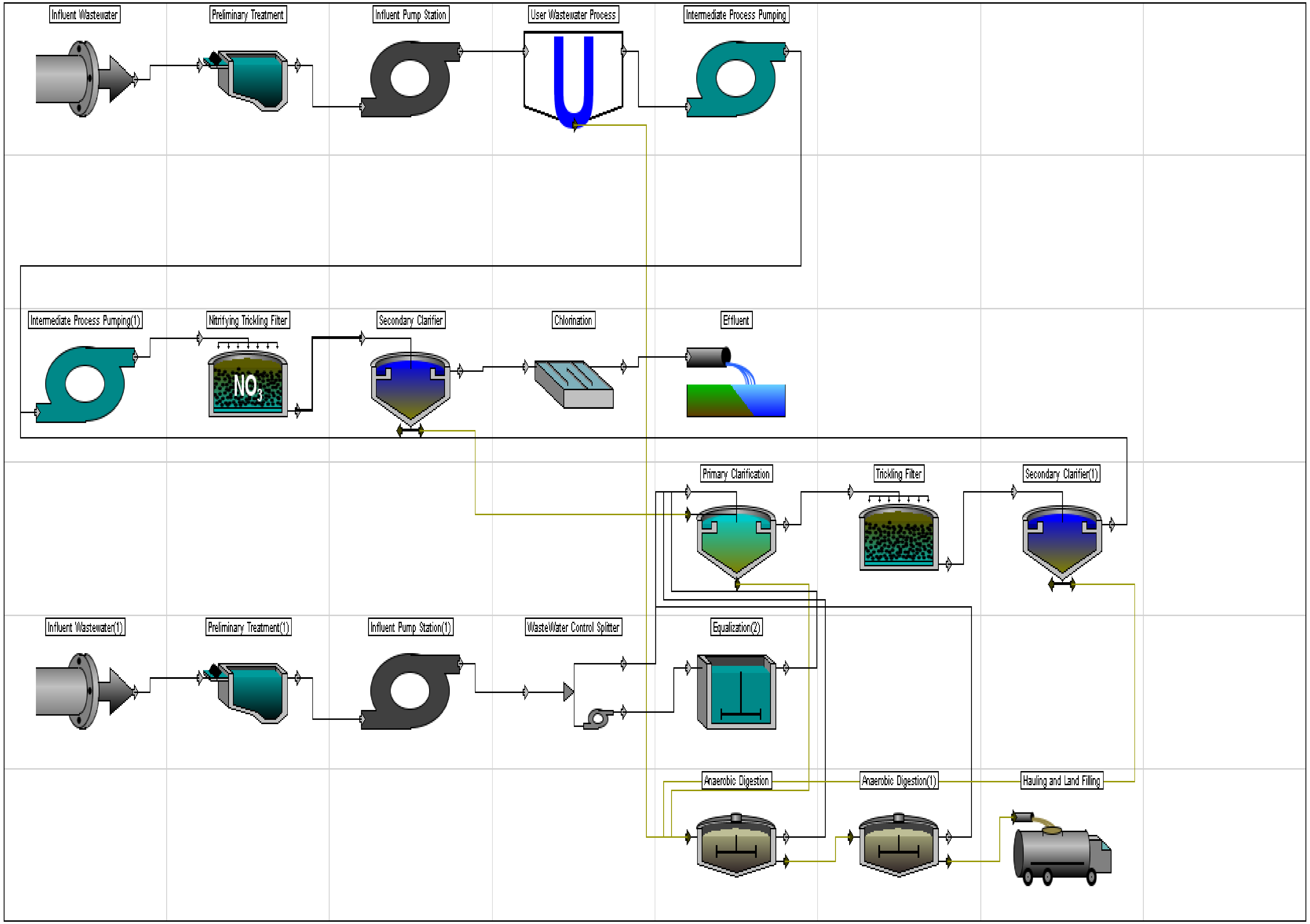

Figure D-1 **Process flow diagram of existing Austin WWTF**

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WWTF

Actual Feature	Model Difference from Actual	Impact on Analysis
Industrial wastewater treatment train.	Modeled as a user process rather than individual processes. CapDetWorks™ does not include anaerobic treatment of industrial strength waste. Manually entered inputs and outputs are based on recorded data.	No upgrades are considered for the industrial train in this analysis.

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-3 Summary of Existing and Estimated Effluent Limits: Austin WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Nov-Mar	1.8-18.0	41 (Dec-Mar)	12.9 MDL 5.9 AML	6.8 MDL 3.1 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Apr-Oct	1.1-10.2	7.8 (Jun-Sep)	3.3 MDL 1.6 AML	3.1 MDL 1.5 AML
Total Chloride (mg/L)	Cal Mo Max	Jan-Dec	282-670	monitor	455 MDL 355 AML	455 MDL 355 AML
Nitrate (mg/L as N)	NA	Jan-Dec	NA	NA	NA	6.7 MDL 5.0 AML
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	2.8-10.8	monitor	NA	NA
Total Phosphorus (kg/day)	Cal Mo Avg	Jun-Sep	87-226	monitor	8.9 AML	No change
Total Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	25-55	monitor	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	9.0-45	30	No change	No change

Cal Mo Avg—calendar month average
Cal Mo Max—calendar month maximum
MDL—maximum daily limit
AML—average monthly limit
(1) From data reported on monthly discharge monitoring reports August 2010 through June 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

Over the past two years, the average ammonia concentration from November to March is 4.2 mg/L and 2.4 mg/L from April to October. Additional treatment is not required to meet the current WQBELs for ammonia but is required to meet future WQBELs.

The future WQBEL for nitrate would require additional treatment.

The current WQBEL for total phosphorus would require additional treatment. The effluent is consistently well over the daily mass loading current WQBEL. At the design AWW, the effective phosphorus concentration limit is 0.28 mg/L.

The current and future WQBELs for chloride would require additional treatment. Over the last 5 years the WWTF has rarely (five occasions) reported an effluent monthly maximum chloride concentration below the current and future average monthly maximum WQBEL of 355 mg/L.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Limits

Treatment for phosphorus the meet the current WQBEL would require ferric chloride addition after the existing secondary clarifier, following the nitrifying trickling filters, and ahead of proposed tertiary filtration.

Additional equipment required would include the following:

- Chemical metering pumps
- Chemical storage tank
- Secondary containment
- Building enclosure
- Truck access

The facility is capable of meeting the existing ammonia WQBEL without modification.

D4.2 Upgrades to Meet Chloride Limit

D4.2.1 Chloride

The 5-year average chloride concentration is 495 mg/L, which is higher than calculated current WQBEL of 355 mg/L (average monthly limit). To meet the current WQBEL, additional treatment would be required.

Figure D-1 shows the relationship between flow and chloride concentration. As flow increases, the chloride concentration decreases. This would allow a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates.

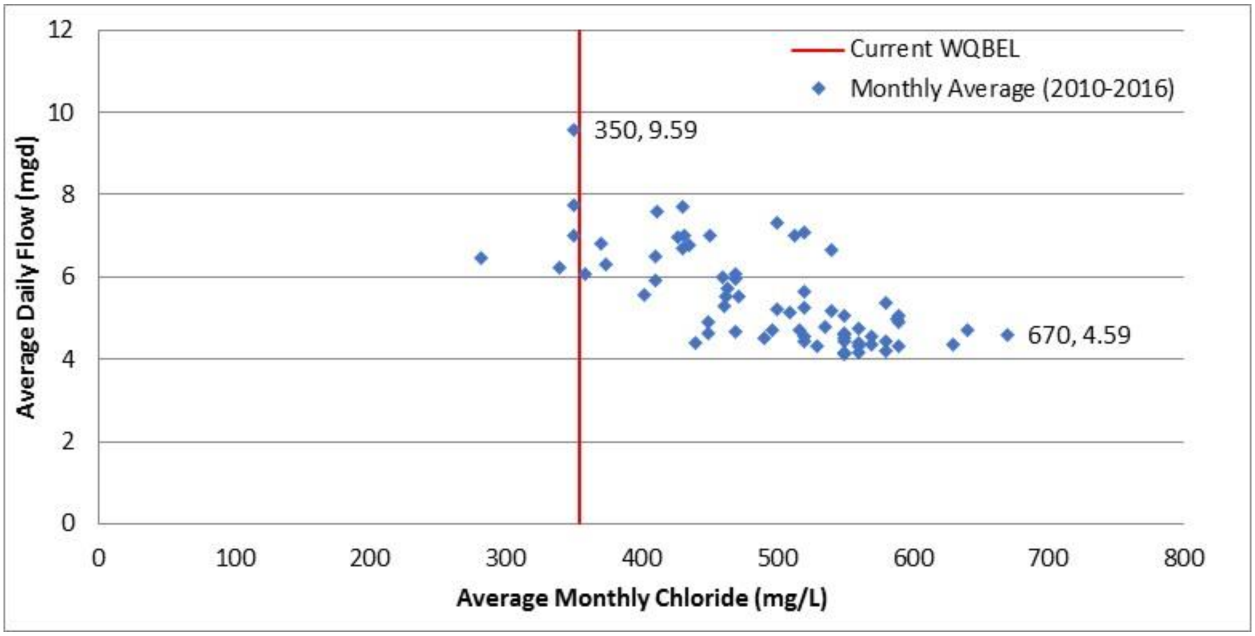

Figure D-1 Effluent Flow and Chloride Concentration Relationship, Austin

Chloride can be removed using reverse osmosis (RO) filtration. Water reaching the RO system would require pretreatment to remove solids with a deep-bed, granular-media filter, or an ultrafilter.

Assuming 99% removal of chloride, a reverse osmosis system can be sized to treat a portion of the flow adequate to bring the blended flow below the monthly average requirement of 355 mg/L.

The extreme conditions recorded in the past 6 years include a high chloride concentration of 670 mg/L at a flow of 4.59 mgd and a chloride concentration of 350 mg/L at a high flow of 9.59 mgd.

At the low flow, high concentration condition, the RO system would be required to treat 47% of the flow, or 1,517 gpm.

No RO treatment would likely be required at the high flow, low concentration condition.

D4.2.2 Treatment System

RO treatment produces a significant brine waste stream. The most viable method of disposal would be evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required for RO treatment:

- The AWW would have the same chloride concentrations as the high flow, low concentration condition observed in the past (this is a conservative assumption as the concentrations would likely be lower).
- The RO would generate 25% of its feed flow as brine
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent without further treatment.

RO treatment of a side stream from the secondary effluent to meet the current WQBEL for chloride would require the following new treatment units:

- Deep bed granular filtration of the RO influent
- RO system capable of treating 1,517 gpm at AWW
- Evaporator/Crystallizer capable of treating 379 gpm at AWW
- Salt storage (6,000 cf required for weekly disposal)
- Truck access

D4.3 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades.

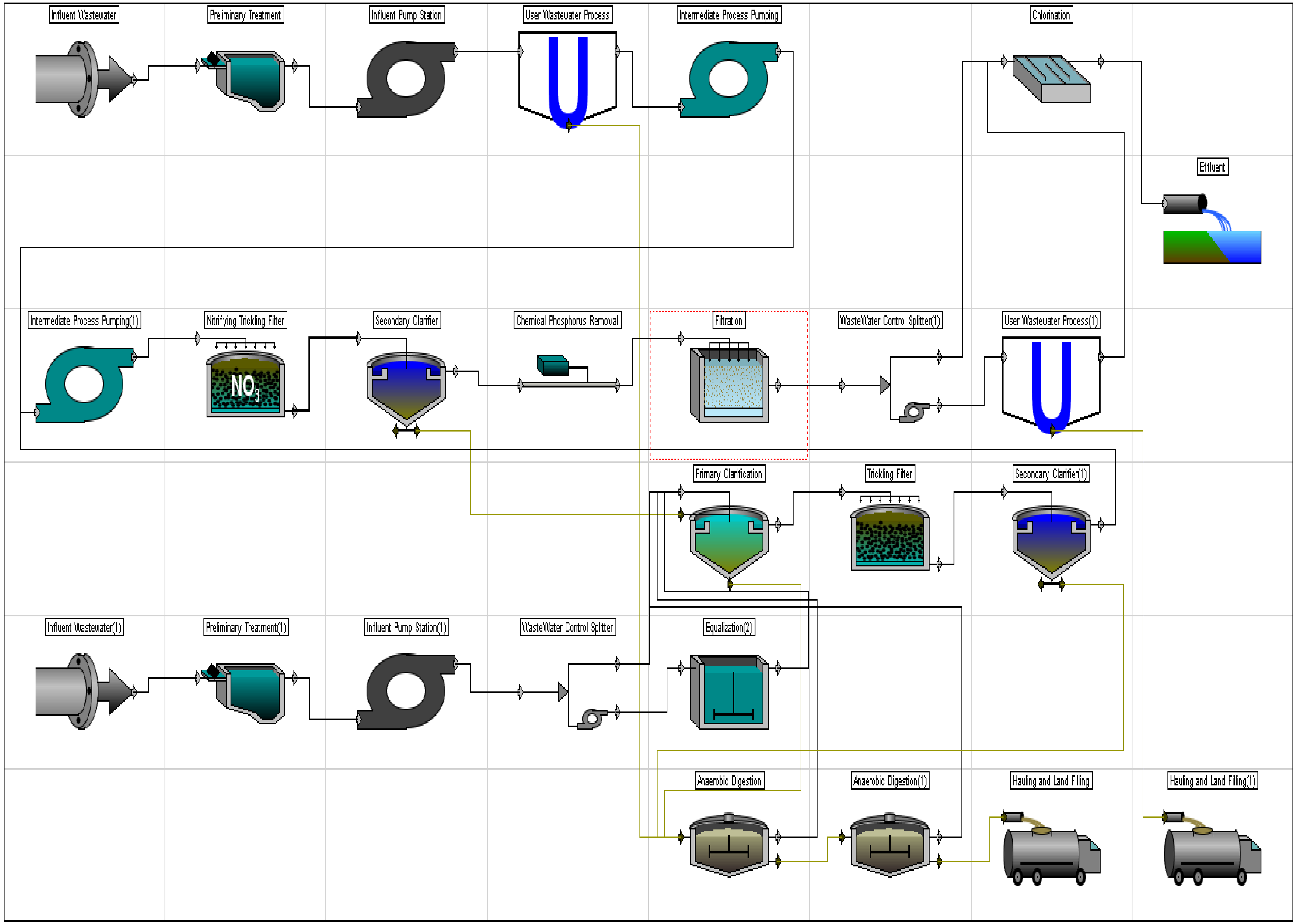

Figure D-2 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Austin

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
Filtration	$2,705,000
WasteWater Control Splitter(1)	$158,000
RO	$4,606,000
Evaporator Crystallizer	$28,254,000
Hauling and Land Filling(1)	$488,000
Lime Feed System	$116,000
Iron Feed System	$323,000
Direct Costs	$7,735,000
Contingencies	$6,658,000
Construction	**$51,043,000**
Engineering, Legal, Admin	$10,209,000
Totals	**$61,252,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $4,135,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Wastewater Control Splitter(1) costs include:
  - Concrete splitter box
  - Duplex pumping for RO side stream
  - Gravity flow to existing chlorine contact tank
- Filtration costs include:
  - Deep-bed, dual media gravity filtration
  - Concrete basins with handrail
  - Automatic valves
  - Backwash tank and pumps
- RO Filtration costs include:
  - Booster pumps
  - Process piping and valves
  - Two 20 x 10 array RO membrane skids with 8" membrane modules
  - Clean-in-place equipment
  - Process equipment building space
- Evaporator/Crystallizer costs include:
  - Water feed system
  - Condenser
  - Crystallizer (evaporator not required)
  - Process equipment building space
- Hauling and Land Filling(1) costs include:
  - Salt storage shed
  - Loading equipment
  - Truck access
- Other Direct Costs include:
  - Mobilization

- Site preparation
- Site electrical
- Yard piping
- Instrumentation and control
- Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from adding RO treatment of the side stream.

Table D-5 Annual costs for improvements to meet the current WQBEL for Austin

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Chemical Phosphorus Removal	$0	$0	$0	$4,000	$0	$4,000
Filtration	$11,000	$6,000	$41,000	$0	$4,000	$62,000
WasteWater Control Splitter(1)	$26,000	$19,000	$1,000	$0	$11,000	$57,000
RO	$37,600	$18,900	$21,200	$275,600	$87,300	$440,600
Evaporator Crystallizer	$150,400	$16,000	$64,000	$125,900	$2,514,300	$2,870,600
Hauling and Land Filling(1)	$12,100	$0	$535,500	$0	$0	$547,600
Lime Feed System	$87,000	$0	$2,000	$0	$0	$89,000
Iron Feed System	$31,000	$0	$4,000	$0	$0	$35,000
Totals	**$355,100**	**$59,900**	**$668,700**	**$405,500**	**$2,616,600**	**$4,105,800**

Annual cost clarifications:

- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- Land application of sludge would increase due to additional solids from the chemical phosphorus removal process.
- Wastewater control splitter(1) includes the cost of pumping to the new filtration train.

- RO filtration and evaporator/crystallizer would include costs for additional staffing, process testing, membrane replacement, cleaning chemicals, and energy.
- Hauling and land filling(1) would include the cost of hauling salt waste to a landfill. The salt waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1 , was estimated based on population, average annual influent flow to the WWTF, approximate water use per person per day, and the number of households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $569/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by more than two times to $962/year per ERU, which is 2.4% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Requirements

The existing trickling filters do not have the capacity to meet future ammonia or nitrate WQBELs, so the trickling filter systems would need to be replaced.

An activated sludge system capable of meeting the ammonia and nitrate WQBELs would include the following:

- 5-stage biological nutrient removal activated sludge process
    - New mixed anaerobic tank
    - 2 new mixed anoxic tanks
    - 2 new aeration tanks
    - New aeration diffusers

  - Reuse existing blower system
  - Reuse existing return activated sludge pumps and pipes
  - New recirculation pumps
  - Reuse existing waste sludge pumps
  - Existing secondary clarifiers can be reused

- Sludge processing
  - Additional sludge hauling facilities are required

If the new activated sludge system is designed to incorporate biological nutrient removal (BNR), the facility could potentially meet the phosphorus limits without additional chemical phosphorus removal. This estimate assumes that in addition to nitrate, the activated sludge system would remove phosphorus to less than 1 mg/L. Chemical addition for removal of phosphorus would potentially continue, but at a lower chemical usage applied primarily to recycle streams high in phosphorus. The chemical phosphorus removal system would be moved to the digester supernatant return to tie up phosphorus released during aerobic digestion. Tertiary filtration is required to meet the future WQBEL phosphorus limit.

D6.2 Upgrades to Meet Chloride Requirements

Improvements detailed in the previous sections for chloride removal to meet current standards would also be used to meet future standards.

D6.3 Summary of Proposed Upgrades

Figure D-3 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

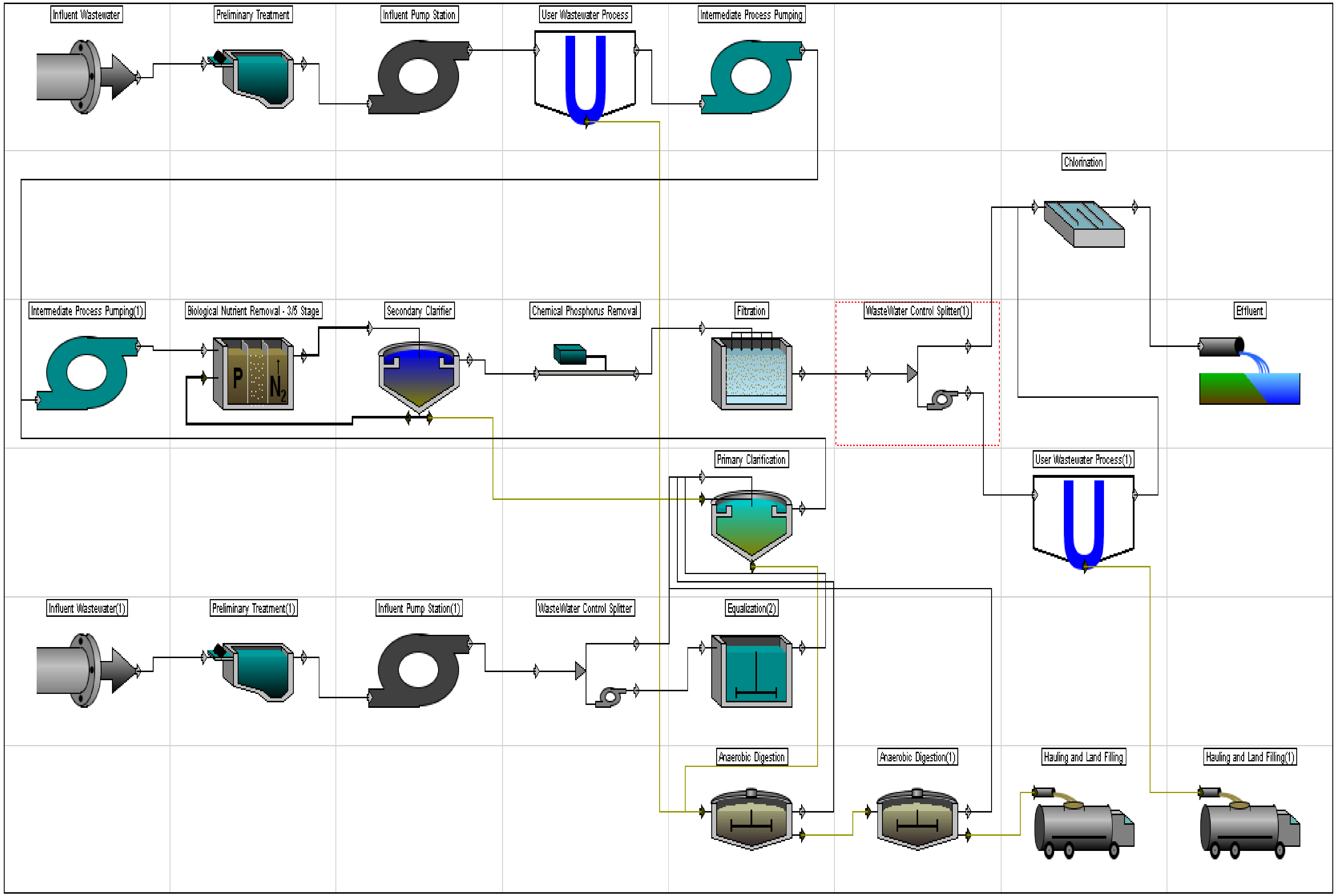

Figure D-3 Process flow diagram of potential WWTF upgrades to meet future WQBELs for Austin

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-6. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-7, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-6 Capital Costs for Improvements to Meet Future WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3/5 Stage	$10,431,000
Filtration	$2,705,000
WasteWater Control Splitter(1)	$158,000
RO	$4,606,000
Evaporator Crystallizer	$28,254,000
Hauling and Land Filling	$613,000
Hauling and Land Filling(1)	$488,000
Blower System	$801,000
Iron Feed System	$323,000
Direct Costs	$7,735,000
Indirect Costs	
Contingencies	$8,418,000
Construction	$64,532,000
Engineering, Legal, Admin	$12,907,000
Totals	**$77,439,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $5,228,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes required to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the potential new WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Biological Nutrient Removal costs include:
    - 5-stage Bardenpho activate sludge process
    - Concrete basins with handrail
    - One anaerobic basin per train
    - Two anoxic basins per train
    - Two aeration basins per train
    - Return activated sludge pumps
    - Recirculation pumps
    - Pump building
    - Fine-bubble diffusers
    - Anaerobic basin mixers
    - Anoxic basin mixers
    - Air piping
- All other costs would be similar to Section D5.1.

D7.2 Annual Costs

Annual costs shown in Table D-7 reflect the projected change in costs incurred from changing the secondary treatment process and adding anaerobic digestion.

Table D-7 Annual costs for improvements to meet the future WQBEL for Austin

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Intermediate Process Pumping(1)	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Biological Nutrient Removal - 3/5 Stage	$1,036,000	$1,036,000	$1,036,000	$1,036,000	$1,036,000	$1,036,000
Secondary Clarifier	$31,000	$31,000	$31,000	$31,000	$31,000	$31,000
Chemical Phosphorus Removal	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000
Filtration	$62,000	$62,000	$62,000	$62,000	$62,000	$62,000
WasteWater Control Splitter(1)	$57,000	$57,000	$57,000	$57,000	$57,000	$57,000
RO	$440,600	$440,600	$440,600	$440,600	$440,600	$440,600
Evaporator Crystallizer	$2,870,600	$2,870,600	$2,870,600	$2,870,600	$2,870,600	$2,870,600
Hauling and Land Filling(1)	$547,600	$547,600	$547,600	$547,600	$547,600	$547,600
Preliminary Treatment(1)	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Influent Pump Station(1)	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Primary Clarification	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Equalization(2)	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Anaerobic Digestion	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000
Anaerobic Digestion(1)	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000
Hauling and Land Filling	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000
Iron Feed System	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000
Totals	**$594,100**	**$239,900**	**$855,700**	**$412,500**	**$3,052,600**	**$5,154,800**

Annual cost clarifications:

- The BNR system annual costs would be partially offset by existing annual costs associated with the trickling filters. The BNR process would have increased costs for operation and maintenance due to a more complex process flow.
- Land application of sludge would increase because the BNR process would generate more waste sludge than the trickling filters.
- The secondary clarifier is an existing process, but would require more operation and maintenance time due to its use for returning activated sludge to the aeration basin.
- Power costs for the blower system are included in the BNR process line item.
- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item. Note that chemical costs would be less than chemical costs for phosphorus removal without BNR.

- Other costs are described in Section D5.2.

D7.3 User Costs

User costs were evaluated as described in Section D5.3.

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $717/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate more than three times to $1,110/year per ERU, which is 2.8% of the median household income.

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Memorandum

To: MMB
From: Katie Wolohan, Jeff Ubl, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Butterfield to meet current and future water quality standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Bryan Oakley, Jon Minne, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Butterfield would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0 – Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Butterfield operates a WWTF which includes a lift station, 4,400 feet of 8-inch force main, two aerated ponds and a 3-cell stabilization pond system.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0022977 (expired February 28, 2015)
- NPDES/SDS permit application dated October 22, 2014
- Wastewater Treatment Facilities Record Drawings, dated March 23, 2012
- Wastewater Treatment Facility Plan, dated June 2009

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow (mgd)	0.290
Design Average Dry Weather Flow (mgd)	0.160
Average Flow (mgd) (1)	0.224
Year Built	1972 and upgrades in 2010
Watershed	Minnesota River
Discharge Location	Butterfield Creek (Class 2C, 3C, 4A, 4B, 5, 6)
Major Treatment Units	2 aerated ponds, 4-cell stabilization pond
Facility Class	C
Service Population(2)	577
Estimated Equivalent Residential Units (ERU)	905
Median Household Income(3)	$47,500
Typical Residential Sewer Rate(4)	$458

(1) City of Butterfield discharge monitoring report influent flow data, April 2010 – May 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the source identified above, and information gathered in a site visit conducted on October 18, 2016. The process flow diagram developed for the model is shown in Figure D-1.

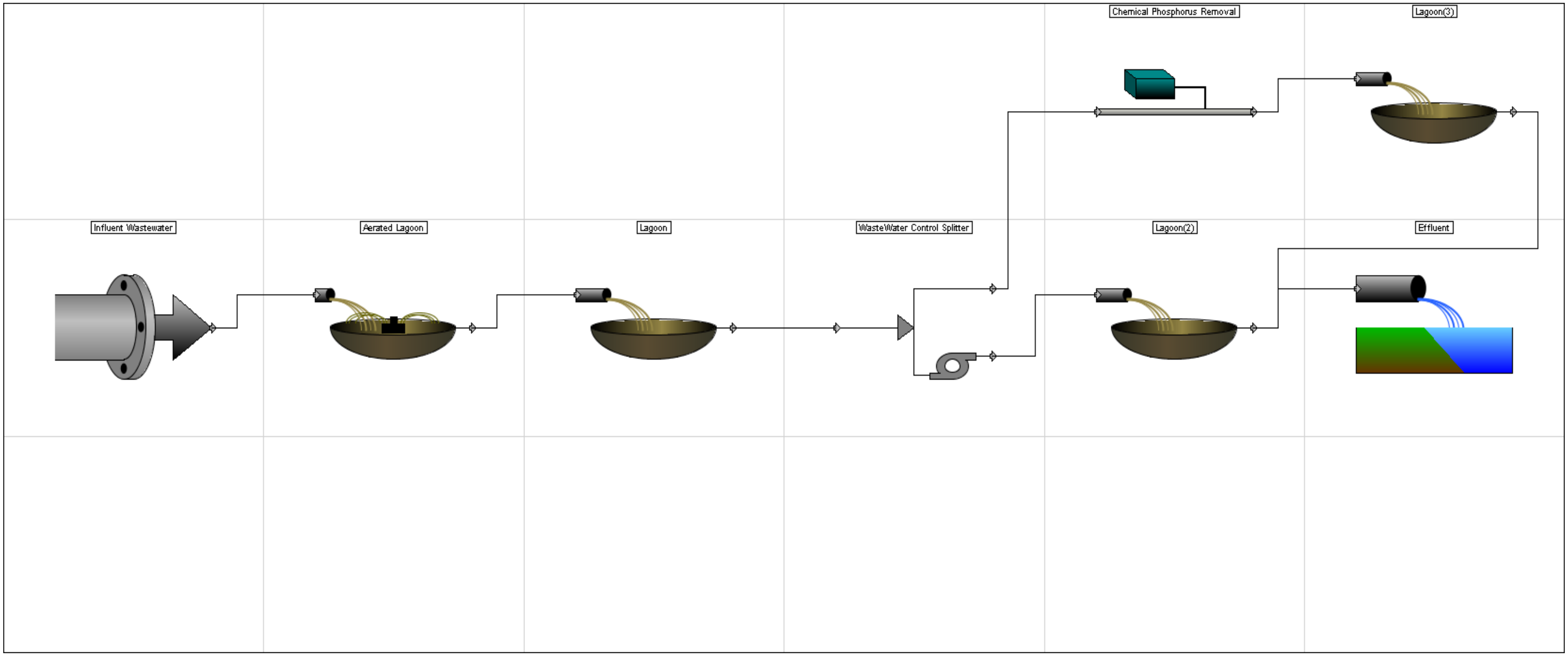

Figure D-1 Process flow diagram of existing Butterfield WWTF

There are no differences between the model and the actual existing facility.

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBELs) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-2 compares effluent characteristics, existing permit limits, current WQBELs and future WQBELs.

Table D-2 Summary of existing and estimated effluent limits: Butterfield WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Mar-Jun	3.1-30.7	monitor	2.5 MDL 1.1 AML	1.7 MDL 0.8 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Sep-Dec	0.1-7.3	monitor	1.8 MDL 0.9 AML	1.5 MDL 0.7 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Nitrate (mg/L as N)	NA	Jan-Dec	NA	NA	NA	8.4 MDL 2.7 AML
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.17-2.5	monitor	4.2 AML	No change
Total Phosphorus (kg/yr)	Cal YTD Total	Jan-Dec	111.7-326.9	372	NA	NA
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	2.0-57.0	45	No change	No change

Cal Mo Avg—calendar month average
Cal YTD Total—Calendar year to date total
MDL—maximum daily limit
AML—average monthly limit
(1) From data reported on monthly discharge monitoring reports April 2010 through May 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

New WQBELs for chlorides, sulfate, and TSS are not expected.

The current and future WQBELs for ammonia would require additional treatment. With treatment for ammonia, the future WQBEL for nitrate would also require treatment.

At the facility's design flow, the permitted phosphorus (P) mass loading rate of 372 kg/yr would require treatment to 1.34 mg/L. At the average flow, which exceeds the average wet weather design flow, the facility would need to treat to 1.2 mg/L P. From April 2010 through May 2016, the facility has maintained an average P discharge concentration of 1.1 mg/L, and since October 2014, the facility has had an average P discharge concentration of 0.40 mg/L. With the additional treatment proposed to meet current and future ammonia and nitrate WQBELs, additional treatment would not be required for P removal to meet the existing permit limit.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Limits

Treatment for ammonia to meet the estimated current WQBELs would require the addition of an aerated tank and secondary clarifier after the two existing aerated ponds and before the two existing primary stabilization ponds. During winter months, to ensure that water temperature coming into biological nitrogen removal is not too low for nitrification to occur, influent would be routed directly to the aerated tank.

Additional equipment required would include the following:

- Preliminary treatment to prevent solids build-up in the downstream aerated tank
- Sludge drying beds for sludge removed from secondary clarification after the aerated tank
- Sludge hauling and land filling from the sludge drying beds
- Truck access

Except for a portion of the footprint of one primary stabilization pond that will be utilized for the aerated tank process and secondary clarifiers, all existing stabilization ponds would be repurposed and continue to be used to achieve 180 days of HRT. The existing larger secondary stabilization pond would still be used for P removal. The facility is capable of meeting the existing P WQBEL without modification.

D4.2 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks^{TM} process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades

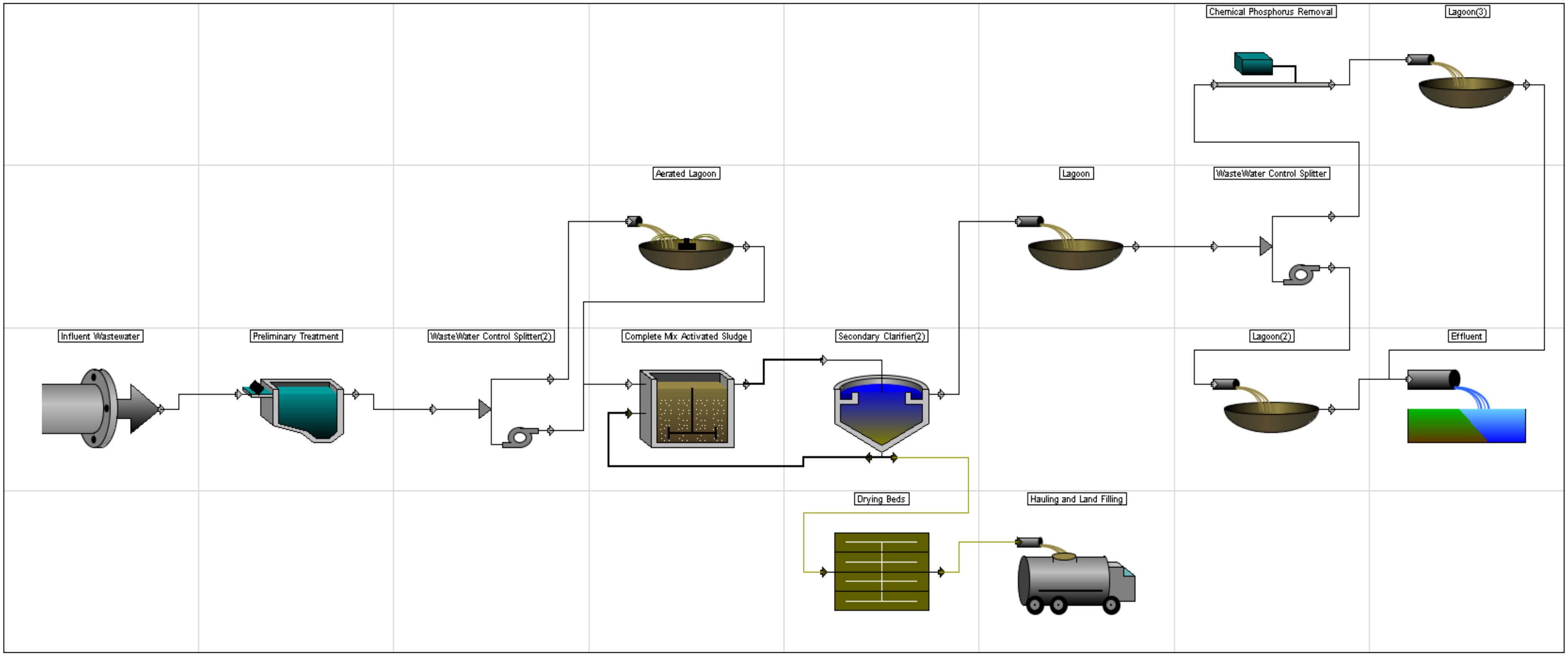

Figure D-2 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Butterfield

Table D 3 describes the differences between the model and the potential facility layout to meet current WQBELs and notes how those differences affect the cost estimates.

Table D-3 Differences between actual WWTF and model for upgrades to meet current WQS

Actual Feature	Model Difference from Actual	Impact on Analysis
The proposed upgrade to meet current ammonia WQBELs would be addition of an aerated tank	A Complete Mix Activated Sludge process was used in CapdetWorks to represent the addition of an aerated tank.	There are small impacts on sludge recycle and wasting rates. These are not important parameters for the cost analysis.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
Preliminary Treatment	$590,000
WasteWater Control Splitter(2)	$68,000
Complete Mix Activated Sludge	$1,046,000
Secondary Clarifier(2)	$296,000
Drying Beds	$1,035,000
Hauling and Land Filling	$340,000
Blower System	$336,000
Direct Costs	$1,033,000
Contingencies	$712,000
Construction Total	**$5,456,000**
Engineering, Legal, Admin	$1,092,000
Totals	**$6,548,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $442,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Wastewater Control Splitter(2) costs include:
    - Concrete splitter box
    - Duplex pumping for complete mix activated sludge system side stream
    - Gravity flow to existing aerated lagoons
- Complete Mix Activated Sludge costs include:
    - Complete mix activated sludge process
    - Concrete basin with handrail
    - Return activated sludge pumps
    - Recirculation pumps
    - Pump building
    - Fine-bubble diffusers
    - Air piping
- Secondary Clarifier(2) costs include:
    - Two 17-ft diameter circular concrete basins with handrail
    - Clarifier covers
    - Return activated sludge pumps
    - Waste activated sludge pumps
- Drying Beds costs include:
    - Membrane-lined earth-basin drying beds
    - Process piping and valves
    - Filter media

- Hauling and Land Filling costs include:
  - Sludge storage shed
  - Loading equipment
  - Truck access
- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.
- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from adding an aerated tank for ammonia removal and sludge drying beds.

Table D-5 Annual costs for improvements to meet the current WQBELs for Butterfield

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Preliminary Treatment	$19,000	$8,000	$2,000	$0	$1,000	$30,000
WasteWater Control Splitter(2)	$19,000	$11,000	$0	$0	$1,000	$31,000
Aerated Lagoon	$0	$1,000	$0	$0	$0	$1,000
Complete Mix Activated Sludge	$68,000	$28,000	$43,000	$0	$28,000	$167,000
Secondary Clarifier(2)	$31,000	$15,000	$1,000	$0	$1,000	$48,000
WasteWater Control Splitter	$0	$1,000	$0	$0	$0	$1,000
Drying Beds	$35,000	$12,000	$7,000	$0	$0	$54,000
Hauling and Land Filling	$1,000	$0	$50,000	$0	$0	$51,000
Totals	**$173,000**	**$76,000**	**$103,000**	**$0**	**$31,000**	**$383,000**

Annual cost clarifications:

- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- Hauling and land filling would include the cost of hauling sludge waste to a landfill. The sludge waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1 was estimated based on population, average annual influent flow to the WWTF, approximate water use per person per day, and the number of households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $912/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by three times to $1,370/year per ERU, which is 2.9% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Limits

Treatment for nitrate to meet the estimated future WQBELs would require the addition of 4-stage Bardenpho biological nutrient removal and secondary clarifier after the two existing aerated ponds and before the two existing primary stabilization ponds. During winter months, to ensure that water temperature coming into biological nitrogen removal is not too low for nitrification to occur, influent would be routed directly to the 4-stage Bardenpho process.

Additional equipment required would include the following:

- Preliminary treatment to prevent solids build-up in downstream 4-stage Bardenpho process unit basins

- Sludge drying beds for sludge removed from secondary clarification after 4-stage Bardenpho
- Sludge hauling and land filling from the sludge drying beds
- Truck access

Except for a portion of the footprint of one primary stabilization pond that will be utilized for the 4-stage Bardenpho process and secondary clarifiers, all existing stabilization ponds would be repurposed and continue to be used to achieve 180 days of HRT. The existing larger secondary stabilization pond would still be used for P removal. The facility is capable of meeting the existing P WQBEL without modification.

D6.2 Summary of Proposed Upgrades

Figure D-3 shows the CapDetWorks^{TM} process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades

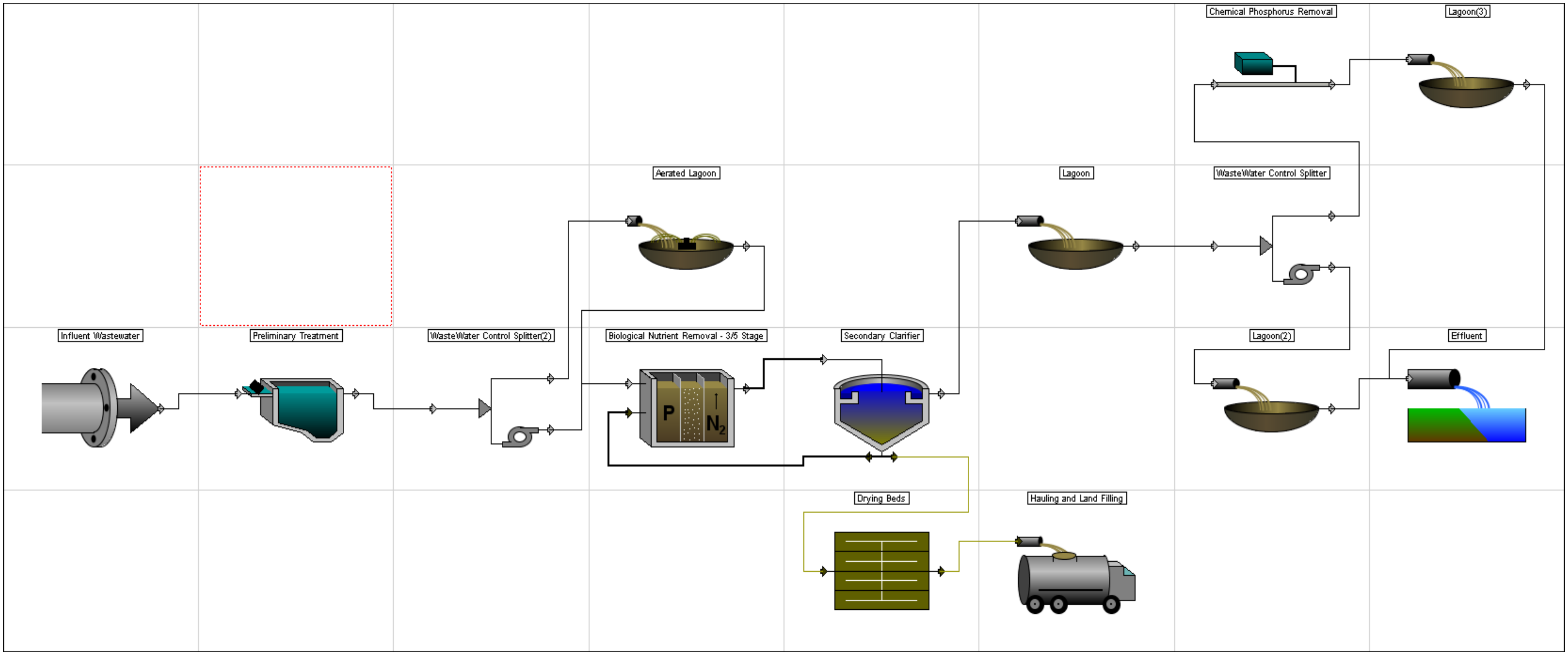

Figure D-3 Process flow diagram of potential WWTF upgrades to meet future WQBELs for Butterfield

Table D-6 describes the differences between the model and the potential facility layout to meet current WQBELs and notes how those differences affect the cost estimates.

Table D-6 Differences between actual WWTF and model for upgrades to meet future WQS

Actual Feature	Model Difference from Actual	Impact on Analysis
The proposed upgrade to meet current ammonia WQBELs would be 4-stage Bardenpho.	The 4-stage Bardenpho process is modeled as a 3/5 stage biological nutrient removal process with no internal recycle from the anoxic to the anaerobic zone, simulating 4-stage Bardenpho.	There are small impacts on sludge recycle and wasting rates. These are not important parameters for the cost analysis.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-7. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-7, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-7 Capital costs for improvements to meet future WQBELs

Process	Capital Cost ($)
Preliminary Treatment	$590,000
WasteWater Control Splitter(2)	$68,000
Biological Nutrient Removal - 3/5 Stage	$1,303,000
Secondary Clarifier	$295,000
Drying Beds	$897,000
Hauling and Land Filling	$338,000
Blower System	$274,000
Direct Costs	$1,033,000
Contingencies	$720,000
Construction Total	**$5,518,000**
Engineering, Legal, Admin	$1,104,000
Totals	**$6,622,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $447,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Wastewater Control Splitter(2) costs include:
  - Concrete splitter box
  - Duplex pumping for 4-stage Bardenpho system side stream
  - Gravity flow to existing aerated lagoons
- Biological Nutrient Removal – 3/5 Stage costs include:
  - Anaerobic/Oxic (A/O) activated sludge process
  - Concrete basins with handrail
  - Return activated sludge pumps
  - Recirculation pumps
  - Pump building
  - Fine-bubble diffusers
  - Anaerobic basin mixers
  - Air piping
- Secondary Clarifier costs include:
  - Two 30-ft diameter circular concrete basins with handrail
  - Clarifier covers
  - Return activated sludge pumps
  - Waste activated sludge pumps
- Drying Beds costs include:
  - Membrane-lined earth-basin drying beds
  - Process piping and valves
  - Filter media
- Hauling and Land Filling costs include:

- Sludge storage shed
- Loading equipment
- Truck access

- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D7.2 Annual Costs

Annual costs shown in Table D-8 reflect the projected change in costs incurred from adding 4-Stage Bardenpho for nitrate removal and sludge drying beds.

Table D-8 Annual costs for improvements to meet the future WQBEL for Butterfield

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Preliminary Treatment	$19,000	$9,000	$2,000	$0	$1,000	$31,000
WasteWater Control Splitter(2)	$19,000	$11,000	$0	$0	$1,000	$31,000
Aerated Lagoon	$0	$1,000	$0	$0	$0	$1,000
Biological Nutrient Removal - 3/5 Stage	$127,000	$56,000	$36,000	$0	$42,000	$261,000
Secondary Clarifier	$30,000	$15,000	$1,000	$0	$1,000	$47,000
Drying Beds	$33,000	$11,000	$6,000	$0	$0	$50,000
Hauling and Land Filling	$1,000	$0	$50,000	$0	$0	$51,000
WasteWater Control Splitter	$0	$1,000	$0	$0	$0	$1,000
Totals	**$229,000**	**$104,000**	**$95,000**	**$0**	**$45,000**	**$473,000**

Annual cost clarifications:

- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- Hauling and land filling would include the cost of hauling sludge waste to a landfill. The sludge waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.

7.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1 was estimated based on population, average annual influent flow to the WWTF, approximate water use per person per day, and the number of households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $1,017/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by more than three times to $1,475/year per ERU, which is 3.1% of the median household income.

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Memorandum

To: MMB
From: Tim Reid, Jon Minne, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Cook to meet Anticipated Water Quality Standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Cook would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0 – Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Cook operates a WWTF which includes secondary treatment of domestic strength wastewater.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MNG580179 (expired August 31, 2015)
- Construction of Wastewater Treatment Facility "As Built Plans", dated May 21, 1986
- City of Cook Comprehensive Plan, December 2015

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of existing Cook WWTF

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	0.184
Average Flow (mgd)(1)	0.079
Year Built	1988, lift station upgraded in 2011
Watershed	Rainy River
Discharge Location	Little Fork River (Class 2C, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Two primary stabilization ponds, 1 secondary stabilization pond
Facility Class	D
Service Population(2)	563
Estimated Equivalent Residential Units (ERU)	264
Median Household Income(3)	$54,559
Typical Residential Sewer Rate(4)	$874

(1) City of Cook discharge monitoring report influent flow data, November 2010 – June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 5, 2016. The process flow diagram developed for the model is shown in Figure D-4.

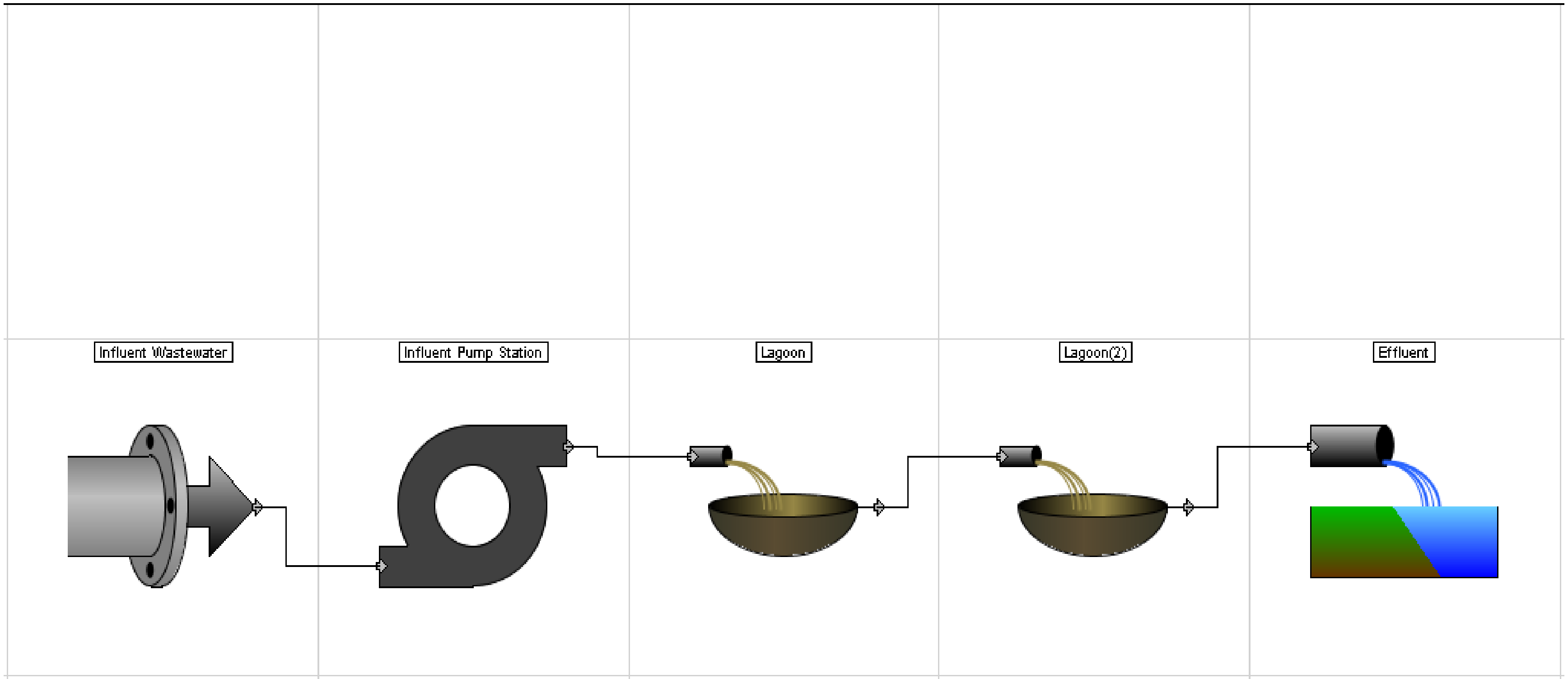

Figure D-4 Process flow diagram of existing Cook WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades may be needed to meet some of the current and future WQBELs. Table D-2 compares effluent characteristics, existing permit limits, current WQBELs and future WQBELs.

Table D-2 Summary of existing and estimated effluent limits: Cook WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia-N (mg/L as N)	Cal Mo Max	Apr-Sep Oct-Mar	1.0-1.7 0.7-1.1	Monitor Monitor	No change	No change
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.82-11.51	Monitor	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	0.3-1123	45	No change	No change

Cal Mo Avg—calendar month average
Cal Mo Max - calendar month maximum
MDL—maximum daily limit
AML—average day of the AWW month
AAF—average annual flow
NA—not applicable
(1) From data reported on monthly discharge monitoring reports November 2010 through June 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

New WQBELs for ammonia, chlorides, nitrate, sulfate, total phosphorus, and total suspended solids (TSS) are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

There are no recommended upgrades to meet current WQBELs.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

There are no recommended upgrades to meet current WQBELs.

D6.0 Proposed Upgrades to Meet Future Standards

There are no recommended upgrades to meet future WQBELs.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

There are no recommended upgrades to meet future WQBELs.

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Memorandum

To: MMB
From: Katie Wolohan, Jeff Ubl, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Fairmont to meet current and future water quality standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jon Minne, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Fairmont would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0	Background information on the existing WWTF.
Section D3.0	Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0	Proposed upgrades to meet current standards
Section D5.0	Estimated costs of proposed upgrades to meet current standards
Section D6.0	Proposed upgrades to meet future standards
Section D7.0	Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Fairmont operates a WWTF which includes two mechanical bar screens, two grit chambers, two primary clarifiers, three activated sludge basins, four secondary clarifiers, and UV disinfection. Biosolids treatment consists of two primary digesters, a sludge storage tank, a belt filter press, and a storage building for dried Class A biosolids.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0030112 (expired April 30, 2015)
- NPDES permit application dated November 17, 2014
- Wastewater Treatment Improvement Record Drawings, dated December 2006
- DRAFT of Existing Wastewater Treatment Facilities Review, dated February 2002
- Fairmont Wastewater Treatment Facility Plan, dated October 2002

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	3.9
Design Average Dry Weather Flow (mgd)	1.15
Average Flow (mgd)(1)	1.48
Year Built	1973 and 2004
Watershed	Minnesota River
Discharge Location	Center Creek (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Primary clarification, activated sludge aeration, secondary clarification, UV disinfection, biosolids treatment
Facility Class	A
Service Population(2)	10,421
Estimated Equivalent Residential Units (ERU)	6,814
Median Household Income(3)	$51,809
Typical Residential Sewer Rate(4)	$866

(1) City of Fairmont discharge monitoring report data, August 2010 – July 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 7, 2016. The process flow diagram developed for the model is shown in Figure D-1.

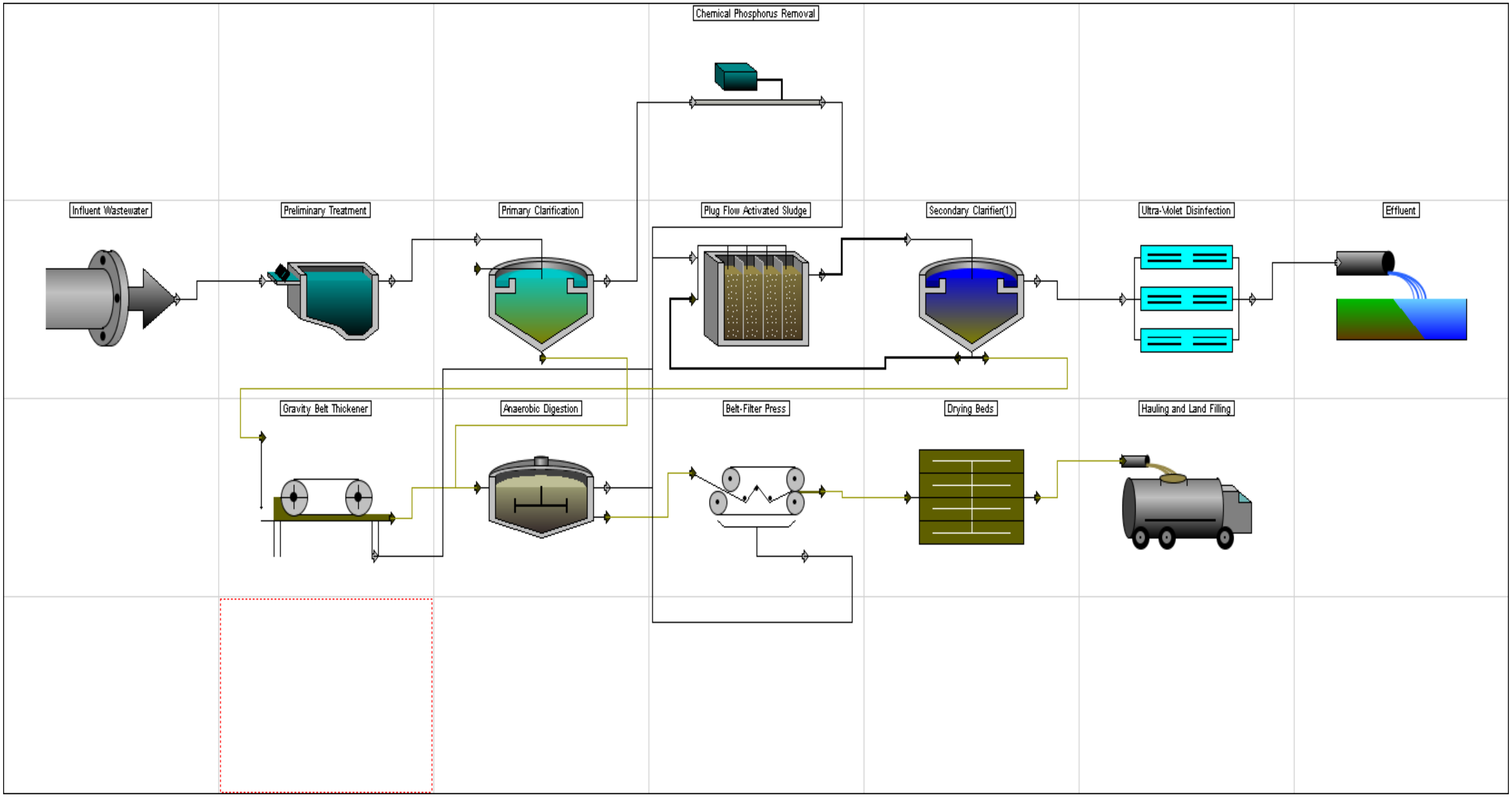

Figure D-1 Process flow diagram of existing Fairmont WWTF

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WWTF

Actual Feature	Model Difference from Actual	Impact on Analysis
The existing secondary treatment system is an extended aeration activated sludge process.	The activated sludge process is modeled as a plug-flow system with a long solids retention time. The software's extended aeration activated sludge module does not accurately track phosphorus in the wastewater stream.	There are small impacts on sludge recycle and wasting rates. These are not important parameters for the cost analysis. The modeled effluent concentration of pollutants of concern approximates observed concentrations.
The existing sludge thickening process includes a rotary drum thickener ahead of anaerobic digestion.	The rotary drum thickener is modeled as a gravity belt thickener. The model does not offer a rotary drum thickener.	There are small impacts on operational costs. These are not important parameters for this cost analysis. The rotary drum thickener is not proposed to be replaced or modified and therefore no increase in cost is anticipated.

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs and future WQBELs.

Table D-3 Summary of Existing and Estimated Effluent Limits: Fairmont WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Dec-Mar	0.01-0.13	5	No change	No change
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Apr-May	0-0.60	5.3	1.29 MDL 0.55 AML	1.68 MDL 0.72 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jun-Sep	0.02-0.26	1	1.39 MDL 0.55 AML	1.02 MDL 0.40 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Oct-Nov	0-0.62	2.7	1.96 MDL 0.77 AML	1.72 MDL 0.67 AML
Total Chloride (mg/L)	Cal Mo Avg	Jan-Dec	118-587	monitor	308 MDL 209 AML	308 MDL 209 AML
Nitrate (mg/L as N)	Cal Mo Avg	Apr, Sep	8.86-29.1	monitor	NA	7.24 MDL 4.26 AML
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.33-0.99	1.0	No change	No change
Total Phosphorus (kg/yr)	Cal Mo Avg	Jan-Dec	NA	NA	4,310.4 AML	No change
Total Phosphorus (kg/day)	Cal Mo Avg	Jan-Dec	0.39-9.0	14.8	11.5 AML	No change
Total Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	34.3-168	monitor	NA	NA
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	2.0-17.0	30	No change	No change

Cal Mo Avg—calendar month average
MDL—maximum daily limit
AML—average monthly limit
NA—not applicable

(1) From data reported on monthly discharge monitoring reports August 2010 through July 2016, with the exception of ammonia nitrogen data which was summarized from January 2013 through July 2016.
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The exceedance of the current WQBEL for ammonia noted above occurred only in the April-May period once during the last 5 years of monitoring. Excluding that period, the ammonia in April-May has not exceeded 0.11 mg/L. No additional treatment is required to meet the current or future WQBEL.

The current and future WQBELs for chloride would require additional treatment. Over the last 5 years the WWTF effluent monthly maximum chloride concentration has been greater than the current and future average monthly maximum WQBELs of 209 mg/L a little more than half the time.

The future WQBEL for nitrate would require additional treatment.

The current WQBEL for total phosphorus (P) would not require additional treatment. Over the last 5 years, the highest P effluent concentration reported is 0.99 mg/L. This would equate to only slightly more than 2,000 kg/year P which is less than half of the current WQBEL.

New WQBELs for sulfate and TSS are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Chloride Limit

D4.1.1 Chloride

The 5-year average chloride concentration is 226 mg/L, which is higher than calculated current WQBEL of 209 mg/L (average monthly limit). To meet the current WQBEL, additional treatment would be required.

The City has centralized lime softening of its source water; therefore, home water softeners are not thought to be the primary cause of the high chloride concentrations. A local significant industrial user has an ion exchange softening process to further soften the municipal water for use in the industrial process. It may be possible to reduce the WWTF effluent chloride concentration to below the current WQBEL by requiring NF softening at the industry, but the impact of such a change has not been quantified. For this analysis it is assumed that the chloride concentrations observed in the past are representative of the future condition.

Figure D-2 shows the relationship between flow and chloride concentration. As flow increases, the chloride concentration decreases. This would allow a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates.

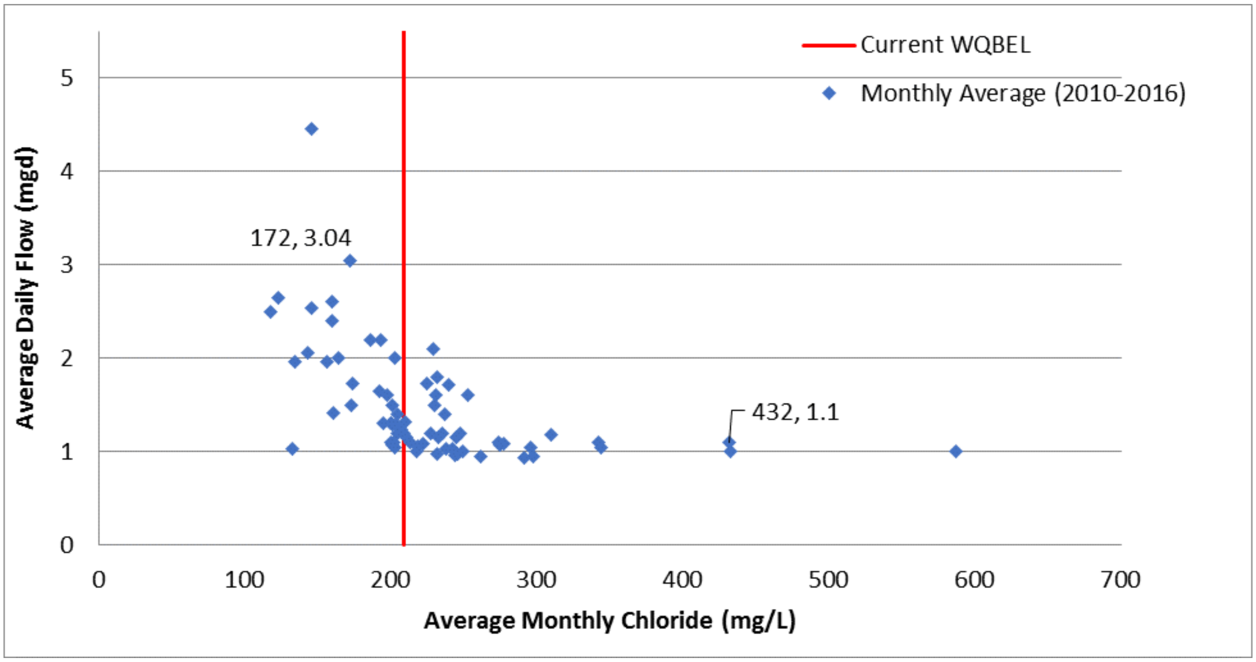

Figure D-2 Effluent Flow and Chloride Concentration Relationship, Fairmont

Chloride can be removed using reverse osmosis (RO) filtration. Water reaching the RO system would require pretreatment to remove solids with a deep-bed, granular-media filter, or an ultrafilter.

Assuming 99% removal of chloride, a reverse osmosis system can be sized to treat a portion of the flow adequate to bring the blended flow below the monthly average current estimated WQBEL requirement of 209 mg/L.

The extreme conditions recorded in the past six years include a high chloride concentration of 432 mg/L (assuming the single 587 mg/L value is an outlier) at a flow of 1.1 mgd and a chloride concentration of 146 mg/L at a high flow of 4.45 mgd.

At the low flow, high concentration condition, the RO system would be required to treat 52% of the flow, or 398 gpm.

No RO treatment would be required at the high flow, low concentration condition.

D4.1.2 Treatment System

RO treatment produces a significant brine waste stream. The most viable method of disposal would be evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required for RO treatment:

- The AWW would have the same chloride concentrations as the high flow, low concentration condition observed in the past (this is a conservative assumption as the concentrations would likely be lower).
- The RO would generate 25% of its feed flow as brine
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent without further treatment.

RO treatment of a side stream from the secondary effluent to meet the current WQBEL for chloride would require the following new treatment units:

- Deep bed granular filtration of the RO influent
- RO system capable of treating 398 gpm at AWW
- Evaporator/Crystallizer capable of treating 100 gpm at AWW
- Salt storage (1,600 cf required for weekly disposal)
- Truck access

D4.2 Summary of Proposed Upgrades

Figure D-3 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades.

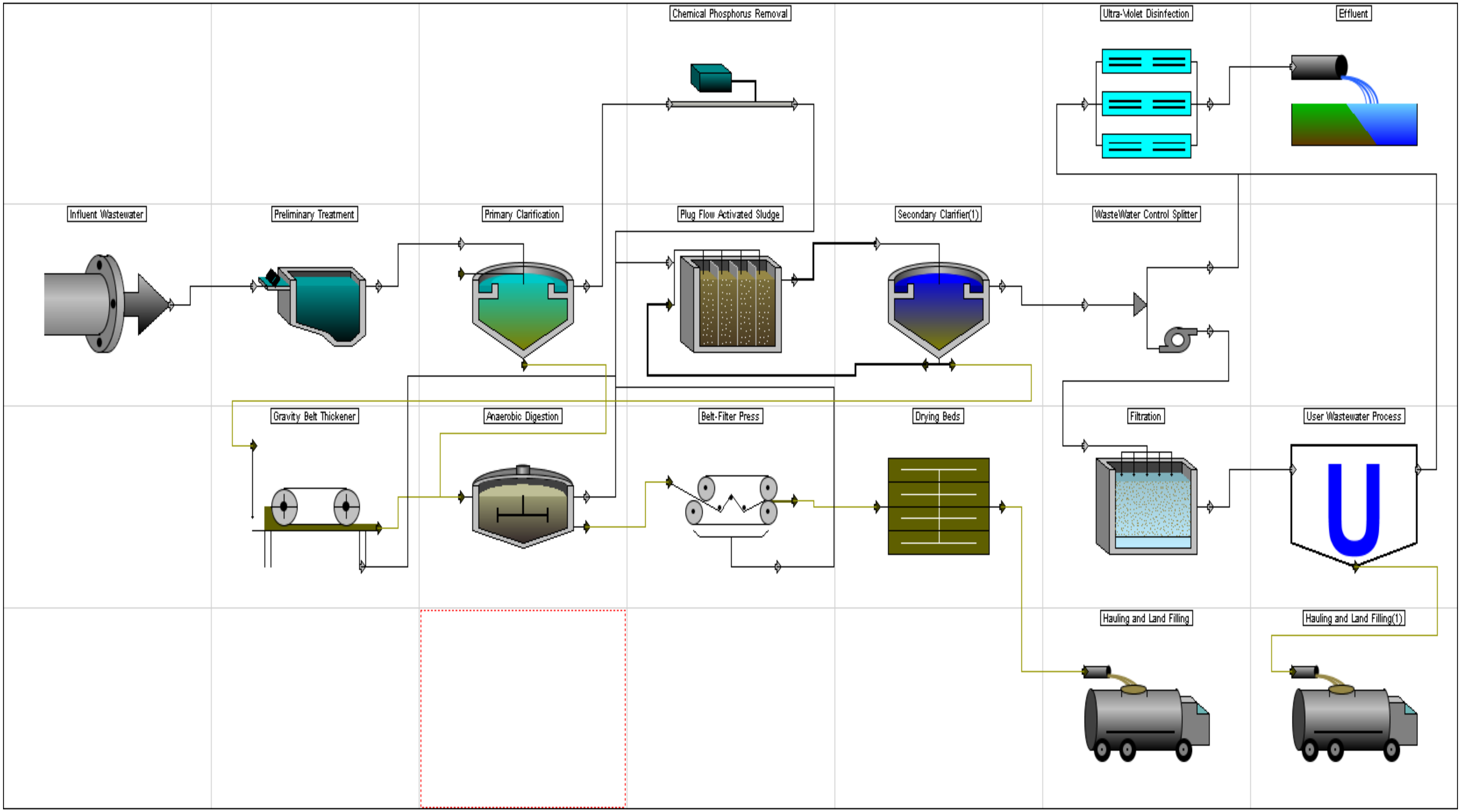

Figure D-3 **Process flow diagram of potential WWTF upgrades to meet current WQBELs for Fairmont**

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
WasteWater Control Splitter	$155,000
Filtration	$1,819,000
RO	$2,907,000
Evaporator Crystallizer	$14,349,000
Hauling and Land Filling(1)	$107,000
Direct Costs	$4,335,000
Contingencies	$3,551,000
Construction Total	**$27,223,000**
Engineering, Legal, Admin	$5,445,000
Totals	**$32,668,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $2,206,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.

- Wastewater Control Splitter costs include:
  - Concrete splitter box
  - Duplex pumping for RO side stream
  - Gravity flow to existing chlorine contact tank
- Filtration costs include:
  - Deep-bed, dual media gravity filtration
  - Concrete basins with handrail
  - Automatic valves
  - Backwash tank and pumps
  - Process equipment building space
- RO Filtration costs include:
  - Booster pumps
  - Process piping and valves
  - Two 20 x 10 array RO membrane skids with 8" membrane modules
  - Clean-in-place equipment
  - Process equipment building space
- Evaporator/Crystallizer costs include:
  - Water feed system
  - Condenser
  - Crystallizer (evaporator not required)
  - Process equipment building space
- Hauling and Land Filling(1) costs include:
  - Salt storage shed
  - Loading equipment
  - Truck access
- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.
- Indirect Costs include:

- Contingencies at 15% of construction costs
- Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from adding RO treatment of the side stream.

Table D-5 Annual costs for improvements to meet the current WQBEL for Fairmont

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
WasteWater Control Splitter	$26,200	$17,900	$900	$0	$10,400	$55,400
Filtration	$4,700	$2,600	$26,200	$0	$1,000	$34,500
RO	$37,600	$1,400	$1,600	$19,900	$6,300	$66,800
Evaporator Crystallizer	$150,400	$3,300	$13,200	$9,100	$181,300	$357,300
Hauling and Land Filling(1)	$900	$0	$39,900	$0	$0	$40,800
Totals	**$219,800**	**$25,200**	**$81,800**	**$29,000**	**$199,000**	**$554,800**

Annual cost clarifications:

- Wastewater control splitter includes the cost of pumping to the new filtration train.
- RO filtration and evaporator/crystallizer would include costs for additional staffing, process testing, membrane replacement, cleaning chemicals, and energy.
- Hauling and land filling would include the cost of hauling salt waste to a landfill. The salt waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.
- The effluent from the RO/evaporator/crystallizer treatment process may not need disinfection prior to discharge. However, this reduction would likely result in only a small cost savings and therefore is not reflected in the annual costs.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated based on population, average annual influent flow to the WWTF, approximate water use per person per day, and the number of households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $405/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by more than 50% to $1,271/year per ERU, which is 2.5% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Requirements

The existing activated sludge process should be capable of meeting the ammonia future WQBELs, but does not have the capacity to remove nitrate to the future WQBELs, so the secondary treatment system would need to be replaced.

An activated sludge system capable of meeting the ammonia WQBEL would include the following:

- 4-stage Bardenpho biological nutrient removal activated sludge process
    - 2 new mixed anoxic tanks
    - 2 new aeration tanks
    - New aeration diffusers
    - Reuse existing blower system
    - Reuse existing return activated sludge pumps and pipes
    - New recirculation pumps
    - Reuse existing waste sludge pumps
    - Existing secondary clarifiers can be reused
- Sludge processing
    - Additional sludge hauling facilities are required

The existing facility is capable of meeting the phosphorus limits with the existing chemical phosphorus removal; however, there would be a reduction in chemical use if the new activated sludge system is designed to incorporate biological nutrient removal (BNR) and supplemented with chemical phosphorus removal. This estimate assumes that in addition to nitrate, the activated sludge system would remove phosphorus to less than 1 mg/L. Chemical addition for removal of phosphorus would continue, but at a lower chemical usage applied primarily to recycle streams high in phosphorus. The chemical phosphorus removal system would be moved to the digester supernatant return to tie up phosphorus released during aerobic digestion. Tertiary filtration is not required to meet the future WQBEL phosphorus limit.

D6.2 Upgrades to Meet Chloride Limits

Improvements detailed in the previous sections for chloride removal to meet current standards would also be used to meet future standards.

D6.3 Summary of Proposed Upgrades

Figure D-4 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

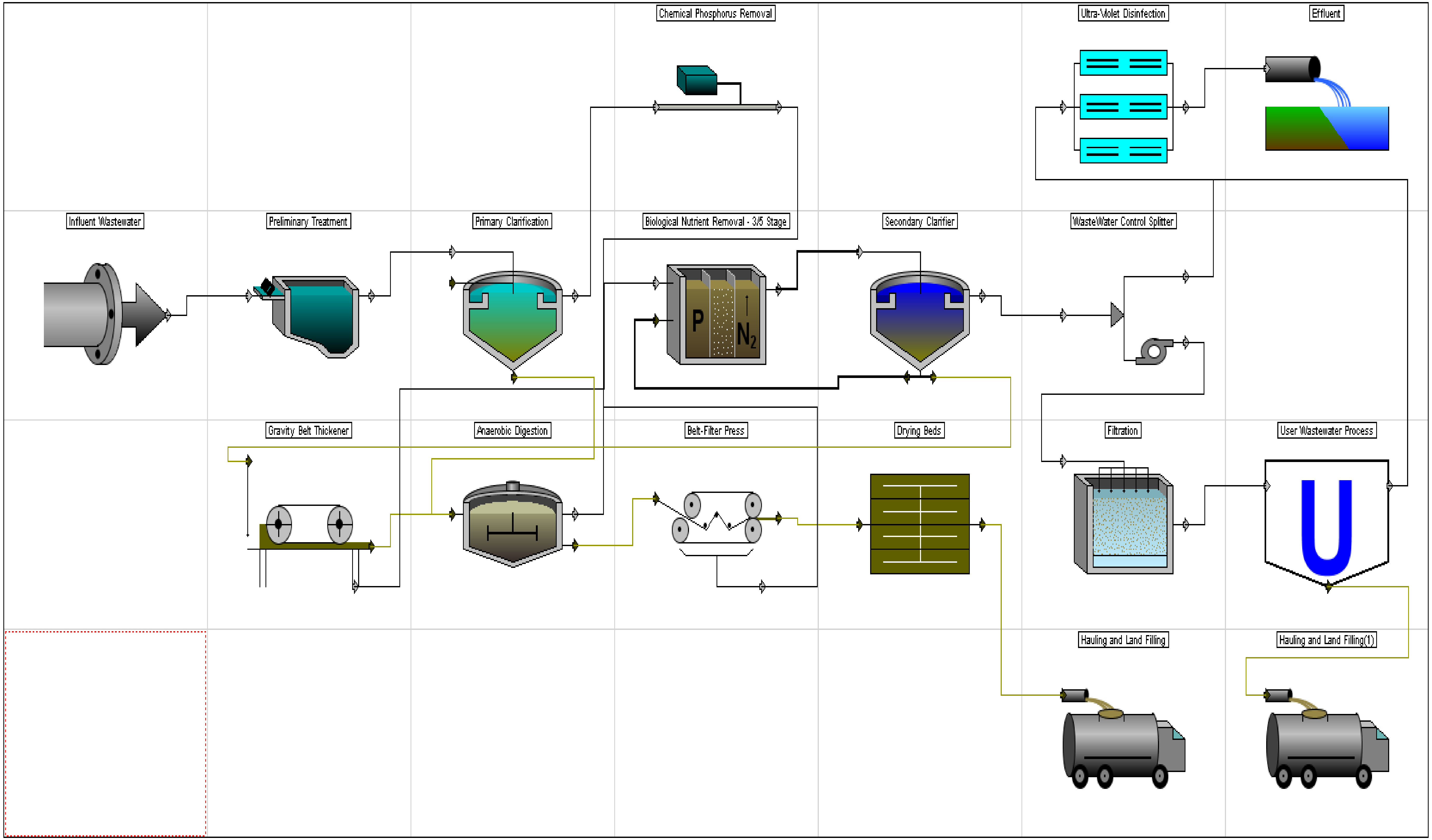

Figure D-4 **Process flow diagram of potential WWTF upgrades to meet future WQBELs for Fairmont**

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-6. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-6, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-6 Capital Costs for improvements to meet future WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3/5 Stage	$3,960,000
WasteWater Control Splitter	$1,819,000
Filtration	$1,119,000
RO	$2,907,000
Evaporator Crystallizer	$14,349,000
Hauling and Land Filling(1)	$131,000
Direct Costs	$4,335,000
Contingencies	$3,643,000
Construction Total	**$32,263,000**
Engineering, Legal, Admin	$6,453,000
Totals	**$38,716,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $2,614,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes required to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the potential new WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.

- Biological Nutrient Removal costs include:
  - Anaerobic/Oxic (A/O) activated sludge process
  - Concrete basins with handrail
  - Return activated sludge pumps
  - Recirculation pumps
  - Pump building
  - Fine-bubble diffusers
  - Anaerobic basin mixers
  - Air piping
- All other costs would be similar to Section D5.1.

D7.2 Annual Costs

Annual costs shown in Table D-7 reflect the projected change in costs incurred from changing the secondary treatment process.

Table D-7 Annual costs for improvements to meet the future WQBEL for Fairmont

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Biological Nutrient Removal - 3/5 Stage	$168,000	$83,300	$76,300	$0	$35,500	$363,100
WasteWater Control Splitter	$26,200	$18,100	$900	$0	$10,400	$55,600
Filtration	$4,700	$2,600	$26,200	$0	$1,000	$34,500
RO	$37,600	$1,400	$1,600	$19,900	$6,300	$66,800
Evaporator Crystallizer	$150,400	$3,300	$13,200	$9,100	$181,300	$357,300
Hauling and Land Filling(1)	$900	$0	$39,900	$0	$0	$40,800
Totals	**$387,800**	**$108,700**	**$158,100**	**$29,000**	**$234,500**	**$918,100**

Annual cost clarifications:

- The BNR system annual costs would be partially offset by existing annual costs associated with the activated sludge process. The BNR process would have increased costs for operation and maintenance due to a more complex process flow.
- Land application of sludge would increase because the BNR process would generate more waste sludge than the existing activated sludge process.
- The secondary clarifier is an existing process, but would require more operation and maintenance time due to its use for returning activated sludge to the aeration basin.
- Power costs for the blower system are included in the BNR process line item.
- Note that chemical costs would be less than chemical costs for phosphorus removal without BNR.
- Other costs are described in Section D5.2.

D7.3 User Costs

User costs were evaluated as described in Section D5.3.

The increase in user cost for upgrades necessary to meet the proposed future WQBELs would be approximately $518/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by more than 60% to $1,384/year per ERU, which is 2.7% of the median household income.

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Memorandum

To: MMB
From: Tim Reid and Jon Minne, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Gilbert to meet Anticipated Water Quality Standards
Date: January 27, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Bryan Oakley, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Gilbert would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0 – Estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Gilbert operates a WWTF which includes secondary treatment of domestic strength wastewater and land application of residual sludge.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0020125 (expired June 30, 2014)
- NPDES permit application dated December 16, 2013
- DRAFT Wastewater Treatment Facility Plan, dated March 2015

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	0.691
Average Flow (mgd)(1)	0.355
Year Built	1959. Update in 1977 and 2010
Watershed	Lake Superior
Discharge Location	Unnamed Ditch (Class 7, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Primary clarifiers, activated sludge, chlorination, secondary clarifier, anaerobic digestion, sand filter
Facility Class	A
Service Population(2)	1,802
Estimated Equivalent Residential Units (ERU)	1,659
Median Household Income(3)	$44,821
Typical Residential Sewer Rate(4)	$822

(1) City of Gilbert discharge monitoring report data, November 2010 – July 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 11, 2016. The process flow diagram developed for the model is shown in Figure D-1.

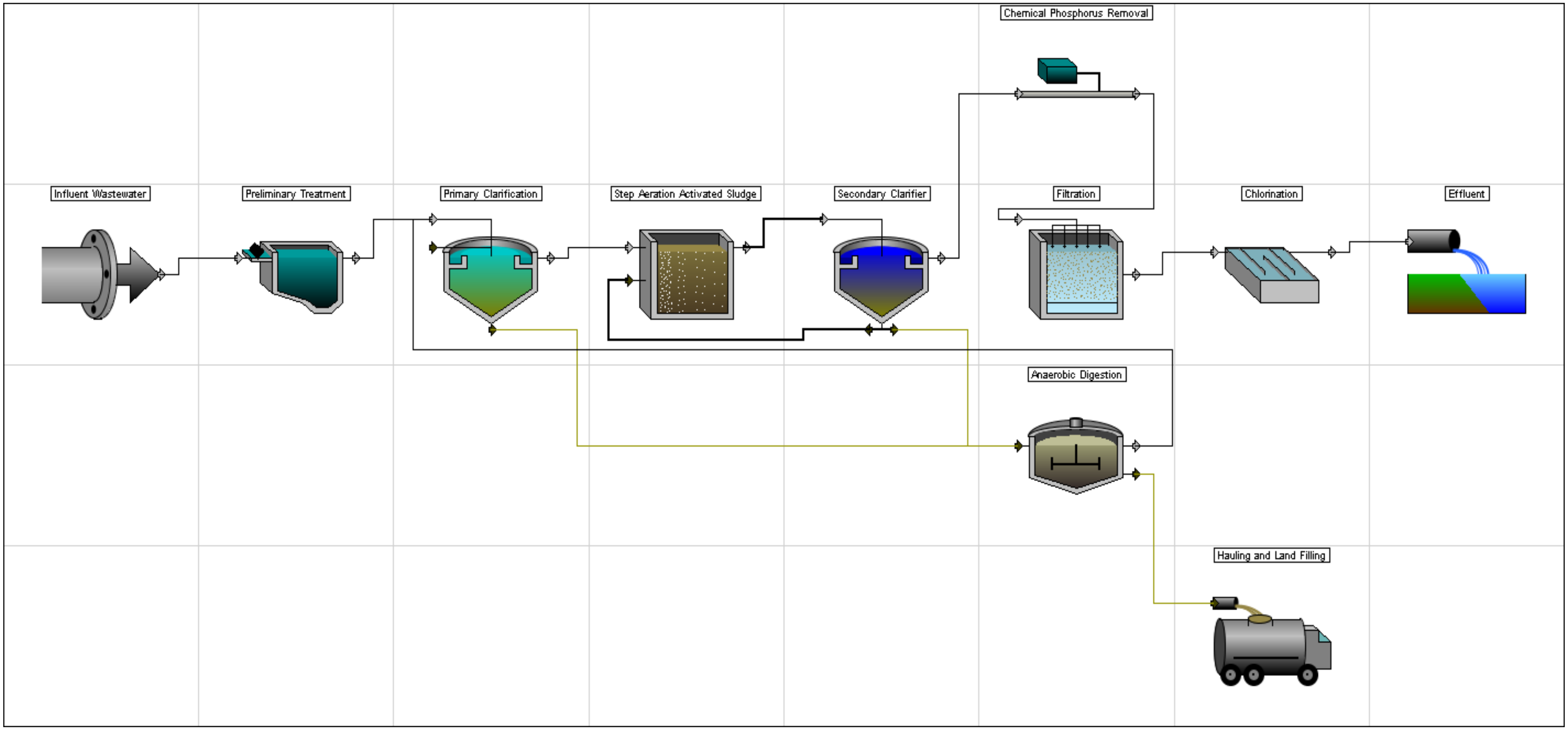

Figure D-1 Process flow diagram of existing Gilbert WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-2 compares effluent characteristics, existing permit limits, current WQBELs and future WQBELs.

Table D-2 Summary of Existing and Estimated Effluent Limits: Gilbert WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Apr-Sep	0.15-6.0	monitor	10 MDL 5 AML	3 MDL 2 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Oct-Mar	0.81	monitor	NA	5 MDL 2 AML
Chloride (mg/L)	Cal Mo Max	Jan-Dec	95.1-214	monitor	292 MDL 213 AML	292 MDL 213 AML
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	12-19	monitor	NA	8 MDL 4 AML
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	31-59	monitor	NA	10 MDL 8 AML
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.17-2.6	1.0	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	1.2-33.3	30	No change	No change

Cal Mo Avg—calendar month average
Cal Mo Max – calendar monthly maximum
MDL—maximum daily limit
AML—average monthly limit
NA—not applicable
(1) From data reported on monthly discharge monitoring reports November 2010 through July 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The current and future WQBELs for TSS was exceeded twice during the last five years for two months in a row in 2010-2011. Since then, every effluent TSS measurement has been below 10 mg/L. As a result, the current system should be capable of treating to less than 14 mg/L.

The exceedance of the current WQBEL for ammonia noted above occurred twice during the last 5 years of monitoring. Excluding that period, the ammonia in Apr-Sep has not exceeded 1.95 mg/L. The existing system should be capable of treating ammonia to less than 1 mg/L. No additional treatment is required to meet the current or future WQBEL.

The future WQBEL for nitrate would require additional treatment.

The current and future WQBELs for phosphorus will continue to follow the permitted discharge limit. No new treatment is required.

The current and future WQBELs for chloride are being met.

The future WQBELs for sulfate would require additional treatment. The facility has never reported a monthly average effluent sulfate concentration below the WQBEL value.

D4.0 Proposed Upgrades to Meet Current Standards

The facility is capable of meeting the existing TSS, ammonia, chloride, and phosphate WQBELs without modification.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

The facility is capable of meeting the existing TSS, ammonia, chloride, and phosphate WQBEL without modification.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Requirements

The existing process would not be capable of meeting the future nitrate WQBELs, so the secondary treatment system would need to be replaced.

An activated sludge system capable of meeting the nitrate WQBEL would include the following:

- 4-stage biological nutrient removal activated sludge process
    - 2 new mixed anoxic tanks
    - 2 new aeration tanks (it may be possible to mitigate some capital costs by reusing existing basins)
    - New aeration diffusers
    - Reuse existing blower system
    - Reuse existing return activated sludge pumps and pipes
    - New recirculation pumps
    - Reuse existing waste sludge pumps
    - Existing secondary clarifiers can be reused

- Sludge processing
  - Additional sludge hauling facilities are required

D6.2 Upgrades to Meet Sulfate Limit

D6.2.1 Sulfate

The 2-year average sulfate concentration is nearly five times the calculated current WQBEL. To meet the current WQBEL, additional treatment would be required.

Figure D-2 shows the relationship between flow and chloride concentration. As flow increases, the chloride concentration decreases. This would allow a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates.

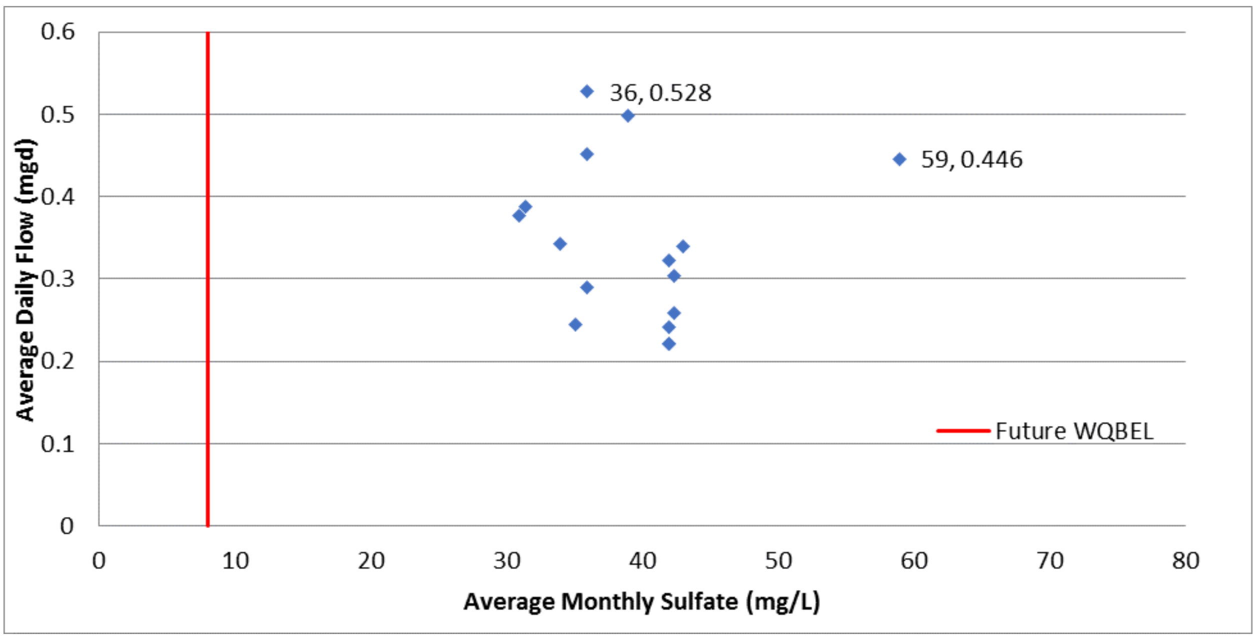

Figure D-2 Effluent Flow and Sulfate Concentration Relationship, Gilbert

Sulfate can be removed using nanofiltration (NF), which is capable of removing 95% of sulfate.

Water reaching the NF system would require pretreatment to remove solids with a deep-bed, granular-media filter, or an ultrafilter.

Assuming 95% removal of sulfate, a NF system can be sized to treat a portion of the flow adequate to bring the blended flow below the monthly average requirement of 8 mg/L.

The extreme conditions recorded in the past 2 years include a high sulfate concentration of 59 mg/L at a flow of 0.446 mgd and a sulfate concentration of 36 mg/L at a high flow of 0.528 mgd. The first scenario would require 282 gpm of NF treatment, while the second scenario would require 300 gpm of NF treatment. The second scenario was used for sizing the system.

D6.2.2 Sulfate Treatment System

NF treatment produces a significant brine waste stream. The most viable method of disposal of brine would be evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required for NF treatment:

- The AWW would have the same sulfate concentrations as the high flow, low concentration conditions observed in the past (this is a conservative assumption as the concentrations would likely be lower).
- The NF would generate 20% of its feed flow as brine
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent without further treatment.

NF treatment of a sidestream for sulfate would require the following new treatment units:

- Deep bed granular filtration of the NF influent (total capacity of 282 gpm)
- NF system capable of treating 282 gpm at AWW
- Evaporator/Crystallizer capable of treating 56 gpm at AWW
- Salt storage (1077 cf required for weekly disposal)
- Truck access

D6.3 Summary of Proposed Upgrades

Figure D-5 shows the CapDetWorks^{TM} process flow diagram for the WWTF upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

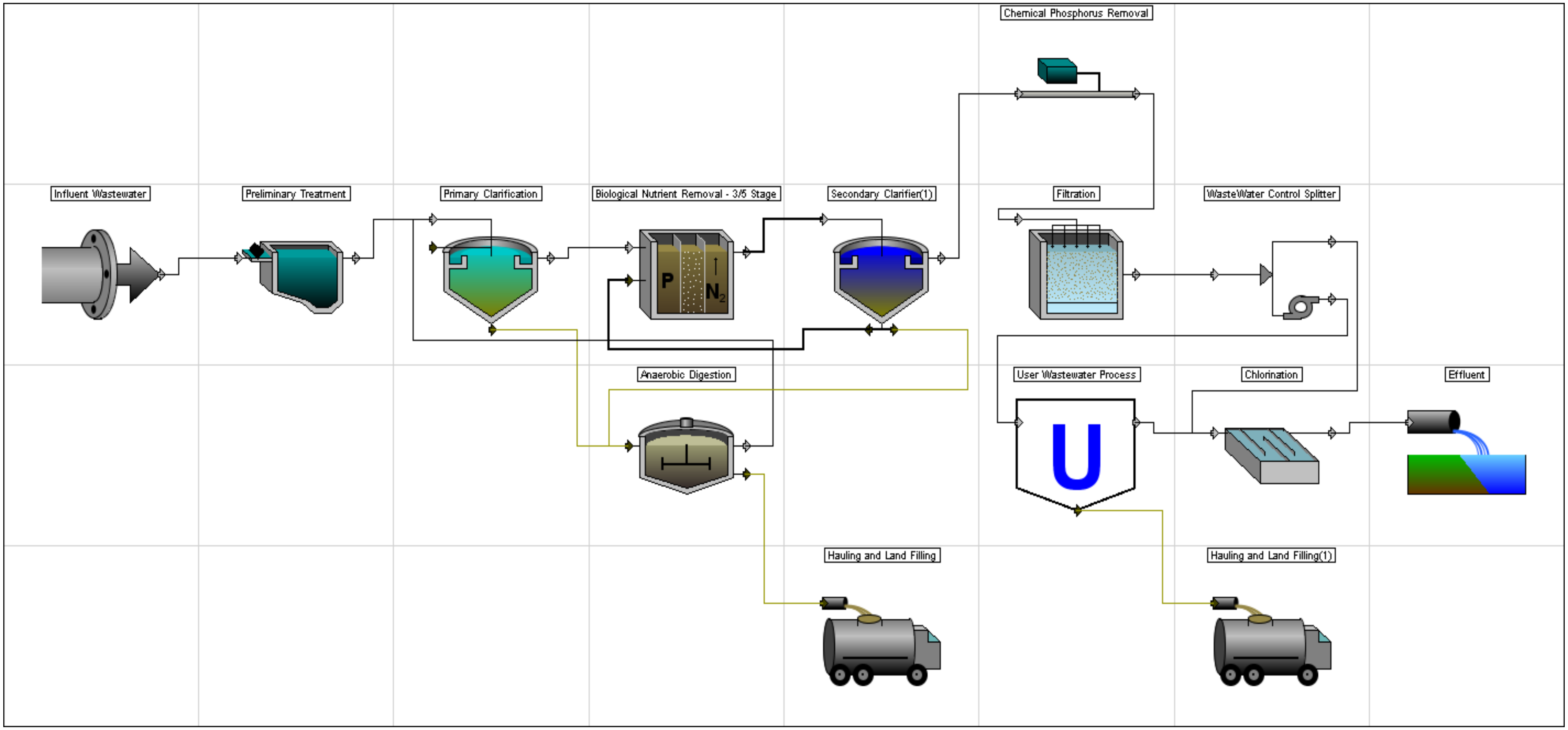

Figure D-5 **Process flow diagram of potential WWTF upgrades to meet future WQBELs for Gilbert**

Table D-3 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-3 Model differences from actual WWTF

Proposed Feature	Model Difference from Actual	Impact on Analysis
The proposed secondary treatment system is a 4-stage biological nutrient removal activated sludge process.	The activated sludge process is modeled as a 5-stage biological nutrient removal activated sludge process. The software did not have a 4-stage option, so it was simulated by turning off the anaerobic zone recycle.	There are small impacts on the costs of each stage.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for improvements to meet future WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3/5 Stage	$804,000
WasteWater Control Splitter	$80,000
NF	$2,364,000
Evap/Cryst	$11,529,000
Hauling and Land Filling(1)	$90,000
Direct Costs	$1,231,000
Contingencies	$2,468,000
Construction	**$18,919,000**
Engineering, Legal, Admin	$3,784,000
Totals	**$22,216,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $1,533,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.

- Future replacement costs.
- Expansion of existing unit processes required to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the potential new WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Biological Nutrient Removal costs include:
    - 4-stage Bardenpho activate sludge process
    - Concrete basins with handrail
    - Return activated sludge pumps
    - Recirculation pumps
    - Pump building
    - Fine-bubble diffusers
    - Anaerobic basin mixers
    - Air piping
- Filtration costs include:
    - Deep-bed, dual media gravity filtration
    - Concrete basins with handrail
    - Automatic valves
    - Backwash tank and pumps
- NF Filtration and Evaporator/Crystallizer costs include:
    - Booster pumps
    - Process piping and valves
    - NF membrane skids with 8" membrane modules
    - Evaporator
    - Crystallizer
    - Clean-in-place equipment
    - Process equipment building space
- Hauling and Land Filling(1) costs include:
    - Salt storage shed
    - Loading equipment
    - Truck access

- Other Direct Costs include:
    - Mobilization
    - Site preparation
    - Site electrical
    - Yard piping
    - Instrumentation and control
    - Administrative building space.
- Indirect Costs include:
    - Contingencies at 15% of construction costs
    - Engineering, legal, and administrative at 20% of construction cost

D7.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from changing the secondary treatment process and adding anaerobic digestion.

Table D-5 Annual costs for improvements to meet the future WQBEL for Watertown

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Biological Nutrient Removal - 3/5 Stage	$100,000	$46,700	$21,100	$0	$19,300	$187,100
WasteWater Control Splitter	$20,200	$12,500	$500	$0	$1,400	$34,600
NF	$37,600	$3,100	$3,500	$28,800	$15,400	$88,400
Evap/Cryst	$150,400	$5,200	$20,700	$19,200	$383,100	$578,600
Hauling and Land Filling(1)	$2,300	$0	$99,700	$0	$0	$102,000
Totals	**$310,500**	**$67,500**	**$145,500**	**$48,000**	**$419,200**	**$990,700**

Annual cost clarifications:

- Hauling and land filling would include the cost of hauling sludge waste to a landfill. The sludge waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.
- The effluent from the NF/evaporator/crystallizer treatment process may not need disinfection prior to discharge. However, this reduction would likely result in only a small cost savings and therefore is not reflected in the annual costs.

D7.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated by dividing the average daily flow (355,000 gpd) by the existing population, dividing by 100 (typical domestic wastewater generation rate in gallons per person per day) and multiplying by the number of residential households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $1,501/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate almost three times to $2,323/year per ERU, which is 5.2% of the median household income.

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Memorandum

To: MMB
From: Tim Reid, Jon Minne, and Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Grand Rapids to meet current and future water quality standards
Date: January 27, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Grand Rapids would not need to upgrade their wastewater treatment facility (WWTF). Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0	Background information on the existing WWTF.
Section D3.0	Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0	Proposed upgrades to meet current standards
Section D5.0	Estimated costs of proposed upgrades to meet current standards
Section D6.0	Proposed upgrades to meet future standards
Section D7.0	Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Grand Rapids operates a WWTF which includes secondary and tertiary treatment of industrial and domestic strength wastewater and land application of residual sludge.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0022080 (expires May 31, 2018)
- NPDES permit application dated December 7, 2012
- Wastewater Treatment Facilities Drawings, dated February 1978, July 1981, June 2001, April 2009
- Conceptual Analysis Report for Wastewater Treatment Plant, dated March 2007

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	15.2
Average Flow (mgd)(1)	6.2
Year Built	1978, Upgraded in 1981, 2001, and 2012
Watershed	Upper Mississippi River
Discharge Location	Mississippi River (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Pre-aeration units, primary clarifiers, activated sludge treatment secondary clarifiers, chlorination, polishing ponds, screw press and gravity belt
Facility Class	A
Service Population(2)	11,281
Estimated Equivalent Residential Units (ERU)	4,897
Median Household Income(3)	$39,974
Typical Residential Sewer Rate(4)	$432

(1) City of Grand Rapids discharge monitoring report data, November 2010 – July 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 14, 2016. The process flow diagram developed for the model is shown in Figure D-1.

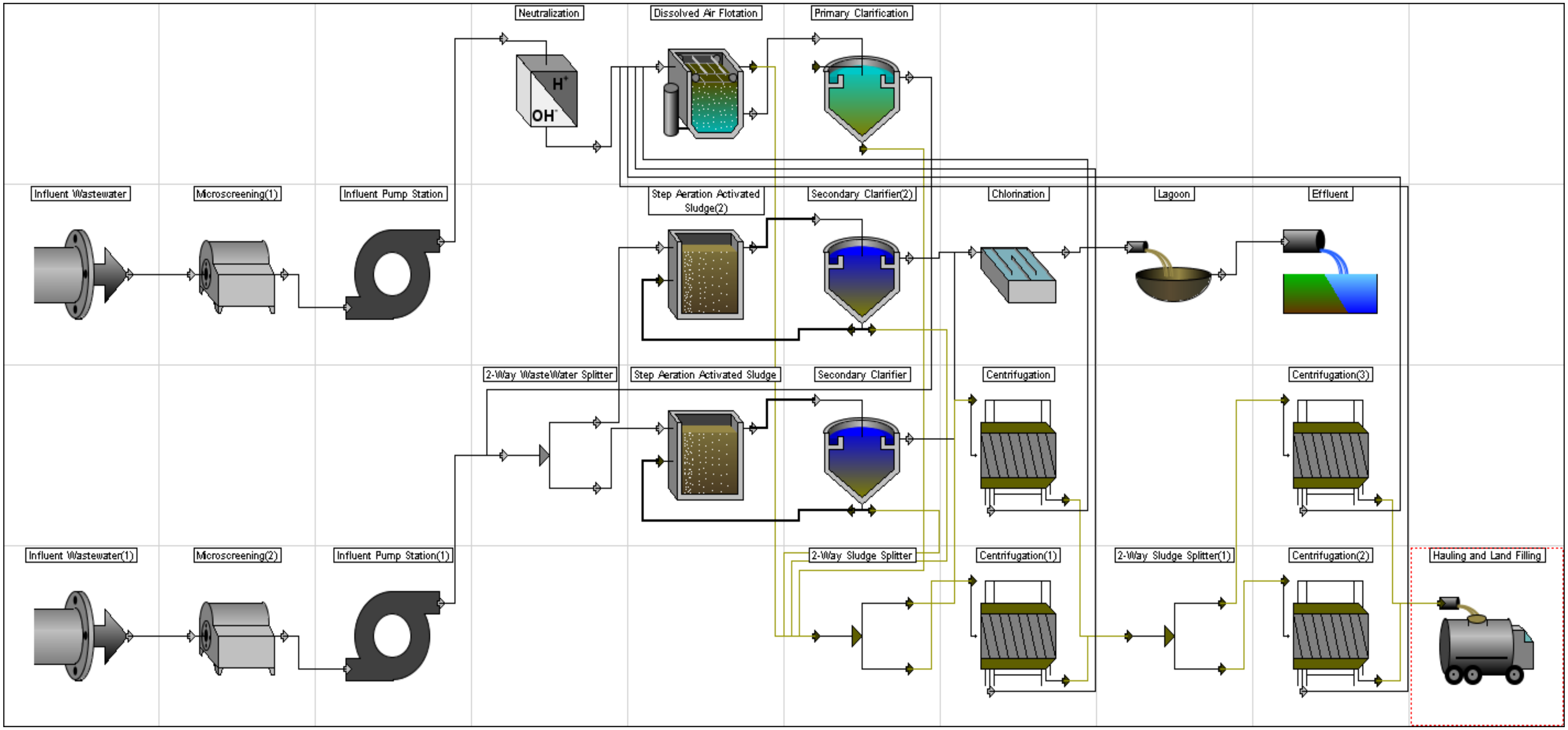

Figure D-1 Process flow diagram of existing Grand Rapids WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBELs) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades may be needed to meet some of current and future WQBELs. Table D-2 compares effluent characteristics, existing permit limits, current WQBELs and future WQBELs.

Table D-2 Summary of Existing and Estimated Effluent Limits: Grand Rapids WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jan-May	0.52-3.2	NA	9.7 MDL 4.9 AML	3.1 MDL 1.6 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jun-Sep	0.36-0.9	8.0	4.0 MDL 2.3 AML	2.4 MDL 1.4 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Oct-Dec	0.22-1.57	NA	7.1 MDL 3.3 AML	3.1 MDL 1.4 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	0.13-3.6	monitor	NA	NA
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.09-0.967	monitor	NA	NA
Total Suspended Solids	Cal Mo Avg	Jan-Dec	1.3-9.0	30	No change	No change

Cal Mo Avg—calendar month average
MDL—maximum daily limit
AML—average monthly limit
NA—not applicable
(1) From data reported on monthly discharge monitoring reports November 2010 through July 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

Exceedances of the current WQBEL for ammonia have not occurred during the last 3 years of monitoring. Exceedances of the future WQBEL for ammonia have occurred four times during the last 3 years of monitoring. Three of those exceedances occurred in the winter of 2013/14 and were less than 0.2 mg/L above the future WQBEL for ammonia. The fourth exceedance of the future WQBEL occurred in January 2016, was associated with unusually high TSS in the effluent, and could have been associated with variation in the industrial waste load in combination with cold weather.

The existing wastewater treatment process should be adequate for meeting the current and future WQBELs for ammonia assuming the industrial waste is adequately pretreated. Additional ammonia treatment should not be required. Based on historical data, indicating higher ammonia effluent concentrations in the winter months, operational practices may need to be adjusted to consistently meet the future WQBEL. These changes could impact overall O&M costs for the facility.

The current and future WQBELs for TSS are being met by the existing WWTF. The current system should be capable of treating to less than 15 mg/L.

WQBELs are not expected for chloride, nitrate, phosphorus, sulfate, or total suspended solids.

D4.0 Proposed Upgrades to Meet Current Standards

The facility is capable of meeting the current TSS and ammonia WQBELs without modification.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

Upgrades are not needed.

D6.0 Proposed Upgrades to Meet Future Standards

The facility is capable of meeting the future TSS and ammonia WQBELs without modification.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

Upgrades are not needed.

Memorandum

To: MMB
From: Katie Wolohan, Jeff Ubl, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Hanska to meet current and future water quality standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jon Minne, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Hanska would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards, if necessary.
- Use the CapDetWorksTM tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0	Background information on the existing WWTF.
Section D3.0	Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0	Proposed upgrades to meet current standards
Section D5.0	Estimated costs of proposed upgrades to meet current standards
Section D6.0	Proposed upgrades to meet future standards
Section D7.0	Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Hanska operates a WWTF which includes one lift station and a two-cell stabilization pond system.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0052663 (expires February 28, 2021)
- Construction of Wastewater Treatment Facility "As Built Plans", dated approximately 1983

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of existing Hanska WWTF

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	0.05
Design Average Dry Weather Flow (mgd)	0.04
Average Flow (mgd)(1)	0.051
Year Built	1983
Watershed	Minnesota River
Discharge Location	County Ditch No. 63
Major Treatment Units	Stabilization ponds (2)
Facility Class	D
Service Population(2)	376
Estimated Equivalent Residential Units (ERU)	208
Median Household Income(3)	$48,676
Typical Residential Sewer Rate(4)	$302/year

(1) City of Hanska monthly discharge monitoring reports influent flow, December 2010 - June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8,000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 18, 2016. The process flow diagram developed for the model is shown in Figure D-1.

There are no differences between the model and the existing WWTF.

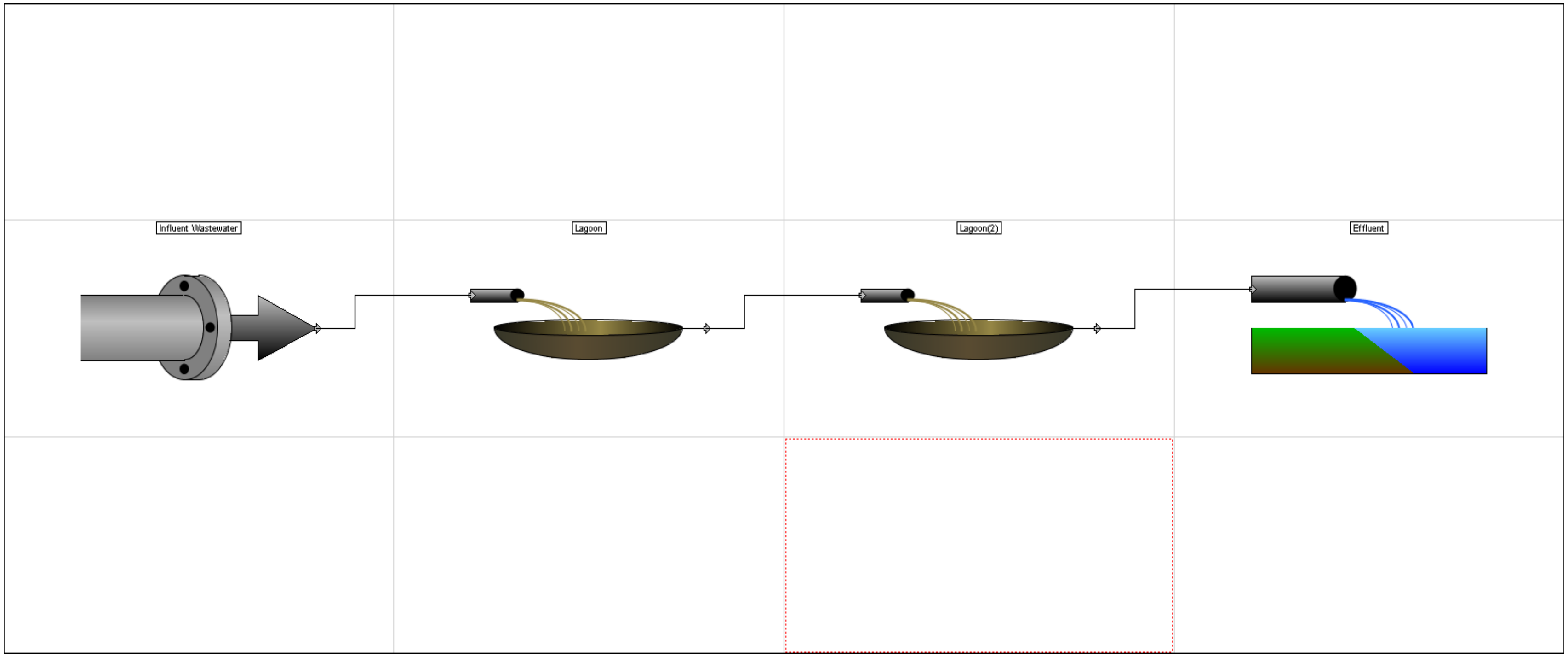

Figure D-1 Process flow diagram of existing Hanska WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

For some WWTFs, current and proposed MPCA water quality standards (WQS) could result in water quality based effluent limits (WQBELs) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs at some WWTFs included as part of the study.

Table D-2 compares effluent characteristics and existing permit limits. Water quality standards for Nitrate, Sulfate, Chlorides, TSS, and P do not apply to Hanska based on the beneficial use classifications for County Ditch No. 63, where the facility discharges. Therefore, no current or future WQBELs were calculated for Hanska, as no current or future water quality standards for Nitrate, Sulfate, Chlorides, TSS, or P apply to this facility's discharge. Despite the receiving water beneficial use classifications, the MPCA has set a numeric P limit for Hanska of 138 kg/year (12-month moving total) to be protective of downstream Lake Pepin. The new P limit is treated as a current WQBEL in the MPCA's January 2016 Statement of Basis that supports the March 1, 2016 NPDES Permit and therefore this memo will also treat it as a WQBEL. Hanska currently has no permit limit requirements, monitoring or otherwise, for Sulfate and Chlorides and does not collect DMR data for these pollutants.

Table D-2 Summary of existing and estimated effluent limits: Hanska WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jan-Dec	Not monitored	monitor	NA	NA
Chloride (mg/L)	Cal Mo Max	Jan-Dec	Not monitored	NA	NA	NA
Nitrate (mg/L as N)(4)	Cal Mo Avg	Jan-Dec	0.06	monitor	NA	NA
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.5-4.8	monitor	NA	NA
Total Phosphorus (kg/year)	Mass limit 12-mo moving total	Jan-Dec	78(5)	138 kg/yr	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec, (Sep-Aug), (Oct-Sep)	3.6-48.5	45	No change	No change

Cal Mo Avg—calendar month average
AAF—average annual flow
NA — not applicable
(1) From data reported on monthly discharge monitoring reports March 2011 through June 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.
(4) DMR data reported as nitrate +nitrite.
(5) 2016 12-month moving total through June 2016.

New WQBELs for TSS, P, Nitrate, Chlorides, and Sulfate are not expected. The Hanska WWTF discharges to County Ditch No. 63 which is designated Class 3C, 4A, 4B, 5, 6, and 7. There are no water quality standards for TSS, P, Nitrate, Chlorides, and Sulfate associated with these beneficial use classifications. However, an upgrade to the WWTF may be needed to meet the existing total phosphorus effluent limit in the facility's current NPDES/SDS permit of 138 kg/year on 12-month moving total basis.

Based on DMR data from March 1, 2011 through June 1, 2016 the WWTF will potentially not meet the 138 kg/year 12-month moving total phosphorus effluent limit. The facility is permitted for an average wet weather design flow of 0.05 mgd. At that flow, the maximum allowable concentration would be 2.0 mg/L, which may not be achievable with the technology in use at the existing WWTF. With only three months of 12-month moving total phosphorus discharge info in 2016, there is not enough information to determine if the mass limit can be met.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Limits

Treatment for phosphorus the meet the existing permit limit would require ferric chloride addition prior to the existing secondary stabilization pond.

Additional equipment required would include the following:

- Chemical metering pumps
- Chemical storage tank
- Secondary containment
- Building enclosure
- Truck access

The existing facility would not require tertiary filtration to meet the phosphorus limit in the existing permit.

Alternatively, ferric chloride addition for treatment of phosphorus in the secondary stabilization pond could be accomplished by applying chemical from a small chemical tank mounted on a pontoon boat. Boat application of ferric chloride would require a launch in and out of the secondary pond, and additional chemical storage may be required for transferring out of delivery trucks. This alternative method may have a lower capital cost but was not evaluated in depth in this study. There are potential safety concerns with this method of chemical application; however, it has been used successfully at numerous facilities in Minnesota.

D4.2 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet the existing permit limit for P. Section D5.0 provides more detail on the recommended upgrades.

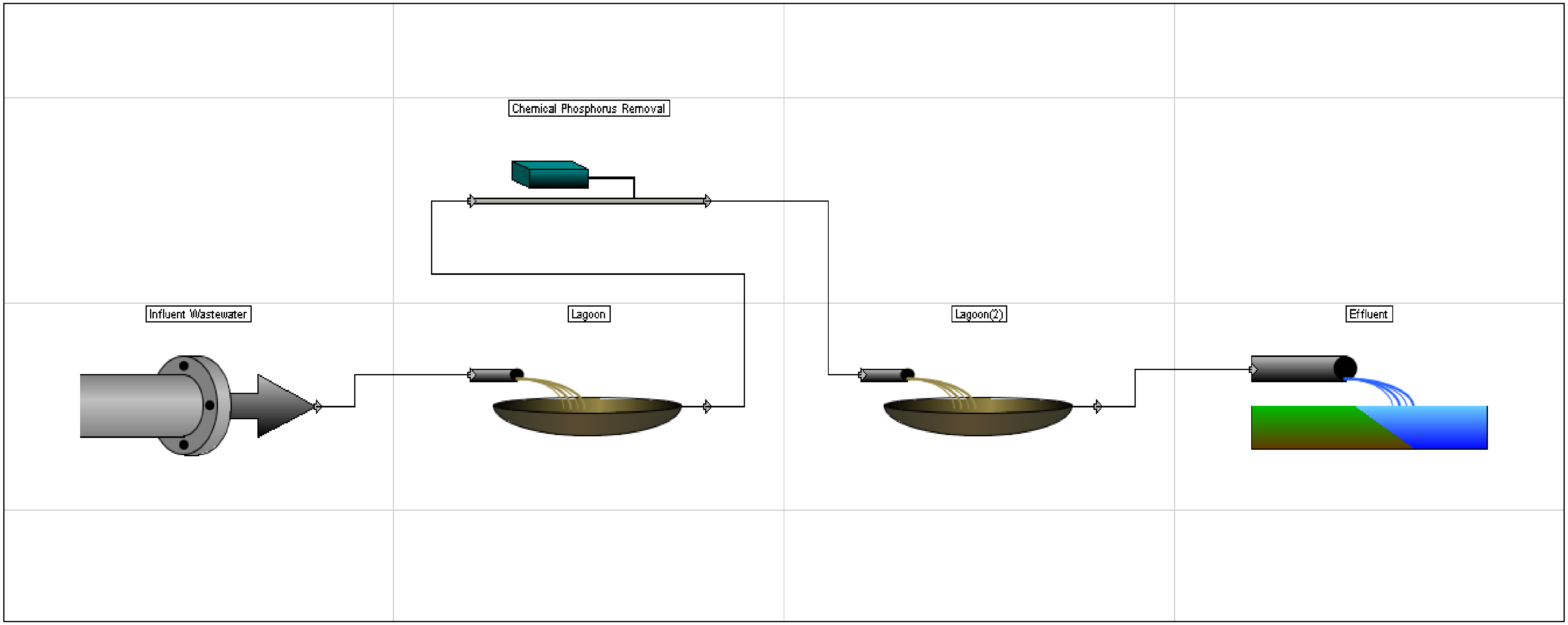

Figure D-2 Process flow diagram of potential WWTF upgrades to meet existing permit limits for Hanska

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-3. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-3, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-3 Capital costs for improvements to meet existing permit limits

Process	Capital Cost ($)
Iron Feed System	$262,000
Direct Costs	$49,000
Contingencies	$47,000
Construction Total	**$358,000**
Engineering, Legal, Admin	$72,000
Totals	**$430,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $29,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the existing permit limits.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's Recommended Practice No. 17R-97: Cost Estimate Classification System. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Other Direct Costs include:
    - Mobilization
    - Site preparation
    - Site electrical

  - Yard piping
  - Instrumentation and control

- Indirect Costs include:

  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

Capital costs associated with boat application of ferric chloride were evaluated and would be approximately $112,000 which includes the boat, chemical storage tanks, chemical transfer pump, and boat ramp.

D5.2 Annual Costs

Annual costs shown in Table D-4 reflect the projected change in costs incurred from adding chemical phosphorus removal to the secondary stabilization pond.

Table D-4 Annual costs for improvements to meet the existing permit limits for Hanska

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Chemical Phosphorus Removal	$0	$0	$0	$1,000	$0	$1,000
Lagoon(2)	$0	$0	$9,200	$0	$0	$9,200
Iron Feed System	$10,300	$0	$4,300	$0	$0	$14,600
Totals	**$10,300**	**$0**	**$13,500**	**$1,000**	**$0**	**$24,800**

Annual cost clarifications:

- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- Lagoon(2) material costs account for increased sludge removal O&M with the addition of chemical phosphorus removal.
- The iron feed system includes costs for operator labor, testing, and materials to maintain the chemical feed pumps.

Operation and maintenance costs associated with boat application of ferric chloride were evaluated and would be approximately $24,000/yr.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated based on population, average annual influent flow to the WWTF, approximate water use per person per day, and the number of households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the existing permit limit for phosphorus would be approximately $258/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate to $560/year per ERU, which is 1.2% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

The upgrades made to meet the current WQBEL would be sufficient to meet the future standards.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

The upgrades made to meet the current WQBEL would be sufficient to meet the future standards.

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Memorandum

To: MMB
From: Tim Reid, Jon Minne, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Hibbing to meet current and future water quality standards
Date: February 9, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Hibbing would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Determine current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks^{TM} tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks^{TM}, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0	Background information on the existing WWTF.
Section D3.0	Estimated effluent limits under current and future water quality standards
Section D4.0	Proposed upgrades to meet current standards
Section D5.0	Estimated costs of proposed upgrades to meet current standards
Section D6.0	Proposed upgrades to meet future standards
Section D7.0	Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Hibbing operates a WWTF which includes secondary treatment of domestic strength wastewater and land application of residual sludge.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0030643 (expires July 31, 2017)
- NPDES permit application dated January 20, 2011
- Facility Plan – Hibbing South Wastewater Treatment Plant, dated August 2009

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	4.5
Average Flow (mgd)(1)	2.78
Year Built	1970, upgraded in 2002 and 2009
Watershed	Lake Superior
Discharge Location	East Swan Creek (Class 2B, 3B, 4A, 4B, 5, 6)
Major Treatment Units	Bar screen, grit removal, primary clarifiers, trickling filters, secondary clarifiers, anaerobic digestion, chlorination/dechlorination
Facility Class	A
Service Population(2)	16,316
Estimated Equivalent Residential Units (ERU)	12,499
Median Household Income(3)	$38,112
Typical Residential Sewer Rate(4)	$620

(1) City of Hibbing discharge monitoring report data, November 2010 – July 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 7, 2016. The process flow diagram developed for the model is shown in Figure D-1.

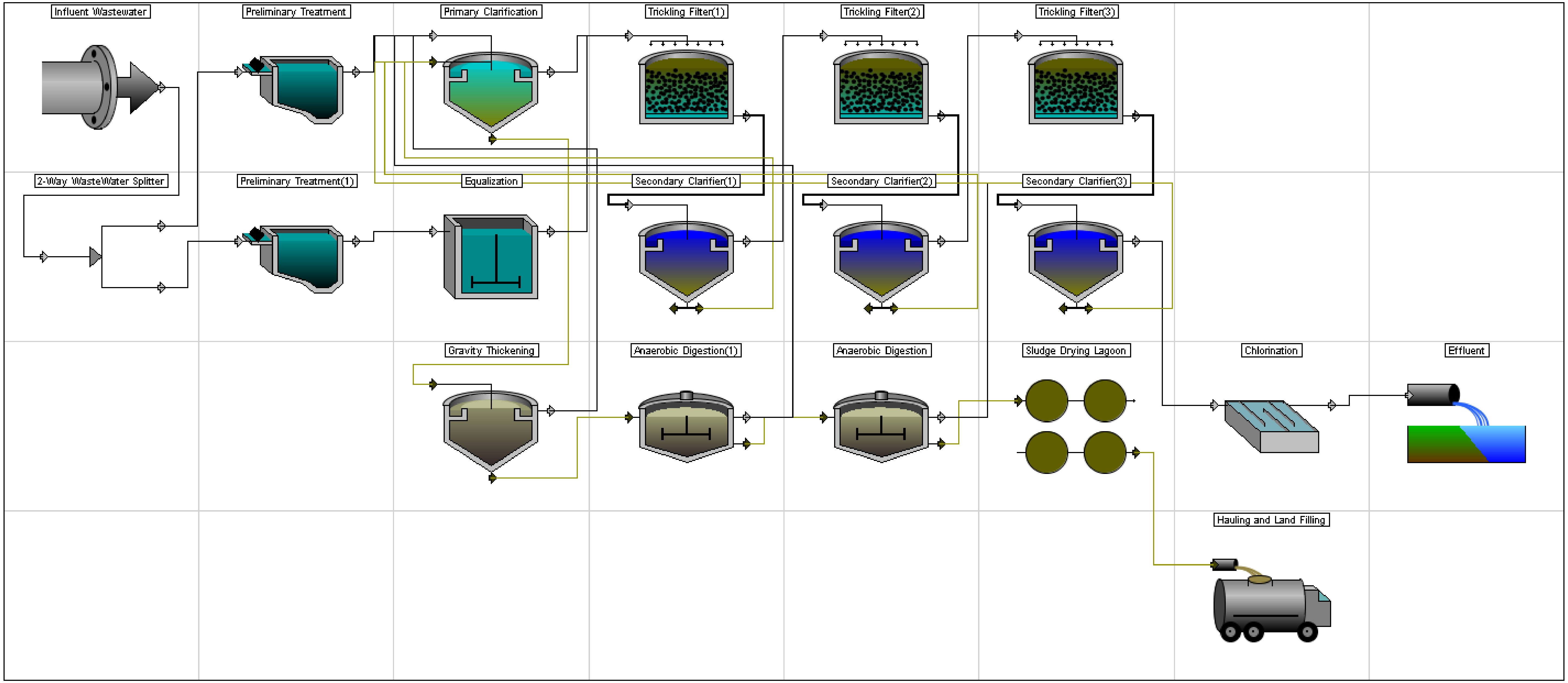

Figure D-1 Process flow diagram of existing Hibbing WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBELs) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-2 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-2 Summary of Existing and Estimated Effluent Limits: Hibbing WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Dec-Mar	0.01-4.1	6.7	19.2 MDL 6.2 AML	4.7 MDL 1.5 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Apr-May	0.008-2.36	8.8	7.1 MDL 2.2 AML	3.3 MDL 1.0 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jun-Sep	0.02-2	1.3	4.2 MDL 1.4 AML	2.3 MDL 0.8 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Oct-Nov	0.04-0.51	4.9	4.1 MDL 1.6 AML	2.9 MDL 1.1 AML
Chloride, Total (mg/L)	Cal Mo Max	Jan-Dec	69-197	Monitor	NA	NA
Nitrate (mg/L)	Cal Mo Avg	Jan-Dec	9.1-17.1	Monitor	NA	6.6 MDL 4.5 AML
Sulfate (mg/L)	Cal Mo Max	Jan-Dec	45-152	Monitor	NA	9.0 MDL 6.0 AML
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.007-0.57	1.0	No change	No change
Total Suspended Solids	Cal Mo Avg	Jan-Dec	1.1-12.3	30	No change	No change

Cal Mo Avg—calendar month average
Cal Mo Max – calendar month maximum
MDL—maximum daily limit
AML—average monthly limit
NA—not applicable
(1) From data reported on monthly discharge monitoring reports November 2010 through July 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The exceedance of the current WQBEL for ammonia noted above occurred once in Dec-Mar, once in Apr-May, and once in Jun-Sep during the last 5 years of monitoring, with zero exceedances in Oct-Nov. Excluding those sampling dates, the ammonia in Dec-Mar, Apr-May, and Jun-Sep have not exceeded 0.75, 0.14, and, 0.6mg/L, respectively. The existing wastewater treatment process should be adequate to meet the current and future WQBELs for ammonia. Additional ammonia treatment processes should not be required. Based on historical data, operational practices may need to be adjusted to consistently meet the future ammonia WQBELs. These changes could impact overall O&M costs for the facility.

The future WQBEL for nitrate would require additional treatment. The facility has never reported a monthly average effluent nitrate concentration below the WQBEL value.

The current and future WQBELs for sulfate would require additional treatment. The facility has never reported a monthly average effluent sulfate concentration below the WQBEL value.

The current WQBEL for total phosphorus would not require additional treatment.

The current and future WQBELs for TSS were exceeded several times in 2011-2013. Effluent TSS concentrations in the past two years have not exceeded 3 mg/L. The current system should be capable of treating to less than 10 mg/L.

D4.0 Proposed Upgrades to Meet Current Standards

The facility is capable of meeting the current WQBELs without modification.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

The facility is capable of meeting the current WQBELs without modification.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutruent Requirements

The existing trickling filters do not have the capacity to meet future nitrate WQBEL, so a suspended growth denitrification process followed by an aerated tank to strip produced nitrogen gas would be needed. The nanofiltration (NF) treatment system proposed to meet a future sulfate WQS is expected to remove about 50% of nitrate in NF feed. As a result, an added denitrification tank would need to remove nitrate to about 9 mg/L in order to meet an AML of 4.5 mg/L in NF effluent.

A denitrification and activated sludge system capable of meeting the nitrate WQBELs would include the following:

- New anoxic tank
- New aeration tank
- New aeration and blower system
- Reuse existing recirculation pumps
- Existing secondary clarifier can be reused

D6.2 Upgrades to Meet Sulfate Limit

6.1.1 Sulfate

The 4-year average sulfate concentration is nearly ten times the calculated current and future WQBEL. To meet the current WQBEL, additional treatment would be required.

Figure D-2 shows the relationship between flow and sulfate concentration. As flow increases, the sulfate concentration decreases. This would allow a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates.

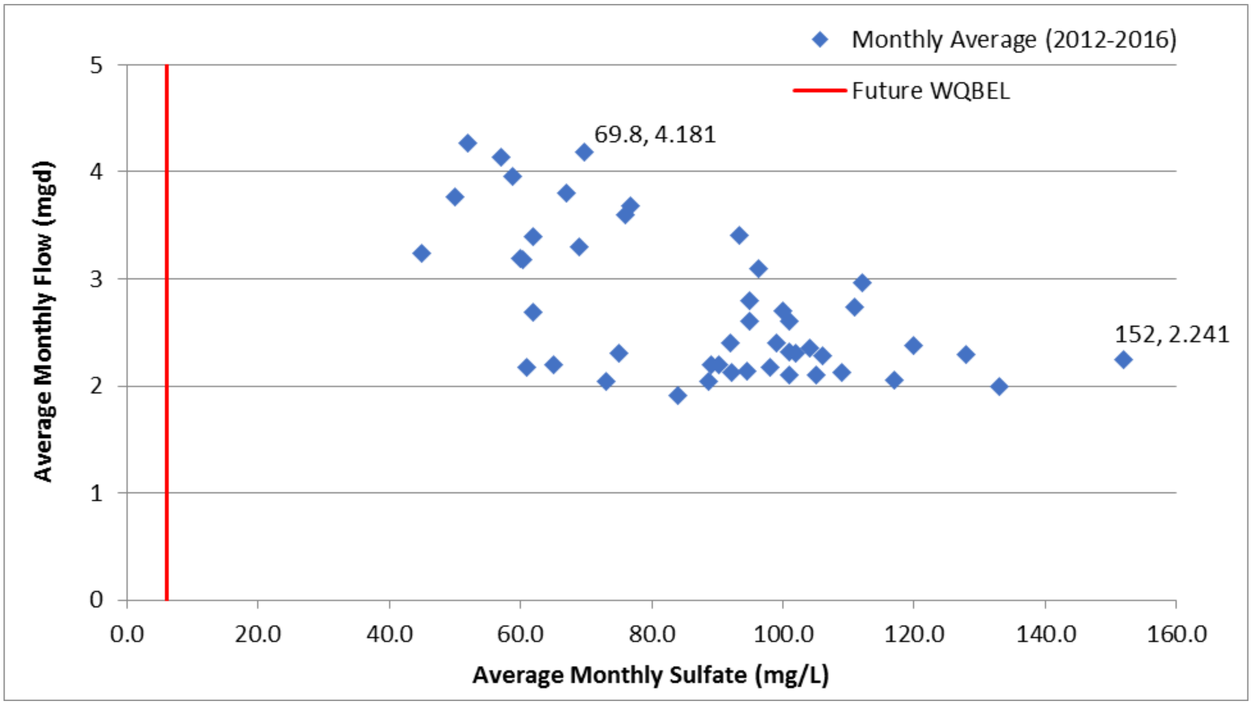

Figure D-2 Effluent Flow and Sulfate Concentration Relationship, Hibbing

Sulfate can be removed using nanofiltration (NF). NF could remove 95% of sulfate.

Water reaching the NF system would require pretreatment to remove solids with a deep-bed, granular-media filter, or an ultrafilter.

Assuming 95% removal of sulfate, an NF system can be sized to treat a portion of the flow adequate to bring the blended flow below the monthly average requirement of 6 mg/L.

The extreme conditions recorded in the past 4 years include a high sulfate concentration of 154 mg/L at a flow of 2.241 mgd and a high sulfate mass with a concentration of 69.8 mg/L at a flow of 4.181 mgd.

6.1.2 Sulfate Treatment System

NF treatment produces a significant brine waste stream. The most viable method of disposal of brine would be evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required for NF treatment:

- The AWW would have the same sulfate concentrations as the high flow, low concentration conditions observed in the past (this is a conservative assumption as the concentrations would likely be lower).
- The NF would generate 20% of its feed flow as brine
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent without further treatment.

NF treatment of a side stream for sulfate would require the following new treatment units:

- Deep bed granular filtration of the NF influent (total capacity of 2,793 gpm)
- NF system capable of treating 2,793 gpm at AWW
- Evaporator/Crystallizer capable of treating 559 gpm at AWW
- Salt storage (10,000 cf required for weekly disposal)
- Truck access

D6.3 Summary of Proposed Upgrades

Figure D-3 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades.

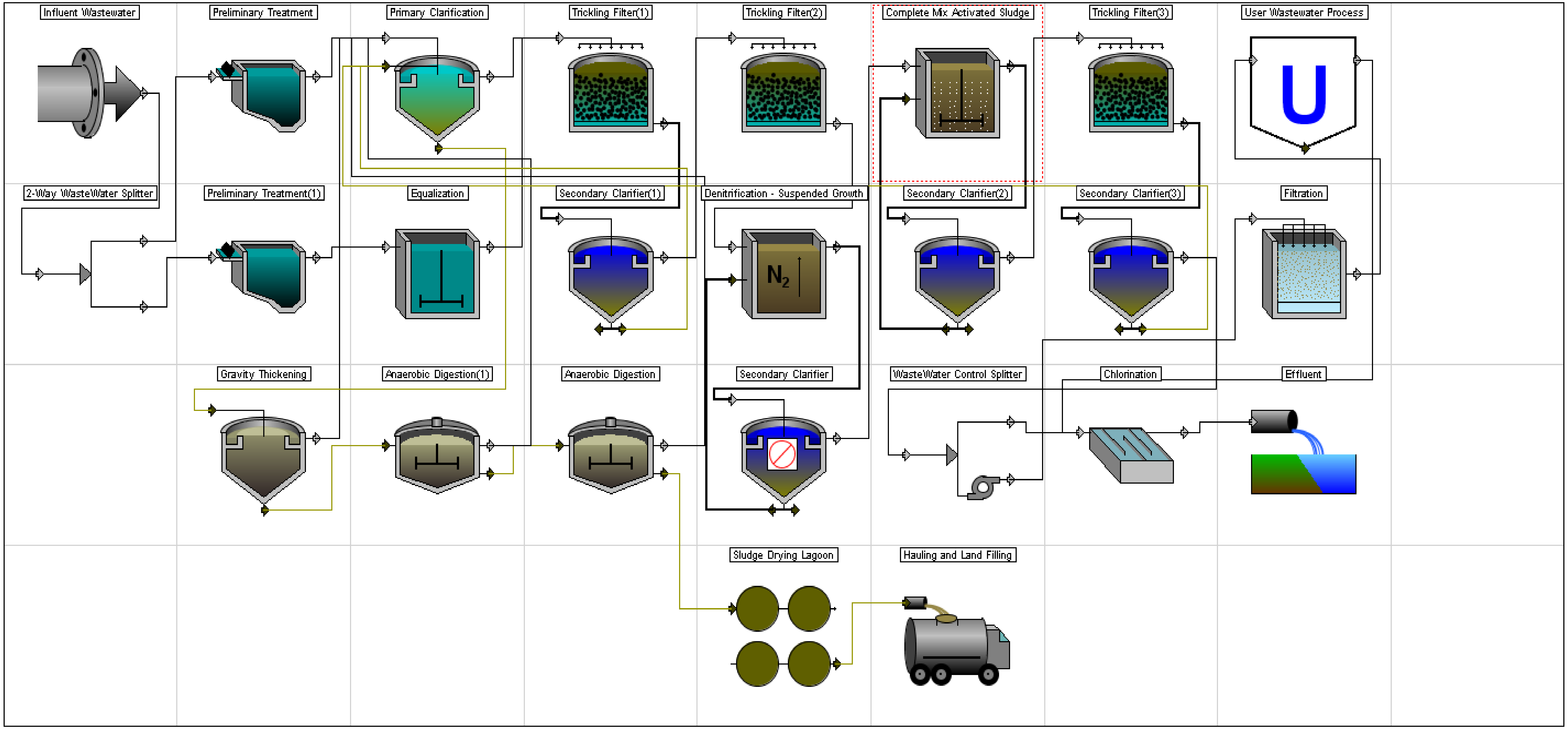

Figure D-3 **Process flow diagram of potential WWTF upgrades to meet future WQBELs for Hibbing**

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-3. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-3, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-3 Capital costs for improvements to meet future WQBELs

Process	Capital Cost ($)
Denitrification - Suspended Growth	$508,000
Blower	$163,000
Aerobic Tank	$492,000
Filtration	$3,691,000
WasteWater Control Splitter	$157,000
NF	$5,271,000
Evap/Cryst	$33,579,000
Hauling and Disposal	$853,000
Direct Costs	$4,514,000
Contingencies	$7,385,000
Construction	**$56,613,000**
Engineering, Legal, Admin	$11,323,000
Totals	**$67,936,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $4,586,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes required to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the potential new WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Denitrification costs include:
    - Denitrification tank
    - Aeration tank
    - Slow speed aerator
    - Vertical turbine pump
    - Blower system
- Filtration costs include:
    - Deep-bed, dual media gravity filtration
    - Concrete basins with handrail
    - Automatic valves
    - Backwash tank and pumps
    - Building to house filters
- NF Filtration costs include:
    - Booster pumps
    - Process piping and valves
    - NF membrane skids with 8" membrane modules
    - Clean-in-place equipment
    - Process equipment building space
- Evaporator/Crystallizer costs include:
    - Process piping and valves
    - Evaporator
    - Crystallizer
    - Process equipment building space
- Hauling and Disposal costs include:
    - Salt storage shed
    - Loading equipment
    - Truck access
- Other Direct Costs include:
    - Mobilization

- Site preparation
- Site electrical
- Yard piping
- Instrumentation and control
- Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs before contractor profit
  - Engineering, legal, and administrative at 20% of construction cost

D7.2 Annual Costs

Annual costs shown in Table D-4 reflect the projected change in costs incurred from changing the secondary treatment process and adding anaerobic digestion.

Table D-4 Annual costs for improvements to meet the future WQBEL for Hibbing

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Denitrification - Suspended Growth	$85,000	$43,400	$4,500	$132,000	$53,200	$318,100
Complete Mix Activated Sludge	$48,700	$25,300	$9,200	$0	$7,800	$91,000
Filtration	$7,200	$4,100	$26,600	$0	$2,100	$40,000
WasteWater Control Splitter	$26,300	$18,600	$900	$0	$10,600	$56,400
NF	$37,600	$28,000	$31,500	$261,300	$139,800	$498,200
Evap/Cryst	$150,400	$19,500	$77,800	$174,400	$3,483,300	$3,905,400
Hauling and Disposal	$18,100	$0	$849,300	$0	$0	$867,400
Totals	$373,300	$143,900	$999,800	$567,700	$3,708,800	**$5,793,500**

Annual cost clarifications:

- Hauling and land filling would include the cost of hauling sludge waste to a landfill. The sludge waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.
- The effluent from the NF/evaporator/crystallizer treatment process may not need disinfection prior to discharge. However, this reduction would likely result in only a small cost savings and therefore is not reflected in the annual costs.

D7.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated by dividing the average daily flow (2,780,000 gpd) by the existing population, dividing by 100 (typical domestic wastewater generation rate in gallons per person per day) and multiplying by the number of residential households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $830/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate to $1,450/year per ERU, which is 3.8% of the median household income.

Memorandum

To: MMB
From: Bryan Oakley, Katie Wolohan, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Lake Crystal to meet Anticipated Water Quality Standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jon Minne, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Lake Crystal would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0	Background information on the existing WWTF.
Section D3.0	Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0	Proposed upgrades to meet current standards
Section D5.0	Estimated costs of proposed upgrades to meet current standards
Section D6.0	Proposed upgrades to meet future standards
Section D7.0	Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Lake Crystal operates a WWTF which includes tertiary treatment of domestic strength wastewater and land application of residual sludge.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0055981 (expired December 22, 2015)
- Construction of Wastewater Treatment Facility "As Built Plans", dated April 22, 1987
- Wastewater Treatment Facility Contract Drawings, dated July 18, 2003

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of existing Lake Crystal WWTF

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	0.59
Design Average Dry Weather Flow (mgd)	0.424
Average Flow (mgd)(1)	0.269
Year Built	1987, upgraded 2003
Watershed	Minnesota River
Discharge Location	Minneopa Creek (Class 7)
Major Treatment Units	Nitrifying rotating biological contactor (RBC), chemical phosphorus removal, anaerobic sludge digestion
Facility Class	B
Service Population(2)	2,554
Estimated Equivalent Residential Units (ERU)	1,270
Median Household Income(3)	$60,318
Typical Residential Sewer Rate(4)	$726/year

(1) City of Lake Crystal discharge monitoring report data, January 2011 – June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 5, 2016. The process flow diagram developed for the model is shown in Figure D-1.

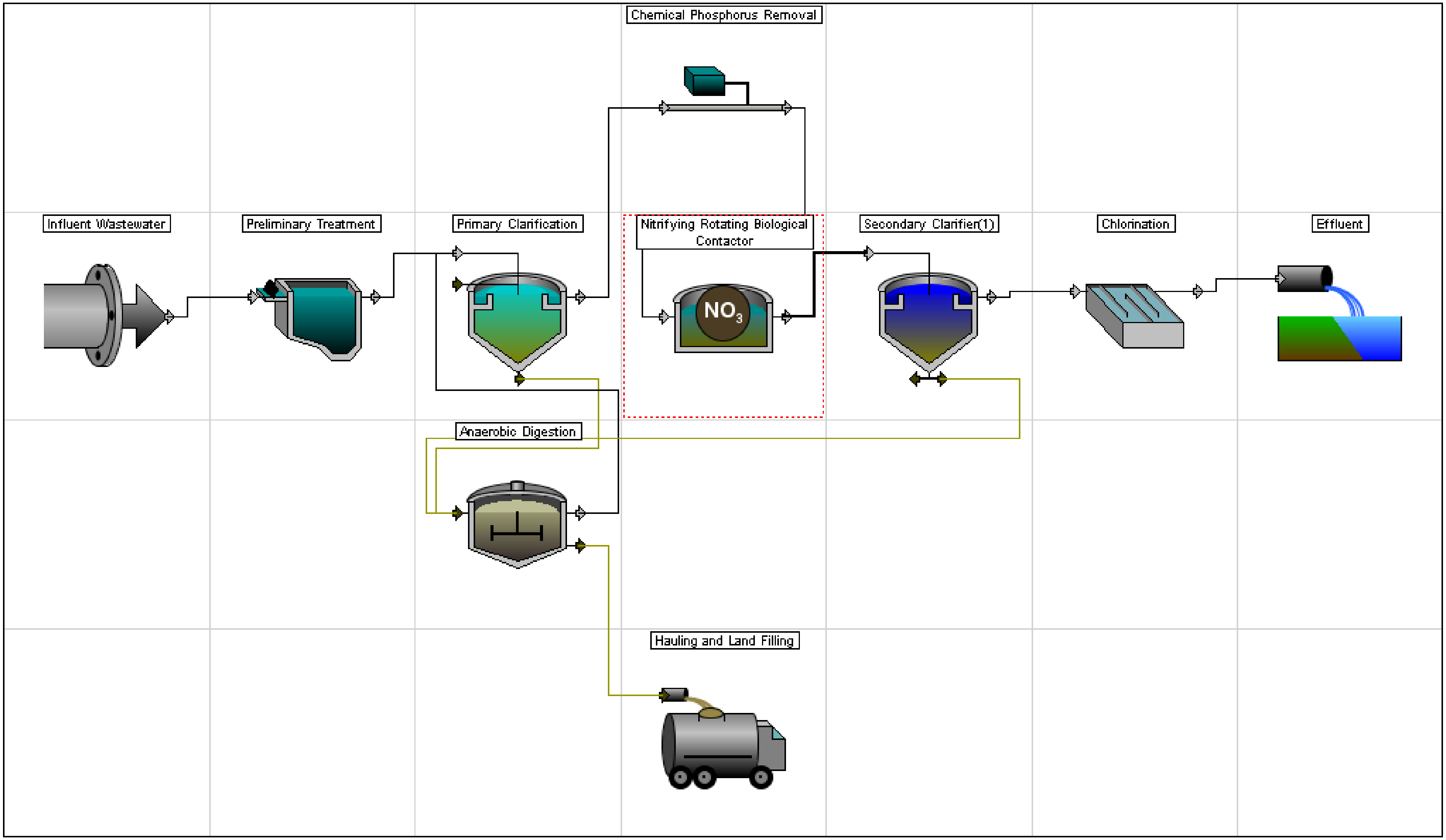

Figure D-1 Process flow diagram of existing Lake Crystal WWTF

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WWTF

Actual Feature	Model Difference from Actual	Impact on Analysis
The RBC are typically operated four in series prior to secondary clarification.	The model does not offer this layout as an option. Model has a single RBC unit process	None. The nitrate in the modeled secondary effluent is similar to the nitrate in the actual effluent.
Chemical is added for phosphorus removal prior to the secondary clarifier.	The model does not offer this layout as an option. In the model, chemical is added for phosphorus removal prior to the RBC.	None. The chemical phosphorus removal target concentration is selected to ensure adequate phosphorus is available to support biological growth in the RBC.
Digested sludge is stored onsite.	The model does not offer sludge storage as an option.	None. This is a site-specific requirement and is evaluated independently of the model.

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-3 Summary of existing and estimated effluent limits: Lake Crystal WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia-N (mg/L)	Cal Mo Avg	Apr-Oct	2.02-9.40	monitor	NA	1.2 MDL 0.6 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	9.3-21.0	NA	NA	NA
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.08-1.20	1.0	No change	No change
Total Phosphorus	Mass limit	Jan-Dec	0.07-0.73 kg/day AML	358 kg/yr (0.98 kg/d at AAF)	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	3.5-15	30	No change	No change

Cal Mo Avg—calendar month average

MDL—maximum daily limit
AML—average day of the AWW month
AAF—average annual flow
NA—not applicable
(1) From data reported on monthly discharge monitoring reports January 2011 through June 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

For ammonia, existing effluent concentrations are higher than the future WQBEL. Therefore, the existing secondary treatment process would need to be upgraded to meet the future WQBEL for ammonia.

New WQBELs for chlorides, nitrate, sulfate, total phosphorus, total suspended solids (TSS) are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

Upgrades are not needed to meet current WQBELs.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

Upgrades are not needed to meet current WQBELs. As flow increases, chemical use would increase, but this would not result in an additional capital cost.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Limits

The existing rotating biological contactor (RBC) process has not demonstrated the capacity to remove ammonia to the future WQBELs, so the secondary treatment system would need to be replaced. Because the existing RBCs are 29 years old it is assumed that they would require replacement soon. This treatment technology is no longer commonly used in municipal wastewater treatment facilities. Therefore this analysis assumes that rather than modifying the existing system, the city would replace the RBCs with an activated sludge system capable of meeting the ammonia WQBEL.

An activated sludge system capable of meeting the ammonia WQBEL would include the following:

- Anaerobic/Oxic (A/O) activated sludge process
  - New mixed anaerobic tank
  - New aeration tank
  - New blower system
  - New return activated sludge pumps and pipes
  - Existing waste sludge pumps can be reused as waste activated sludge pumps
  - Existing secondary clarifiers can be reused
- Sludge processing

- Conversion of the existing anaerobic digester to aerobic
- Additional sludge hauling facilities

At existing flows, the existing facility is capable of meeting the phosphorus limits without modification; however, there would be a reduction in chemical use if the activated sludge system is designed to incorporate biological nutrient removal (BNR). This estimate assumes that in addition to ammonia, the activated sludge system would remove phosphorus. Chemical addition for removal of phosphorus would continue, but at a lower chemical usage.

The anaerobic digester is undersized for the future load. In addition, anaerobic digestion returns a very high concentration of phosphorus in the supernatant. This would be reduced by converting the anaerobic digester to aerobic. The chemical phosphorus removal system would be moved to the digester supernatant return to tie up phosphorus released during digestion.

The facility is rated for an AWW of 0.59 mgd and has not experienced a monthly average flow greater than 0.53 mgd or a daily maximum greater than 1.50 mgd in the past 5 years. Tertiary filtration would not be needed to meet the future WQBEL phosphorus limit.

D6.2 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

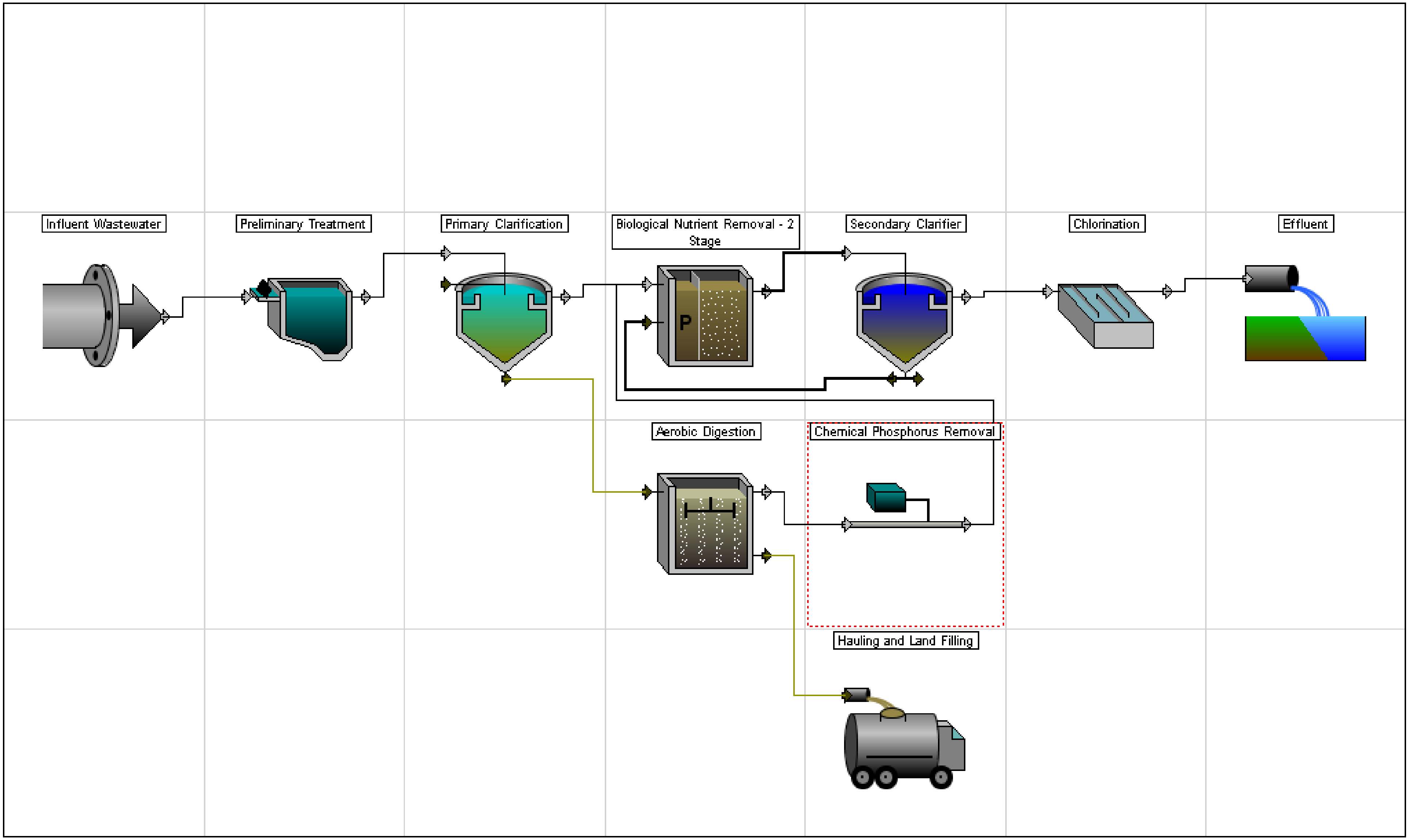

Figure D-2 Process flow diagram of potential WWTF upgrades for Lake Crystal

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for Improvements to Meet Future WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3 Stage	$915,000
Blower System	$447,000
Aerobic Digestion	$352,000
Hauling and Land Filling	$10,000
Direct Costs	$957,000
Contingencies	$403,000
Construction Total	**$3,084,000**
Engineering, Legal, Admin	$617,000
Totals	**$3,701,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $250,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Aerobic digestion costs include:

  - Reuse of existing 40-ft diameter concrete tank
  - Removal of existing floating cover
  - Fixed cover with ventilation
  - Coarse-bubble aeration diffusers
  - Multi-level decant piping
  - Sludge pumps

- Biological Nutrient Removal costs include:
  - Anaerobic/Anoxic/Oxic (A2O) activate sludge process
  - Concrete basins with handrail
  - Return activated sludge pumps
  - Recirculation pumps
  - Pump building
  - Fine-bubble diffusers
  - Anaerobic basin mixers
  - Air piping

- Hauling and Land Filling costs include:
  - Proportioned additional vehicle cost

- Blower System costs include:
  - Air blowers required for BNR and aerobic digestion
  - Blower building space

The following costs are evaluated separately from unit processes:

- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D7.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from changing the secondary treatment process and adding anaerobic digestion.

Table D-5 Annual costs for improvements to meet the future WQBEL for Lake Crystal

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Biological Nutrient Removal - 3 Stage	$81,800	$28,900	$10,100	$0	$18,600	$139,400
Secondary Clarifier	$14,900	$8,200	$500	$0	$100	$23,700
Aerobic Digestion	$12,700	$2,100	$17,200	$0	$8,400	$40,400
Hauling and Land Filling	$1,800	$0	$0	$0	$0	$1,800
Totals	**$111,200**	**$39,200**	**$27,800**	**$0**	**$27,100**	**$205,300**

Annual cost clarifications:

- The BNR system annual costs are partially offset by existing annual costs associated with the RBC process.
- The secondary clarifier is an existing process, but would require more operation and maintenance time due to its use for returning activated sludge to the aeration basin.
- The aerobic digestion costs are partially offset by existing annual costs associated with the anaerobic digestion process.
- Land application of sludge would increase because the BNR process would generate more waste sludge than the RBC process.
- Power costs for the blower system are included in the BNR process and aerobic digestion process line items for energy.
- Note that chemical costs would decrease substantially with the change in process, but would still be required to meet the mass phosphorus load limits.

D7.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was calculated as follows:

The City has approximately 900 active residential connections and 75 commercial connections. Some of the residential connections are multi-family units, so an assumption of 1,110 total residential connections was deemed reasonable. 12.6% of the sewer rate revenue derives from commercial connections, so 1,270 ERU is used for calculation of the user costs.

The increase in user costs is calculated as follows.

$$Increase\ in\ User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $358/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase by over 40% to $1,084/year per ERU, which is 1.8% of the median household income.

Memorandum

To: MMB
From: Tim Reid, Jon Minne, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Nashwauk to meet Anticipated Water Quality Standards
Date: January 27, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Nashwauk would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 Background information on the existing WWTF.
Section D3.0 Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0 Proposed upgrades to meet current standards
Section D5.0 Estimated costs of proposed upgrades to meet current standards
Section D6.0 Proposed upgrades to meet future standards
Section D7.0 Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Nashwauk operates a WWTF which includes secondary treatment of domestic strength wastewater.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MNG580184 (expired August 31, 2015)
- Preliminary Engineering Report, dated August 2005

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of existing Nashwauk WWTF

Parameter	Value or Descriptor
Design Average Wet Weather Flow (mgd)	0.353
Average Flow (mgd)(1)	0.189
Year Built	1988
Watershed	Upper Mississippi River
Discharge Location	Hanna Reservoir #2 (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Bar screen, equalization basin, two primary stabilization ponds, one secondary stabilization pond
Facility Class	D
Service Population(2)	987
Estimated Equivalent Residential Units (ERU)	811
Median Household Income(3)	$34,333
Typical Residential Sewer Rate(4)	$500

(1) City of Nashwauk discharge monitoring report data, May 2011 – June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks,™ based on the sources identified above, and information gathered in a site visit conducted on October 4, 2016. The process flow diagram developed for the model is shown in Figure D-1.

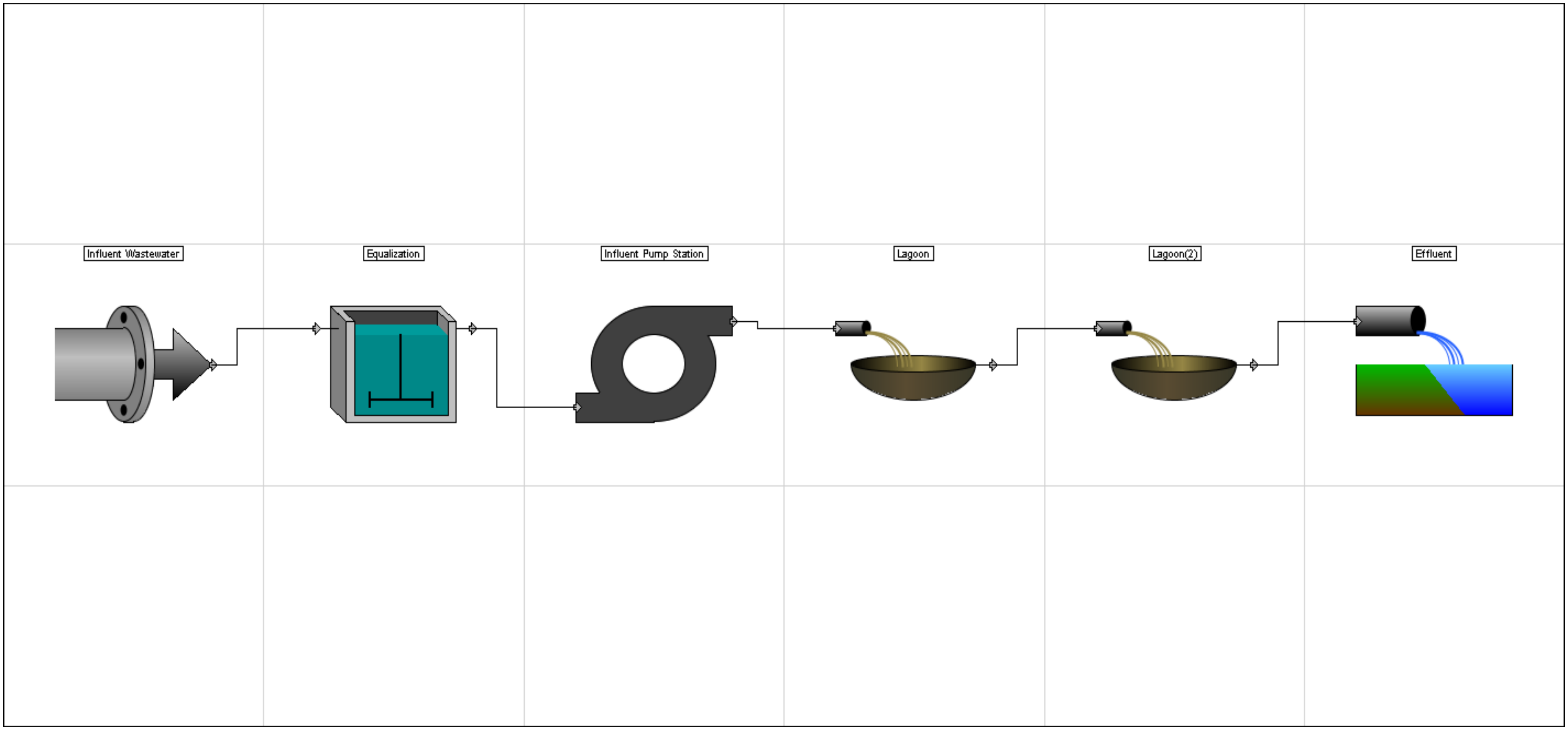

Figure D-1 Process flow diagram of existing Nashwauk WWTF

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WWTF

Actual Feature	Model Difference from Actual	Impact on Analysis
Equalization basin is actually an emergency storage pond during power failures.	Equalization is used in the modeled manner during periods, but not under regular operation.	None

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs). Treatment process upgrades would be needed to meet some of current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-3 Summary of existing and estimated effluent limits: Nashwauk WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia-N (mg/L)	Cal Mo Avg	Apr-Sep	0.66	Monitor	1,7 MDL 0.8 AML	1.3 MDL 0.7 AML
Ammonia-N (mg/L)	Cal Mo Avg	Oct-Mar	1.9	Monitor	5.2 MDL 2.6 AML	3.4 MDL 1.7 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	not monitored	NA	NA	NA
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.47-1.60	1.0	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	3.0-62.0	45	No change	No change

Cal Mo Avg—calendar month average
MDL—maximum daily limit
AML—average day of the AWW month
AAF—average annual flow
NA—not applicable
(1) From data reported on monthly discharge monitoring reports May 2011 through June 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The current and future TSS WQEBLs are not currently being met, and will require upgrades.

The existing ammonia effluent range is lower than the current WQBELs, but this is based on only two sampling periods. It is unlikely the pond system is capable of reliably meeting the current WQBELs for ammonia.

One of the two effluent ammonia concentrations sampled is higher than the future WQBEL. Therefore, the existing process would need to be upgraded to meet the future WQBEL for ammonia.

The existing total phosphorus concentration permit limit was exceeded four times in the past 5 years. With the exception of these exceedances, effluent concentrations and mass loadings are less than required by the current permit. The facility has made adjustments to the alum feed system and currently meets the phosphorus requirements.

New WQBELs for chloride, nitrate, sulfate, and TSS are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Limits

Upgrades are needed to reliably meet current TSS and ammonia limits WQBELs. The limits could be reliably met using an activated sludge package plant. Additional equipment would require:

- An activated sludge secondary treatment system
- A sludge drying bed capable of dewatering and storing waste activated sludge
- Transfer structures to facilitate transfer from the aerated pond to the stabilization ponds

D4.2 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet future WQBELs. Section D6.0 provides more detail on the recommended upgrades.

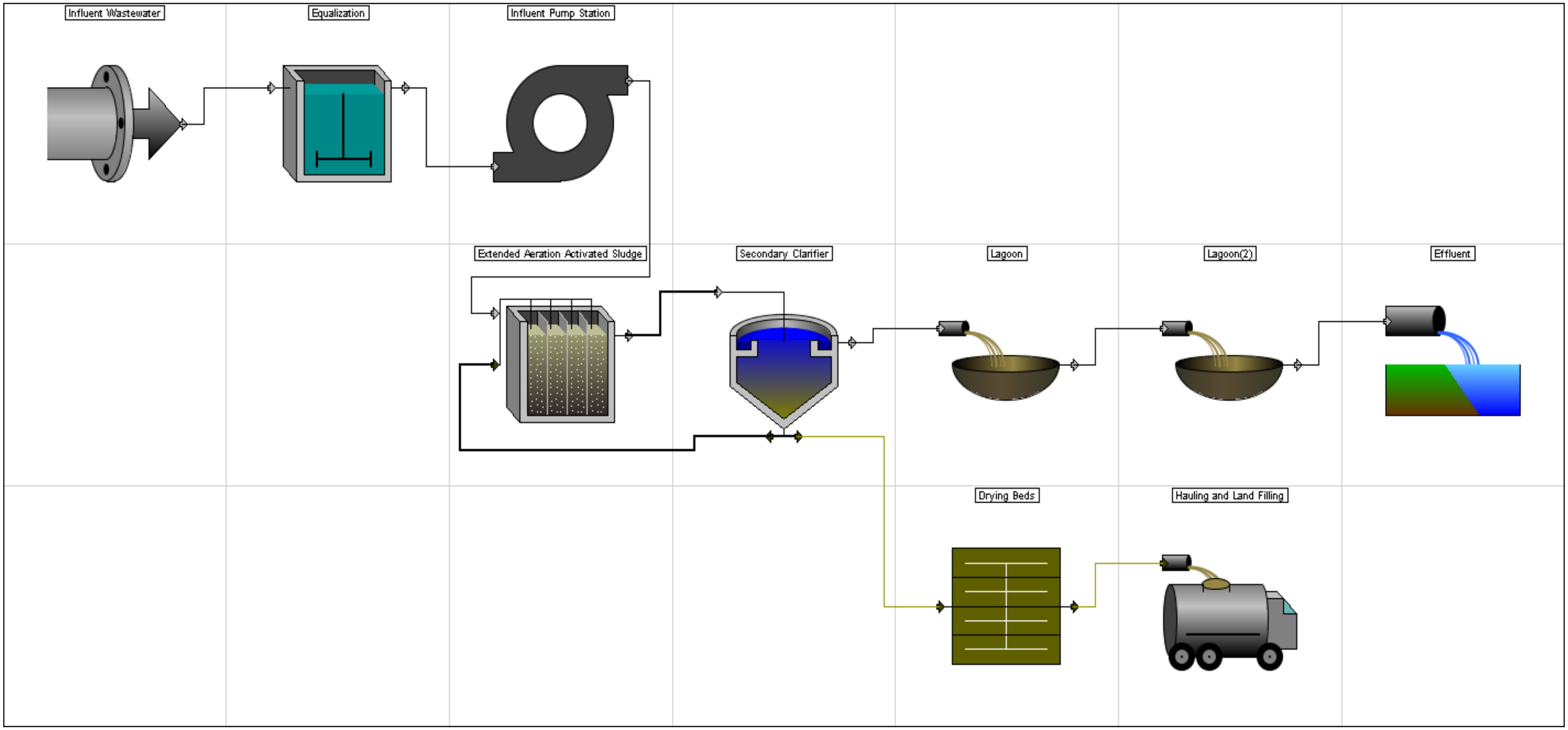

Figure D-2 Process flow diagram of potential WWTF upgrades for Nashwauk

The proposed process would allow the City to meet the ammonia WQBEL using activated sludge. The activated sludge system could be upgraded for biological phosphorus removal, but that is not included in this cost estimate as the City's chemical cost is relatively low.

Activated sludge and secondary clarification are expected to meet the TSS WQBEL of 11 mg/L. TSS in the ponds may periodically exceed the TSS WQBEL due to algal blooms which would require the pond discharge to be halted. This estimate assumes that the existing stabilization ponds will be kept in service to allow seasonal discharges; however, the ponds could be removed from service if a continuous discharge is preferred. This would require adding disinfection.

Sludge wasted from the activated sludge system could be stored in a sludge drying bed for periodic land application.

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system. Amortization is a function of service life and interest rate.

Table D-4 Capital costs for Improvements to Meet Future WQBELs

Process	Capital Cost ($)
Extended Aeration Activated Sludge	$552,000
Secondary Clarifier	$375,000
Drying Beds	$318,000
Hauling and Land Filling	$336,000
Blower System	$232,000
Direct Costs	$773,000
Contingencies	$647,000
Construction	**$3,233,000**
Engineering, Legal, Admin	$647,000
Totals	**$3,880,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $262,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life.
- Future replacement costs.
- Expansion of existing unit processes to treat flow beyond the existing design capacity.
- Collection system upgrades.
- Other capital costs that are not required to meet the future WQBELs.

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Extended Aeration Activated Sludge costs include:
  - Concrete aeration basin
  - Fine-bubble aeration diffuser system
  - Gravity flow to secondary clarifier
- Secondary clarifier costs include:
  - Two 16-ft diameter circular concrete basins with handrail
  - Clarifier covers
  - Return activated sludge pumps
  - Waste activated sludge pumps
- Sludge drying bed:
  - Membrane-lined earth-basin drying beds
  - Process piping and valves
  - Filter media
- Hauling and Land Filling costs include:
  - Loading equipment
  - Truck access
- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs before contractor profit
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from changing the secondary treatment process by adding an aerated pond system.

Table D-5 Annual costs for improvements to meet the future WQBEL for Nashwauk

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Extended Aeration Activated Sludge	$53,400	$21,800	$22,600	$0	$12,800	$110,600
Secondary Clarifier	$28,700	$13,200	$1,400	$0	$800	$44,100
Drying Beds	$20,900	$6,800	$2,100	$0	$0	$29,800
Hauling and Land Filling	$200	$0	$49,700	$0	$0	$49,900
Totals	**$103,200**	**$41,800**	**$75,800**	**$0**	**$13,600**	**$234,400**

Annual cost clarifications:

- Power costs for the blower system are included in the activated sludge process line item.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU includes all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated by dividing the average daily flow (189,000 gpd) by the existing population, dividing by 100 (typical domestic wastewater generation rate in gallons per person per day) and multiplying by the number of residential households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the proposed WQBEL would be approximately $758/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate to $1,258/year per ERU, which is 3.7% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

Upgrades proposed to meet current WQBELs would be sufficient to meet future WQBELs.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

Upgrades proposed to meet current WQBELs would be sufficient to meet future WQBELs.

Memorandum

To: MMB
From: Katie Wolohan, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Rochester to meet current and future water quality standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Jon Minne, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Rochester would need to upgrade their water reclamation plant (WRP). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WRP effluent limits based on current and future water quality standards.
- Conduct a site visit to the WRP to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0- Background information on the existing WRP.
Section D3.0 – Performance of existing WRP relative to estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Rochester operates a WRP which includes tertiary treatment of domestic strength wastewater and land application of residual sludge.

The WRP is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0024619 (expired April 30, 2015)
- Construction of Water Reclamation Plant "As Built Plans" 1980 expansion, dated November 19, 1979
- Record drawings of 1990 Solids Handling Improvements dated April 1990
- Record drawings of 2004 Plant Expansion dated August 2004
- Rochester Water Reclamation Plant facility tour brochure
- City of Rochester Wastewater Rates and Fees Study dated October 2015

Table D-1 summarizes WRP information from those documents.

Table D-1 Summary of existing Rochester WRP

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	19.1 High Purity Oxygen (HPO) 4.75 Activated Sludge (AS)
Design Average Dry Weather Flow (mgd)	15.86
Average Flow (mgd)(1)	13.16
Year Built	1952, upgraded 1982 (HPO), 1990 (solids handling), and 2004 (AS)
Watershed	Lower Mississippi
Discharge Location	South Fork of the Zumbro River (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	High purity oxygen (HPO) activated sludge, conventional air-activated sludge (AS), chemical phosphorus removal, anaerobic sludge digestion
Facility Class	A
Service Population(2)	111,907
Estimated Equivalent Residential Units (ERU)	67,586
Median Household Income(3)	$63,472

(1) City of Rochester discharge monitoring report data, June 2010 – June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WRP was developed using CapDetWorks™, based on the sources identified above, and information gathered in a site visit conducted on October 12, 2016. The process flow diagram developed for the model is shown in Figure D-1.

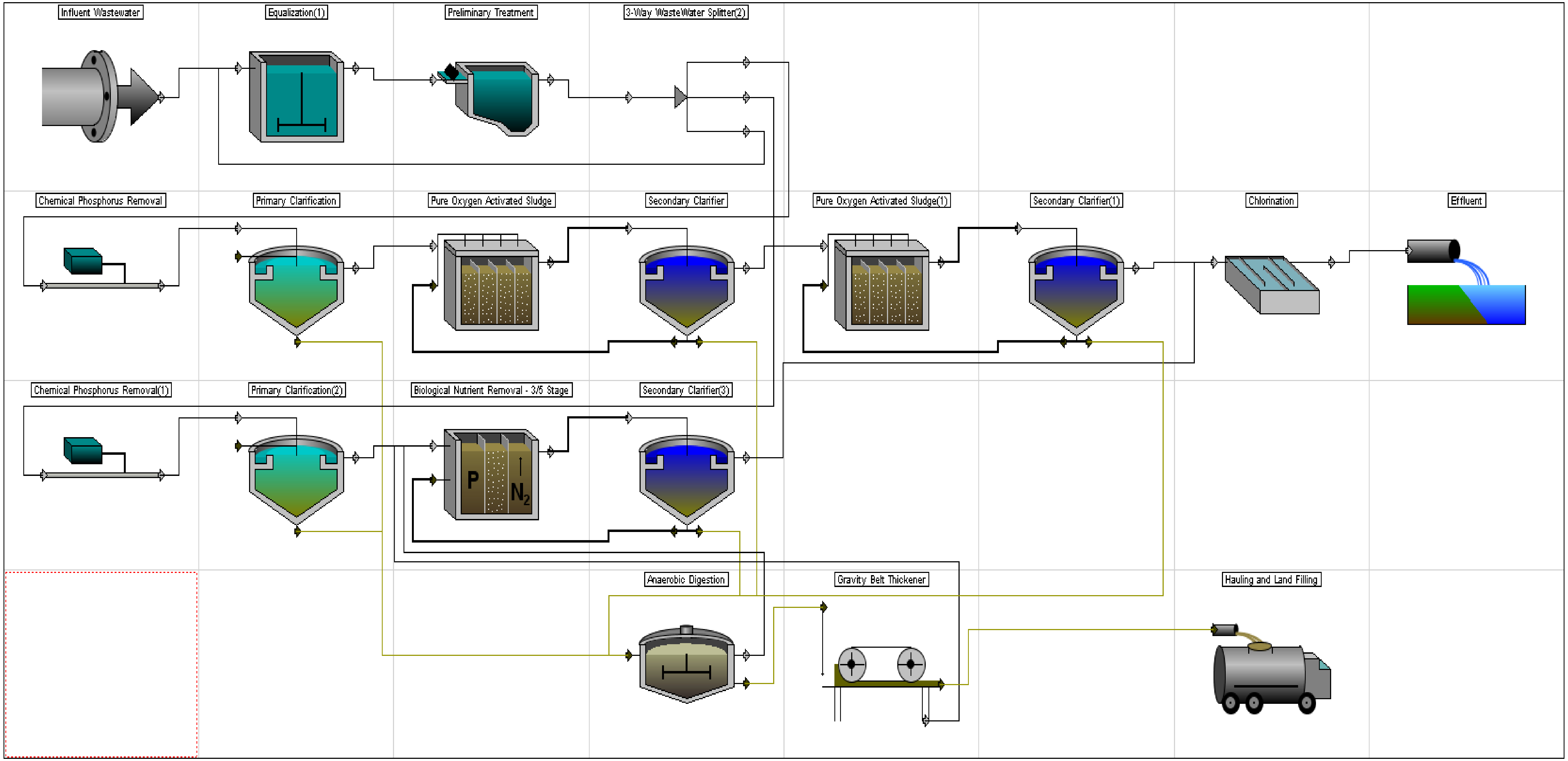

Figure D-1 Process flow diagram of existing Rochester WRP

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WRP

Actual Feature	Model Difference from Actual	Impact on Analysis
Waste activated sludge from primary clarification on both trains is transferred to a blend tank prior to anaerobic digestion.	The model does not offer sludge storage as an option.	None. This is a site-specific requirement and is evaluated independently of the model.
Waste activated sludge from the intermediate clarifiers and final secondary clarifiers on the HPO train is transferred to a holding tank. Waste activated sludge from the secondary clarifiers on the AS train is transferred to the same holding tank.	The model does not offer sludge storage as an option.	None. This is a site-specific requirement and is evaluated independently of the model.
Digested sludge is stored onsite prior to gravity belt thickening. Thickened sludge is also stored onsite prior to loadout.	The model does not offer sludge storage as an option.	None. This is a site-specific requirement and is evaluated independently of the model.
Chlorine contact basin effluent is sent through dechlorination prior to discharge.	The model does not offer dechlorination as a unit process.	None. This is a site-specific requirement and is evaluated independently of the model.

D3.0 Performance of Existing WRP Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBELs) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades would be needed to meet some current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-3 Summary of existing and estimated effluent limits: Rochester WRP

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia-N (mg/L)	Cal Mo Avg	Dec-Mar	0.02-0.32	5.0	10.2 MDL 8.5 AML	4.0 MDL 3.4 AML
Ammonia-N (mg/L)	Cal Mo Avg	Apr-May	0.04-0.77	10.0	4.0 MLD 3.2 AML	2.2 MDL 1.8 AML
Ammonia-N (mg/L)	Cal Mo Avg	Jun-Sep	0.06-0.73	3.0	2.7 MDL 1.5 AML	1.7 MDL 1.0 AML
Ammonia-N (mg/L)	Cal Mo Avg	Oct-Nov	0.03-1.1	3.0	5.7 MDL 2.9 AML	3.5 MDL 1.8 AML
Total Chloride (mg/L)	Cal Mo Max	Jan-Dec	260-430	monitor	292MDL 252 AML	No change
Nitrate-N (mg/L)	Cal Mo Avg	Jan-Dec	17-30	monitor	NA	8.3 MDL 3.9 AML
Total Phosphorus (mg/L)	Cal Mo Avg	Jun-Sep	0.50-1.0	1.0	0.11 AML	No change
Total Phosphorus (kg/d)	Mass Limit 12-mo avg	Jun-Sep	33.4-43.6 kg/d 12-mo avg	72.2 kg/d (0.10 kg/d at AAF)	6.76 kg/d AML	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	4.0-15.0	30	No change	No change

Cal Mo Avg—calendar month average
MDL—maximum daily limit
AML—average day of the AWW month
AAF—average annual flow
NA — not applicable
(1) From data reported on monthly discharge monitoring reports June 2010 through June 2016.
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The current WQBEL for chloride would require additional treatment.

The future WQBELs for nitrate would require additional treatment. In order to address the transformation of organic nitrogen and ammonia nitrogen into nitrate in the receiving water, effluent limits derived from the nitrate water quality standards are set as total nitrogen, not as nitrate-nitrogen.

For total phosphorus, the existing permit limit includes concentration and mass limits. The current WQBEL concentrations were calculated based on the current river eutrophication standards for the Central River Nutrient Region (0.1 mg/L phosphorus) and the permitted average dry weather design flow of 15.86 mgd. The existing WRP is not capable of meeting these limits.

New WQBELs for total suspended solids (TSS) and ammonia are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Requirements

Treatment for phosphorus to meet the current WQBELs would require ferric chloride addition prior to the existing secondary (final) clarifiers and new tertiary filtration.

Additional equipment required would include the following:

- Chemical metering pumps
- Chemical storage tanks
- Secondary containment
- Building enclosure
- Truck access

Tertiary filtration is required to meet phosphorus limits lower than 0.5 mg/L. It can also be used as pretreatment for membrane processes to remove chloride as discussed in Section D4.2.

The facility is capable of meeting the current and future ammonia WQBELs without modification.

D4.2 Upgrades to Meet Chloride Requirements

The current and future estimated WQBELs for chloride are the same. The 6-year average chloride concentration is 125% of the estimated average monthly current and future WQBEL. Of the 73 reported samples, all have been above the current and future WQBEL average monthly limit and 51 have been above the maximum daily limit. To meet the current WQBELs, additional treatment would be required.

Figure D-2 shows the relationship between flow and chloride concentration. Generally, as flow increases, the chloride concentration decreases. Note that chloride is reported as Maximum Monthly on the Rochester discharge monitoring reports (DMR); however, only one test is reported each month, so this is treated as an average monthly concentration.

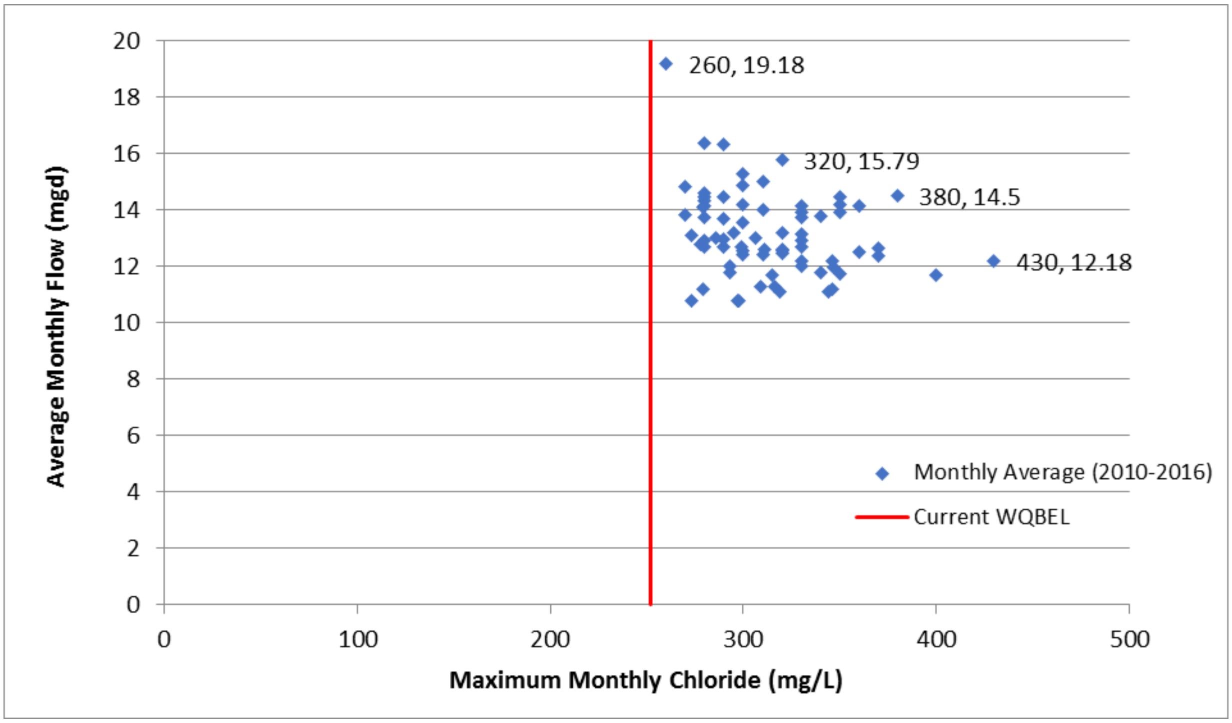

Figure D-2 Effluent Flow and Chloride Concentration Relationship, Rochester

Effluent chloride could be reduced approximately 10 mg/L by changing the disinfection process from chlorination/dechlorination to ultraviolet (UV) light disinfection. However, this change alone would not be sufficient to meet the chloride WQBEL, but could potentially reduce the size of other treatment options. A more detailed cost estimate considering chemical costs and power costs would be required to determine the most cost effective combination of alternatives. An upgrade to UV disinfection is not part of this estimate.

Chloride treatment to meet the current and future WQBELs would require the addition of reverse osmosis (RO) filtration. Water would require pretreatment prior to the RO system to remove solids which could foul the RO membranes. This can be accomplished with a deep-bed media filter or an ultrafilter. For this analysis, a deep bed media filter is assumed.

RO treatment technology removes 99% of chloride, therefore, a reverse osmosis system can be sized to treat a portion of the flow adequate to bring the blended flow below the average monthly limit of 252 mg/L.

The extreme conditions recorded over the past 6 years include a high chloride concentration of 430 mg/L at a flow of 12.18 mgd and a chloride concentration of 260 mg/L at a high flow of 19.18 mgd.

At the low flow, high concentration condition, the RO system would be required to treat 42% of the flow, or 3,537 gpm.

At the average wet weather design flow and the low concentration condition, the RO system would be required to treat only 3% of the flow, or 514 gpm to meet the average monthly limit of 252 mg/L.

RO treatment produces a significant brine waste stream. The most viable method of disposal would be evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required:

- The chloride concentration at the low flow condition is used as the design scenario.
- The RO will generate 25% of its feed flow as brine.
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent for final disinfection.

RO treatment of a side stream from the secondary effluent to meet the current WQBEL for chloride would require the following new treatment units:

- Deep bed granular filtration of the RO influent
- RO system capable of treating 3,537 gpm at the high concentration condition
- Evaporator/Crystallizer capable of treating 884 gpm at the high concentration condition
- Salt storage (6,700 cf required for weekly disposal)
- Truck access

D4.3 Summary of Proposed Upgrades

Figure D-3 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet future WQBELs. Section D5.0 provides more detail on the recommended upgrades.

Table D-4 describes the differences between the model and the proposed facility to meet current WQBELs and notes how those differences affect the cost estimates.

Table D-4 Model differences from proposed WRP to meet current WQBELs

Actual Feature	Model Difference from Actual	Impact on Analysis
A portion of the effluent from the deep bed granular filtration process unit will be sent through an RO system. The RO reject stream will be reduced to salt in an evaporation crystallization unit following RO.	The model does not offer RO or evaporation/crystallization as unit process options. The User Wastewater Process shown in Figure D-3 represents the RO and evaporator crystallizer.	A separate cost estimate calculations tool was developed to calculate costs associated with RO and evaporation crystallization using current and relevant cost information from vendor quotes and literature.

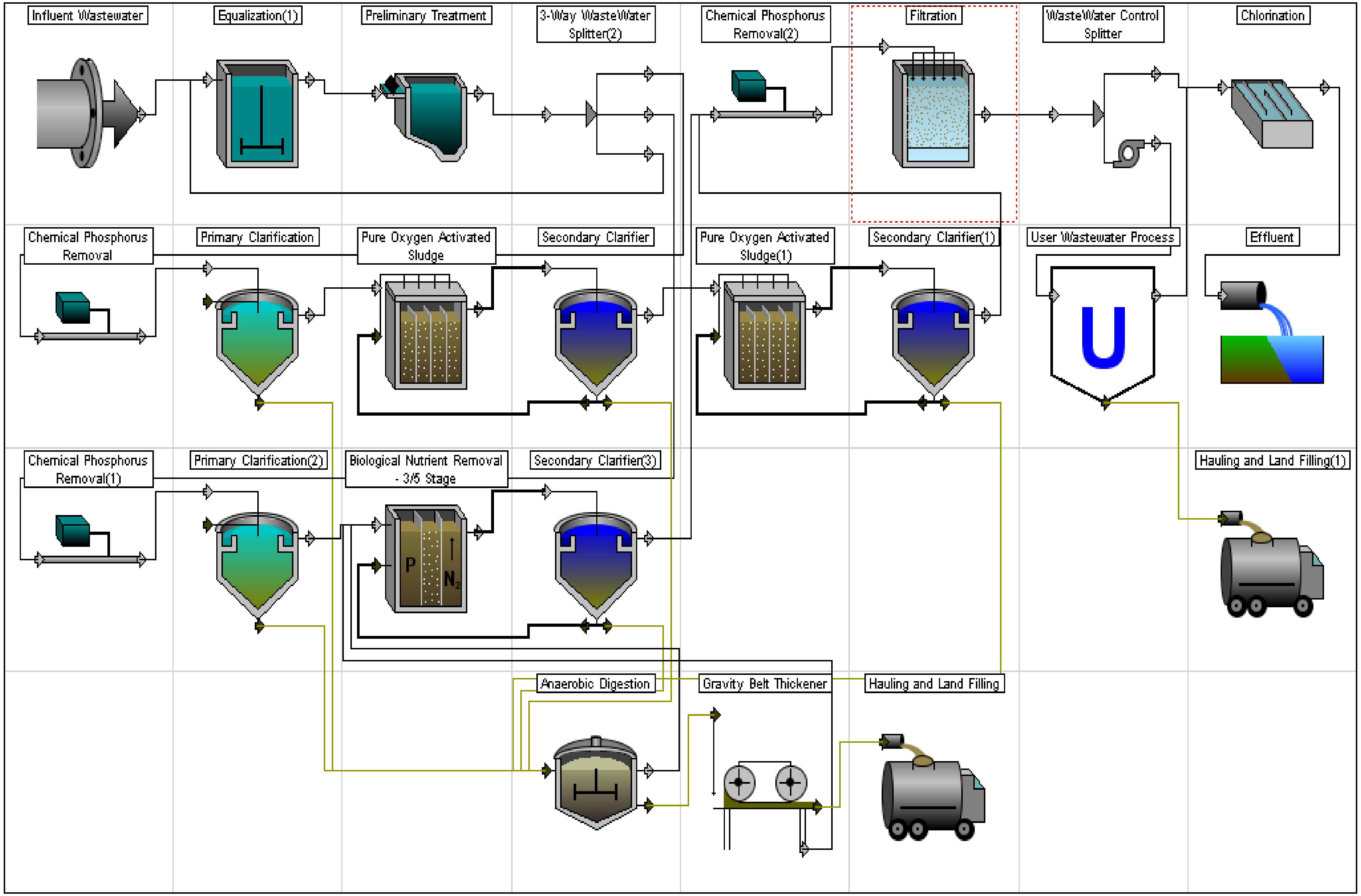

Figure D-3 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Rochester

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-5. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-5, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-5 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
Filtration	$4,306,000
WasteWater Control Splitter	$210,000
Iron Feed System	$66,000
RO	$6,474,000
Evaporator/Crystallizer	$42,060,000
Hauling and Land Filling(1)	$547,000
Direct Costs	$16,303,000
Contingencies	$10,495,000
Construction Total	**$80,461,000**
Engineering, Legal, Admin	$16,093,000
Totals	**$96,554,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $6,518,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life
- Future replacement costs
- Expansion of existing unit processes to treat flow beyond the existing design capacity
- Collection system upgrades
- Other capital costs that are not required to meet the future WQBELs

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.

- No additional land is required
- Filtration costs include:
    - Deep-bed, dual media gravity filtration
    - Concrete basins with handrail
    - Automatic valves
    - Backwash tank and pumps
    - Process equipment building space
- Wastewater Control Splitter costs include:
    - Concrete splitter box
    - Duplex pumping for RO side stream
    - Gravity flow to existing chlorine contact tank
- Iron Feed System costs include:
    - Extension of existing iron feed to new filters
- RO Filtration costs include:
    - Booster pumps
    - Process piping and valves
    - Six 20x10 array RO membrane skids with 8″ membrane modules
    - Clean-in-place equipment
    - Process building equipment space
- Evaporator/Crystallizer costs include:
    - Evaporator/crystallizer equipment
    - Salt storage shed
    - Loading equipment
    - Truck access
    - Process building equipment space
- Hauling and Land Filling(1) costs include:
    - Salt storage shed
    - Loading equipment
    - Truck access
- Other Direct Costs include:
    - Mobilization
    - Site preparation
    - Site electrical

- Yard piping
- Instrumentation and control
- Administrative building space

- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-6 reflect the projected change in costs incurred from adding pretreatment filtration, RO, and evaporator/crystallizer treatment of the side stream.

Table D-6 Annual costs for improvements to meet the current WQBELs for Rochester

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Chemical Phosphorus Removal(2)	$0	$0	$0	$426,500	$0	$426,500
Iron Feed System	$2,000	$0	$100	$0	$0	$2,100
Hauling and Land Filling	$0	$0	$34,200	$0	$0	$34,200
Filtration	$20,100	$12,600	$84,600	$0	$12,000	$129,300
WasteWater Control Splitter	$28,900	$22,200	$1,300	$0	$22,100	$74,500
RO	$37,600	$31,800	$35,700	$463,700	$146,800	$715,600
Evaporator/Crystallizer	$150,400	$21,900	$87,400	$211,800	$4,230,700	$4,702,200
Hauling and Land Filling(1)	$9,800	$0	$433,300	$0	$0	$443,100
Totals	**$248,800**	**$88,379**	**$676,600**	**$1,102,000**	**$4,411,600**	**$6,527,379**

Annual cost clarifications:

- The iron feed system costs assume that all required storage and transfer pumps are existing additional metering pumps will be required.
- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- pH adjustment if necessary to meet the phosphorus discharge concentration is not included in the chemical costs.
- The effluent from the RO/evaporator/crystallizer treatment process may not need disinfection prior to discharge. However, this reduction would likely result in only a small cost savings and therefore is not reflected in the annual costs.
- Hauling and land filling includes tipping fees as material costs.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was calculated as follows:

The City has approximately 35,145 active residential connections, 2,983 commercial connections, and nine (9) industrial connections. 48% of the sewer rate revenue derives from commercial and industrial connections, so 67,586 ERU is used for calculation of the user costs.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The user cost for upgrades necessary to meet the current WQBEL would be approximately $193/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover capital costs) and volume of use fees (typically applied to recover annual costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate by 40% to $771/year per ERU, which is 1.2% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Limits

The existing BNR process has the capacity to remove nitrate to less than 10 mg/L. The existing HPO activated sludge system does not have the capacity to remove nitrate to future WQBELs. A denitrification basin is proposed prior to secondary clarification as part of the HPO train. In combination with tertiary treatment proposed for chlorides, the future nitrate WQBEL can be met.

System upgrades capable of meeting the nitrate WQBELs would include the following:

- Denitrification – suspended growth basin
- Process pumps
- Yard piping
- Basin mixers

Upgrading the HPO system to achieve biological phosphorus removal would be challenging if possible at all. Although the HPO system would require upgrades for nitrogen removal, the analysis assumes that chemical phosphorus removal systems required for the current phosphorus WQBEL would also be required for the future phosphorus WQBEL.

D6.2 Summary of Proposed Upgrades

Figure D-4 shows the CapDetWorks™ process flow diagram for the WRP upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

Table D-7 describes the differences between the model and the proposed facility to meet future WQBELs and notes how those differences affect the cost estimates.

Table D-7 Model differences from proposed WRP to meet future WQBELs

Actual Feature	Model Difference from Actual	Impact on Analysis
A portion of the effluent from the deep bed granular filtration process unit will be sent through an RO system. The RO reject stream will be reduced to salt in an evaporation crystallization unit following RO treatment.	The model does not offer RO or evaporation/crystallization as unit process options. The User Wastewater Process shown in Figure D-4 represents the RO and evaporator crystallizer.	A separate cost estimate calculations tool was developed to calculate costs associated with RO and evaporation crystallization using current and relevant cost information from vendor quotes and literature.
The Denitrification basin added on the HPO train would be located between the second stage of the HPO process and existing secondary clarification. No additional secondary clarification would be added.	The model pairs each Pure Oxygen Activated Sludge basin with secondary clarification, and additional unit processes cannot be added in between. The model automatically pairs a secondary clarifier with the Denitrification basin, though as mentioned, existing secondary clarification will be used after denitrification.	The secondary clarifier that was automatically added with the Denitrification basin was not included in the cost estimate.

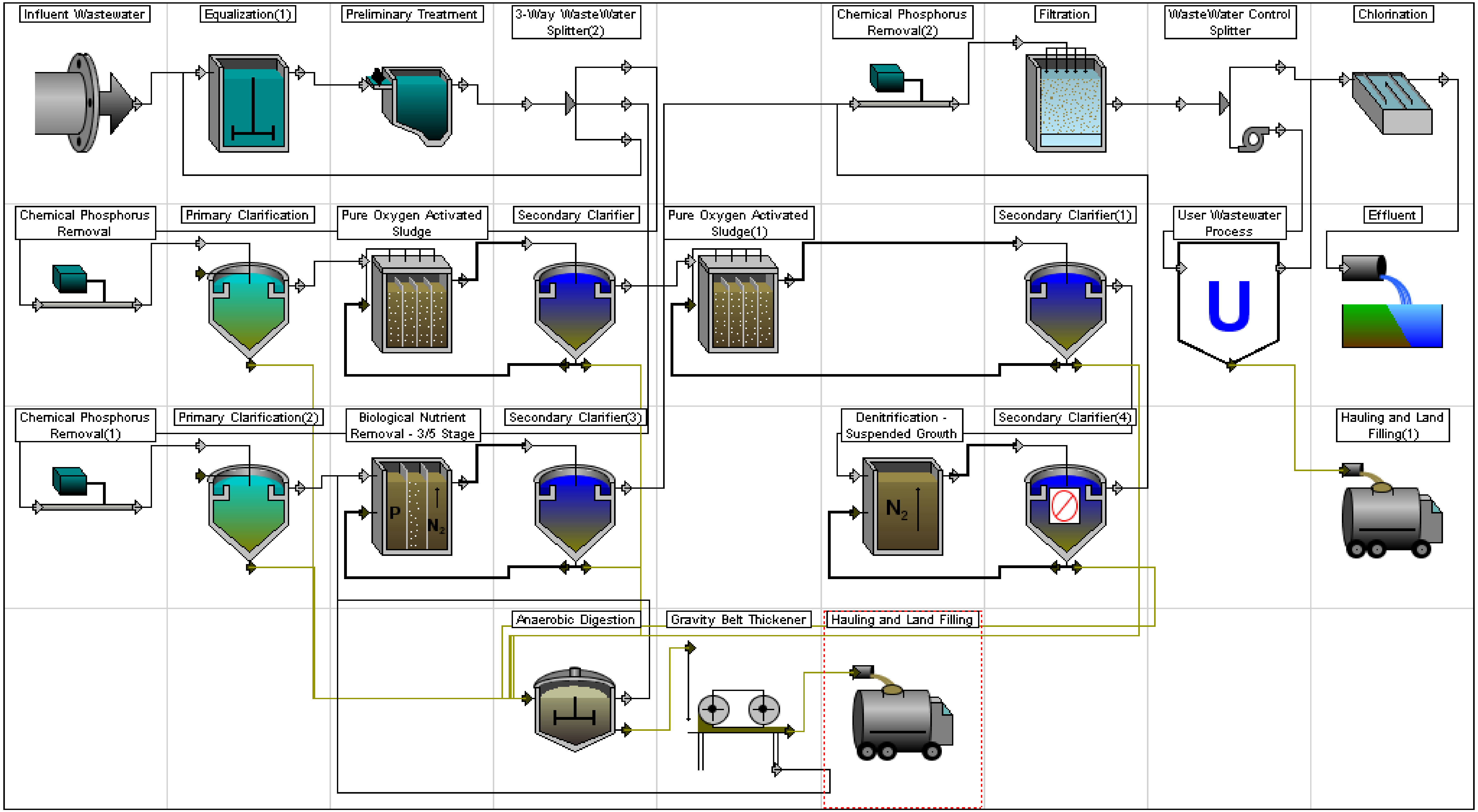

Figure D-4 **Process flow diagram of potential WRP upgrades for Rochester**

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-8. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-8, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-8 Capital costs for Improvements to Meet Future WQBELs

Process	Capital Cost ($)
Filtration	$4,306,000
Denitrification - Suspended Growth	$1,727,000
WasteWater Control Splitter	$210,000
Iron Feed System	$68,000
RO	$6,473,000
Evaporator/Crystallizer	$42,056,000
Hauling and Land Filling(1)	$547,000
Direct Costs	$16,303,000
Contingencies	$17,923,000
Construction Total	**$89,613,000**
Engineering, Legal, Admin	$17,923,000
Totals	**$107,536,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $7,259,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life
- Future replacement costs
- Expansion of existing unit processes to treat flow beyond the existing design capacity
- Collection system upgrades
- Other capital costs that are not required to meet the future WQBELs

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Denitrification – Suspended Growth costs include:
    - Anoxic zone added into the existing HPO process
    - Concrete basins with handrail
    - Denitrification basin mixers
    - Recirculation pumps
    - Pump building space
- All other costs would be similar to Section D5.1.

D7.2 Annual Costs

Annual costs shown in Table D-9 reflect the projected change in costs incurred from changing the secondary treatment process and adding anaerobic digestion.

Table D-9 Annual costs for improvements to meet the future WQBELs for Rochester

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Chemical Phosphorus Removal(2)	$0	$0	$0	$426,500	$0	$426,500
Iron Feed System	$2,000	$0	$100	$0	$0	$2,100
Filtration	$20,000	$12,800	$84,600	$0	$12,000	$129,400
WasteWater Control Splitter	$28,900	$22,400	$1,300	$0	$22,100	$74,700
Chlorination	$0	$400	$0	$0	$0	$400
RO	$37,600	$31,800	$35,700	$463,700	$146,800	$715,600
Evaporator/Crystallizer	$150,400	$21,900	$87,400	$211,800	$4,230,700	$4,702,200
Hauling and Land Filling(1)	$9,800	$0	$433,300	$0	$0	$443,100
Pure Oxygen Activated Sludge	$0	$1,000	$0	$0	$0	$1,000
Pure Oxygen Activated Sludge(1)	$0	$900	$0	$0	$0	$900
Secondary Clarifier(1)	$0	$1,200	$0	$0	$0	$1,200
Denitrification - Suspended Growth	$139,000	$80,000	$6,900	$965,000	$210,000	$1,400,900
Biological Nutrient Removal - 3/5 Stage	$8,000	$8,000	$27,000	$0	$30,000	$73,000
Secondary Clarifier(3)	$300	$900	$0	$0	$100	$1,300
Anaerobic Digestion	$17,000	$12,000	$117,000	$0	$99,000	$245,000
Gravity Belt Thickener	$5,900	$1,600	$0	$6,900	$2,100	$16,500
Hauling and Land Filling	$28,000	$0	$104,200	$0	$0	$132,200
Totals	**$446,900**	**$194,900**	**$897,500**	**$2,073,900**	**$4,752,800**	**$8,366,000**

Annual cost clarifications:

- Additional operation and maintenance costs are incurred in some existing unit processes receiving additional recycle flow
- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- The effluent from the RO/evaporator/crystallizer treatment process may not need disinfection prior to discharge. However, this reduction would likely result in only a small cost savings and therefore is not reflected in the annual costs.

D7.3 User Costs

User costs were evaluated as described in Section D5.3.

The increase in user cost for upgrades necessary to meet the future WQBEL would be approximately $231/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover capital costs) and volume of use fees (typically applied to recover annual costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D- would increase the typical residential sewer rate to $809/year per ERU, which is 1.3% of the median household income.

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Memorandum

To: MMB
From: Tim Reid, Jon Minne, Bryan Oakley, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Serpent Lake to meet Anticipated Water Quality Standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the Serpent Lake Sanitary Sewer District would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF.
Section D3.0 – Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The Serpent Lake Sanitary Sewer District operates a WWTF which includes secondary treatment of domestic strength wastewater from the cities of Crosby, Cuyuna, Deerwood, and Ironton.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MNG580000 (expired August 31, 2015)

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of existing Serpent Lake WWTF

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	0.672
Average Flow (mgd)(1)	0.404
Year Built	1986
Watershed	Mississippi River
Discharge Location	Rabbit Creek (Class 2B, 3C, 4A, 4B, 5, 6)
Major Treatment Units	Two primary stabilization ponds, one secondary stabilization pond
Facility Class	D
Service Population(2)	3798
Estimated Equivalent Residential Units (ERU)	1123
Median Household Income(3)	$29,206
Typical Residential Sewer Rate(4)	$739

(1) Serpent Lake Sanitary Sewer District discharge monitoring report data, April 2010 – April 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™ based on the sources identified above, and information gathered in a site visit conducted on October 5, 2016. The process flow diagram developed for the model is shown in Figure D-1.

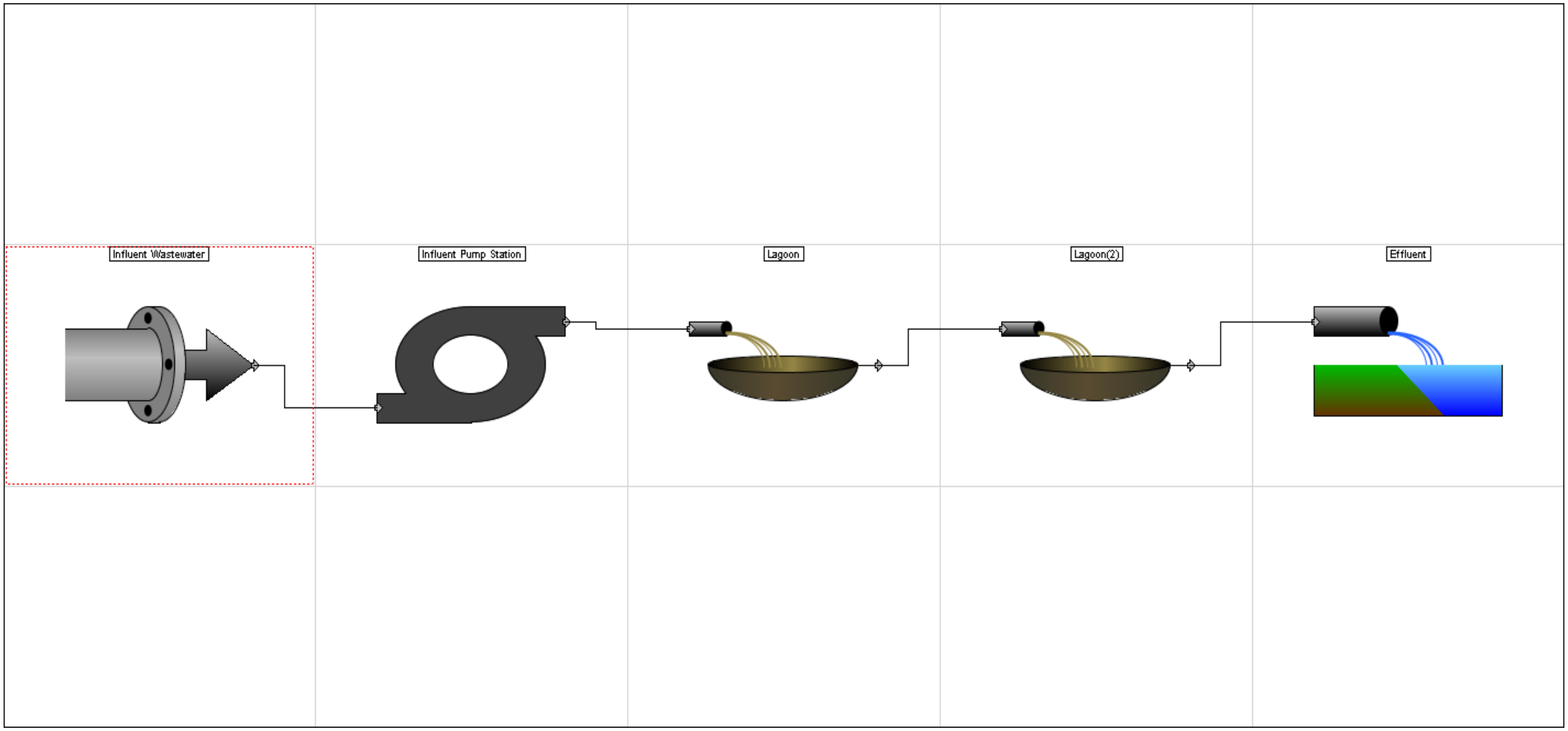

Figure D-1 Process flow diagram of existing Serpent Lake WWTF

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBEL) that are different than existing permit limits for several parameters. This study estimated potential WQBELS under current standards (current WQBELS) and potential WQBELS under future standards (future WQBELs).Treatment process upgrades may be needed to meet some of current and future WQBELs.

Table D-2 compares effluent characteristics, existing permit limits, current WQBELs, and future WQBELs.

Table D-2 Summary of existing and estimated effluent limits: Serpent Lake WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia-N (mg/L)	Cal Mo Max	Apr-Sep Oct-Mar	20.5 0.16	monitor	2.2 MDL 1.1 AML	1.6 MDL 0.8 AML
Ammonia-N (mg/L)	Cal Mo Avg	Apr-Sep Oct-Mar	2.38-20.5 0.1-0.16	monitor	No change	No change
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	0.05-0.38	monitor	No change	No change
Sulfate (mg/L)	Cal Mo Avg	Jan-Dec	Not monitored	NA	NA	NA
Total Phosphorus (kg/yr)	Cal Mo Avg	Jan-Dec	Not monitored	NA	928 (kg/yr)	No change
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	0.11-0.59	1.0	No change	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	4.0-24.0	45	No change	No change

Cal Mo Avg—calendar month average
Cal Mo Max – calendar month maximum
MDL—maximum daily limit
AML—average day of the AWW month
AAF—average annual flow
(1) From data reported on monthly discharge monitoring reports April 2010 through April 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

Existing effluent concentrations are higher than the current and future WQBEL for ammonia. Therefore, the existing process would need to be upgraded to meet the current and future WQBEL for ammonia.

New WQBELs for chloride, nitrate, phosphorus, sulfate, and TSS are not expected.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Requirements

Upgrades are needed to meet current and future ammonia WQBELs. The limits could be met using an aerated pond prior to the stabilization ponds and aerated rock filter following the secondary pond for ammonia polishing. Due to temperature dependencies for ammonia removal, there would be a period of recirculation from the aerated rock filter prior to spring discharge. Additional equipment would require:

- An activated sludge secondary treatment system
- A sludge drying bed capable of dewatering and storing waste activated sludge

D4.2 Summary of Proposed Upgrades

Figure D-2 shows the CapDetWorks™ process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on costs of the recommended upgrades. Section D6.0 provides information on meeting future WQBEL limits.

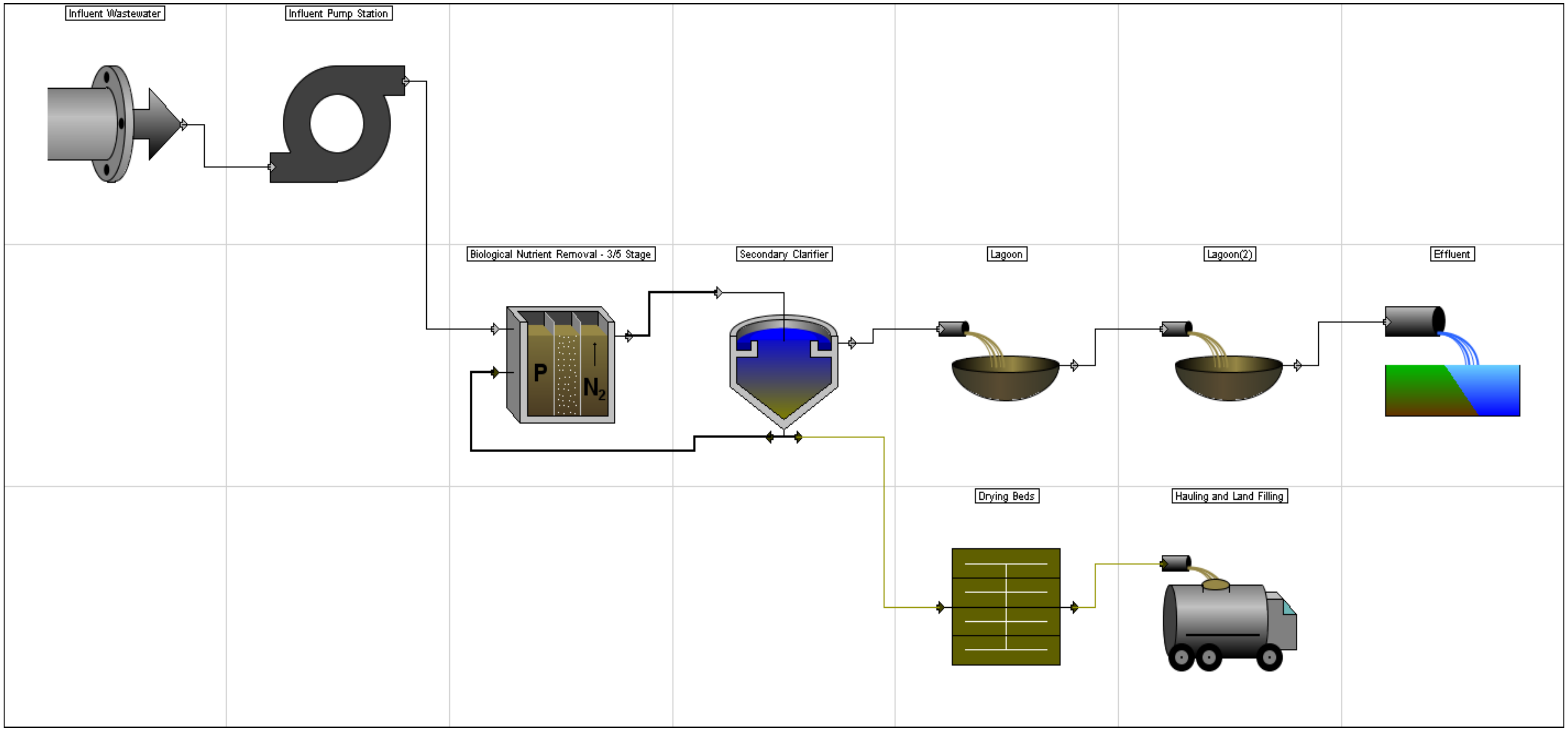

Figure D-2 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Serpent Lake

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-3. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-3, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-3 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3/5 Stage	$1,083,000
Secondary Clarifier	$380,000
Drying Beds	$719,000
Hauling and Land Filling	$337,000
Blower System	$225,000
Direct Costs	$1,284,000
Contingencies	$605,000
Construction	**$4,633,000**
Engineering, Legal, Admin	$927,000
Totals	**$5,560,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source www.enr.com dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $376,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life
- Future replacement costs
- Expansion of existing unit processes to treat flow beyond the existing design capacity
- Collection system upgrades
- Other capital costs that are not required to meet the future WQBELs

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%
- Additional land required for treatment process is not included in capital costs

- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
- Indirect Costs include:
  - Contingencies at 25% of construction costs before contractor profit
  - Contractor profit at 12% of total construction cost
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-4 reflect the projected change in costs incurred from adding aerated pond.

Table D-4 Annual costs for improvements to meet the current WQBEL for Serpent Lake

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Biological Nutrient Removal - 3/5 Stage	$138,000	$65,900	$24,900	$0	$35,900	$264,700
Secondary Clarifier	$30,000	$14,600	$1,900	$0	$800	$47,300
Drying Beds	$29,600	$10,100	$4,600	$0	$0	$44,300
Hauling and Land Filling	$500	$0	$49,700	$0	$0	$50,200
Totals	**$198,100**	**$90,600**	**$81,100**	**$0**	**$36,700**	**$406,500**

Annual cost clarifications:

- Power costs for the blower system are included in the biological nutrient removal process line item.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). ERU include all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was estimated based on population, average annual influent flow to the WWTF, typical per capita wastewater generation rates, and the number of households.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $697/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume of use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate to $1,436/year per ERU, which is 4.9% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

Upgrades made to meet current WQBELs would be sufficient to meet future WQBELs.

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

Upgrades made to meet current WQBELs would be sufficient to meet future WQBELs.

Memorandum

To: MMB
From: Bryan Oakley, Katie Wolohan, Barr Engineering Co.
Subject: MMB cost analysis for upgrading wastewater treatment at Watertown to meet current and future water quality standards
Date: January 26, 2017
Project: 23621125.00 WWCE
c: Dale Finnesgaard, Jon Minne, Jeff Ubl, Barr Engineering Co.; Seth Peterson, Paul Saffert, Bolton and Menk

D1.0 Introduction

To meet effluent limits based on current and future water quality standards, the City of Watertown would need to upgrade their wastewater treatment facility (WWTF). This memorandum summarizes the estimated capital and operating/maintenance costs of these upgrades. Costs were estimated as follows:

- Identify applicable current and future water quality standards.
- Estimate WWTF effluent limits based on current and future water quality standards.
- Conduct a site visit to the WWTF to get first-hand information.
- Select treatment units to meet effluent limits based on current and future water quality standards.
- Use the CapDetWorks™ tool to provide consistent process flow diagrams and cost estimates.

CapDetWorks™, from Hydromantis Environmental Software Solutions, Inc., is the industry standard software used during preliminary design to develop capital and operating cost estimates for wastewater treatment plant projects.

This memorandum presents the following information:

Section D2.0 - Background information on the existing WWTF
Section D3.0 – Performance of existing WWTF relative to estimated effluent limits under current and future water quality standards
Section D4.0 – Proposed upgrades to meet current standards
Section D5.0 – Estimated costs of proposed upgrades to meet current standards
Section D6.0 – Proposed upgrades to meet future standards
Section D7.0 – Estimated costs of proposed upgrades to meet future standards

D2.0 Existing Wastewater Treatment

The City of Watertown operates a WWTF which includes secondary treatment of domestic strength wastewater and land application of residual sludge.

The WWTF is described in the following documents:

- National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Number MN0020940 (expired October 30, 2014)
- NPDES permit application dated April 2, 2014
- Wastewater Treatment Facilities "As Constructed" Drawings, dated October 12, 1992
- DRAFT Wastewater Treatment Facility Plan, dated August 2015

Table D-1 summarizes WWTF information from those documents.

Table D-1 Summary of current wastewater treatment information

Parameter	Value or Descriptor
Design Average Wet Weather Flow million gallons per day (mgd)	1.20
Design Average Dry Weather Flow (mgd)	0.63
Average Flow (mgd)(1)	0.375
Year Built	1992
Watershed	Upper Mississippi River
Discharge Location	South Fork of Crow River Creek (Class 2B)
Major Treatment Units	Flow equalization, extended aeration activated sludge, tertiary filtration, aerobic sludge digestion
Facility Class	B
Service Population(2)	4,254
Estimated Equivalent Residential Units (ERU)	2013
Median Household Income(3)	$74,583

(1) City of Watertown discharge monitoring report data, January 2010 – June 2016
(2) Minnesota State Demographer 2015 estimate (source: www.mn.gov/admin/demography/)
(3) 2014 American Community Survey (source: www.factfinder.census.gov)
(4) Assumes 8000 gallons of water use per month

A model of the existing WWTF was developed using CapDetWorks™, based on the sources identified above and information gathered in a site visit conducted on October 5, 2016. The process flow diagram developed for the model is shown in Figure D-1.

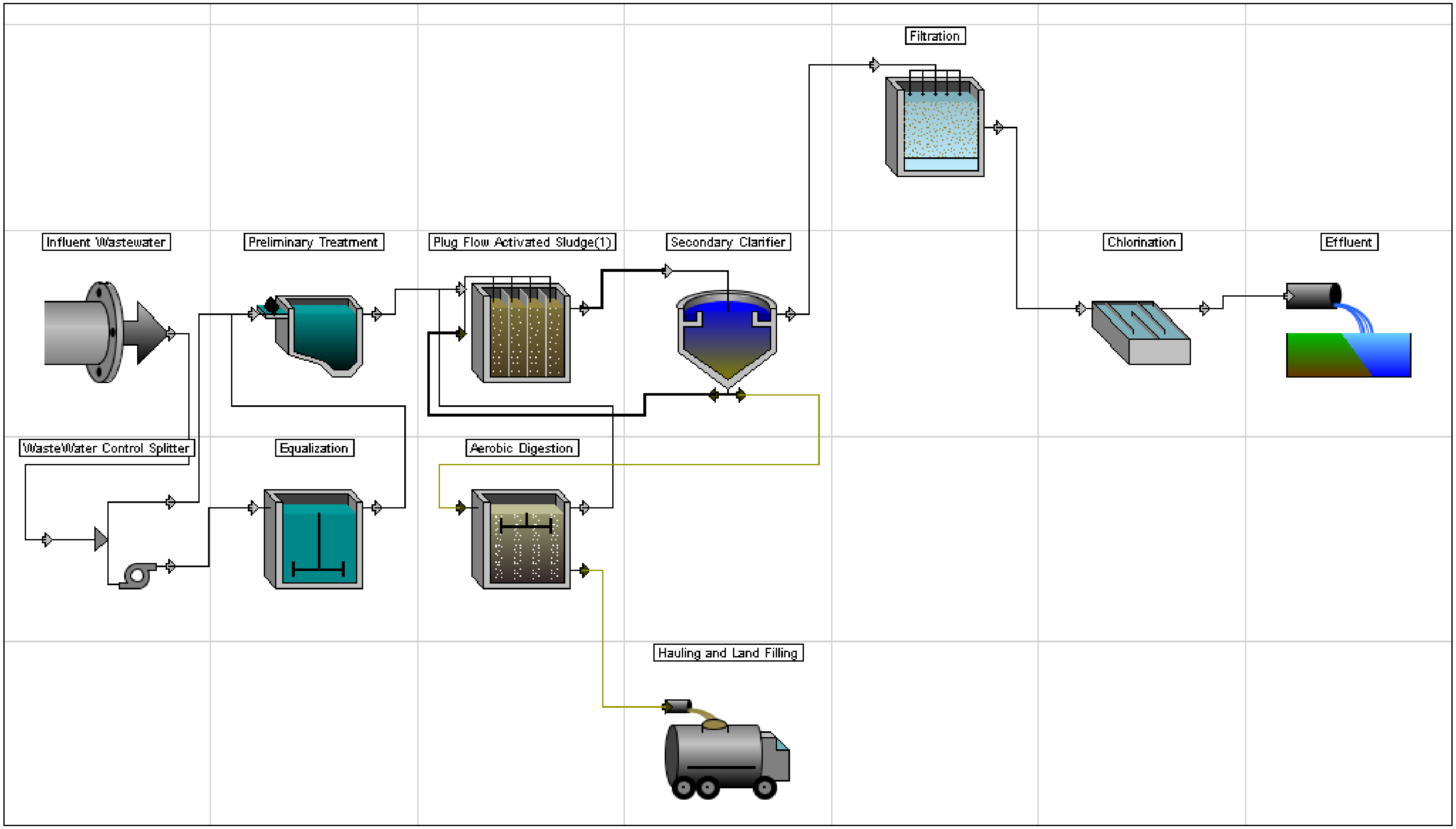

Figure D-1 Process flow diagram of existing Watertown WWTF

Table D-2 describes the differences between the model and the actual existing facility and notes how those differences affect the cost estimates.

Table D-2 Model differences from actual WWTF

Actual Feature	Model Difference from Actual	Impact on Analysis
The existing secondary treatment system is a 3-train extended aeration activated sludge process.	The activated sludge process is modeled as a plug-flow system with a long solids retention time. The software's extended aeration activated sludge module does not accurately track phosphorus in the wastewater stream.	There are small impacts on sludge recycle and wasting rates. These are not important parameters for the cost analysis. The modeled effluent concentration of pollutants of concern approximates observed concentrations.
The existing sludge digester was originally designed as an anaerobic digester, but was converted to an aerobic digester at some time in the past.	Sludge digestion is modeled as an aerobic digester. Detailed information on the design of the digester is not available.	There may be some minor differences in the water quality of the recycle from the digester to the aeration basin influent.
Sludge is concentrated prior to processing in the digester using a sludge batching tank.	The existing sludge batching tank is not modeled. The software does not offer this unit process as an option.	None. The sludge batching supernatant is mixed with the digester recycle.
Digested sludge is stored onsite.	The model does not offer sludge storage as an option.	None. This is a site-specific requirement and is evaluated independently of the model.

D3.0 Performance of Existing WWTF Relative to Effluent Limits Under Current and Future Standards

Current and proposed Minnesota Pollution Control Agency (MPCA) water quality standards (WQS) could result in water quality based effluent limits (WQBELs) that are different than existing permit limits for several parameters. This study estimated potential WQBELs under current standards (current WQBELs) and potential WQBELs under future standards (future WQBELs). Treatment process upgrades would be needed to meet some current and future WQBELs. Table D-3 compares effluent characteristics, existing permit limits, current WQBELs and future WQBELs.

Table D-3 Summary of existing and estimated effluent limits: Watertown WWTF

Parameter	Limit Type	Effective Period	Existing Effluent Range(1)	Existing Permit Limit	Current WQBEL(2)	Future WQBEL(3)
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Jun-Sep	0.16-0.90	1.4	No change	2.4 MDL 1.2 AML
Ammonia Nitrogen (mg/L as N)	Cal Mo Avg	Oct-Nov	0.16-4.31	5.1	11.6 MDL 4.3 AML	3.8 MDL 1.4 AML
Chloride (mg/L)	Cal Mo Avg	Jan-Dec	351-755	monitor	270 MDL 219 AML	No change
Nitrate (mg/L as N)	Cal Mo Avg	Jan-Dec	14.0-33.3	monitor	NA	6 MDL 4.6 AML
Total Phosphorus (mg/L)	Cal Mo Avg	Jan-Dec	1.31-4.80	monitor	0.53	No change
Total Phosphorus (kg/yr)	12-Mo Rolling Avg	Jan-Dec	1,275-1,664	monitor	1,394.8	No change
Total Suspended Solids (mg/L)	Cal Mo Avg	Jan-Dec	1.0-9.5	30	No change	No change

Cal Mo Avg—calendar month average
MDL—maximum daily limit
AML—average monthly limit
NA—not applicable
(1) From data reported on monthly discharge monitoring reports January 2010 through June 2016
(2) Water quality based effluent limit to meet current water quality standards, estimated for this study.
(3) Water quality based effluent limit to meet future water quality standards, estimated for this study.

The exceedance of the current WQBEL for ammonia noted above occurred once during the last 5 years of monitoring. Excluding that period, the ammonia in Oct-Nov has not exceeded 0.3 mg/L. No additional treatment would be required to meet the current or future WQBEL.

The current WQBELs for chloride would require additional treatment. The facility has never reported a monthly average effluent chloride concentration below the WQBEL value.

The future WQBEL for nitrate would require additional treatment.

The current WQBEL for total phosphorus would require additional treatment. The effluent is consistently near the annual mass loading for the future WQBEL, but this limit is not meaningful since at the current WQBEL concentration limit and the permitted average wet weather (AWW) flow, the effective annual mass limit would be 925.5 kg/yr. Treatment to lower than the future WQBEL would not be required to achieve the annual mass limit.

D4.0 Proposed Upgrades to Meet Current Standards

D4.1 Upgrades to Meet Nutrient Limits

Treatment for phosphorus the meet the current WQBEL would require ferric chloride addition prior to the existing secondary clarifier and existing tertiary filter.

Additional equipment required would include the following:

- Chemical metering pumps
- Chemical storage tank
- Secondary containment
- Building enclosure
- Truck access

The existing facility includes tertiary filtration which would not be required to meet the phosphorus WQBEL.

The facility is capable of meeting the existing ammonia WQBEL without modification.

D4.2 Upgrades to Meet Chloride Limit

D4.2.1 Chloride

The 5-year average chloride concentration is more than twice the estimated current WQBEL. To meet the current WQBEL, additional treatment would be required.

Figure D-2 shows the relationship between flow and chloride concentration. As flow increases, the chloride concentration decreases. This would allow a treatment system to be sized to treat a constant side stream of flow at varying influent flow rates.

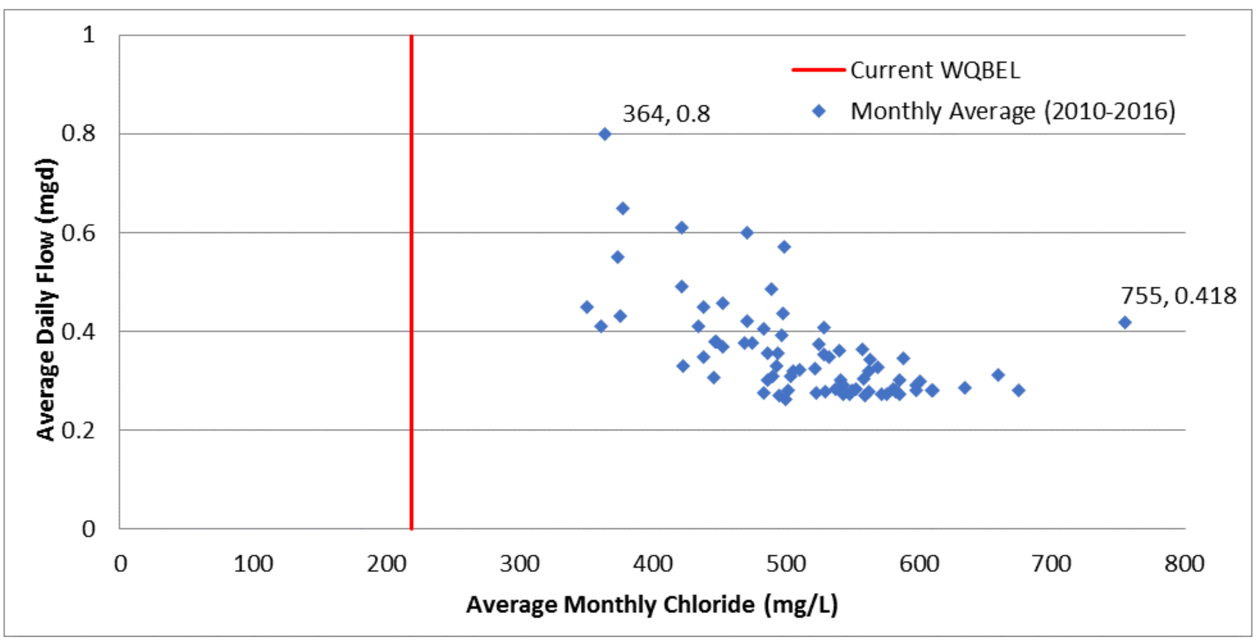

Figure D-2 Effluent Flow and Chloride Concentration Relationship, Watertown

Chloride can be removed using reverse osmosis (RO) filtration. Water reaching the RO system would require pretreatment to remove solids with a deep-bed, granular-media filter, or an ultrafilter.

Assuming 99% removal of chloride, a reverse osmosis system can be sized to treat a portion of the flow adequate to bring the blended flow below the monthly average requirement of 219 mg/L.

The extreme conditions recorded in the past 6 years include a high chloride concentration of 755 mg/L at a flow of 0.418 mgd and a chloride concentration of 364 mg/L at a high flow of 0.8 mgd.

At the low flow, high concentration condition, the RO system would be required to treat 72% of the flow, or 208 gpm.

At the average wet weather design flow and the low concentration condition, the RO system would be required to treat 40% of the flow, or 335 gpm to meet the average monthly limit of 219 mg/L.

D4.2.2Chloride Treatment System

RO treatments produce a significant brine waste stream. The most viable method of disposal would be evaporation, crystallization, and landfill disposal.

Assumptions used for calculation of the side stream treatment capacity required for RO treatment:

- The AWW would have the same chloride concentrations as the high flow, low concentration condition observed in the past (this is a conservative assumption as the concentrations would likely be lower).
- The RO would generate 25% of its feed flow as brine
- The evaporator/concentrator will be required to concentrate the brine to 60% solids for landfill disposal.
- Evaporator condensate can be returned to the wastewater effluent without further treatment.

RO treatment of a side stream from the secondary effluent to meet the current WQBEL for chloride would require the following new treatment units:

- Deep bed granular filtration of the RO influent
- RO system capable of treating 335 gpm at AWW
- Evaporator/Crystallizer capable of treating 84 gpm at AWW
- Salt storage (1,400 cf required for weekly disposal)
- Truck access

Because a new filtration system would be required to pretreat the RO influent, and the existing tertiary filter would not be required to meet the current phosphorus WQBEL, it is assumed that the existing tertiary filter will be abandoned.

D4.3 Summary of Proposed Upgrades

Figure D-3 shows the CapDetWorks^{TM} process flow diagram for the WWTF upgraded to meet current WQBELs. Section D5.0 provides more detail on the recommended upgrades.

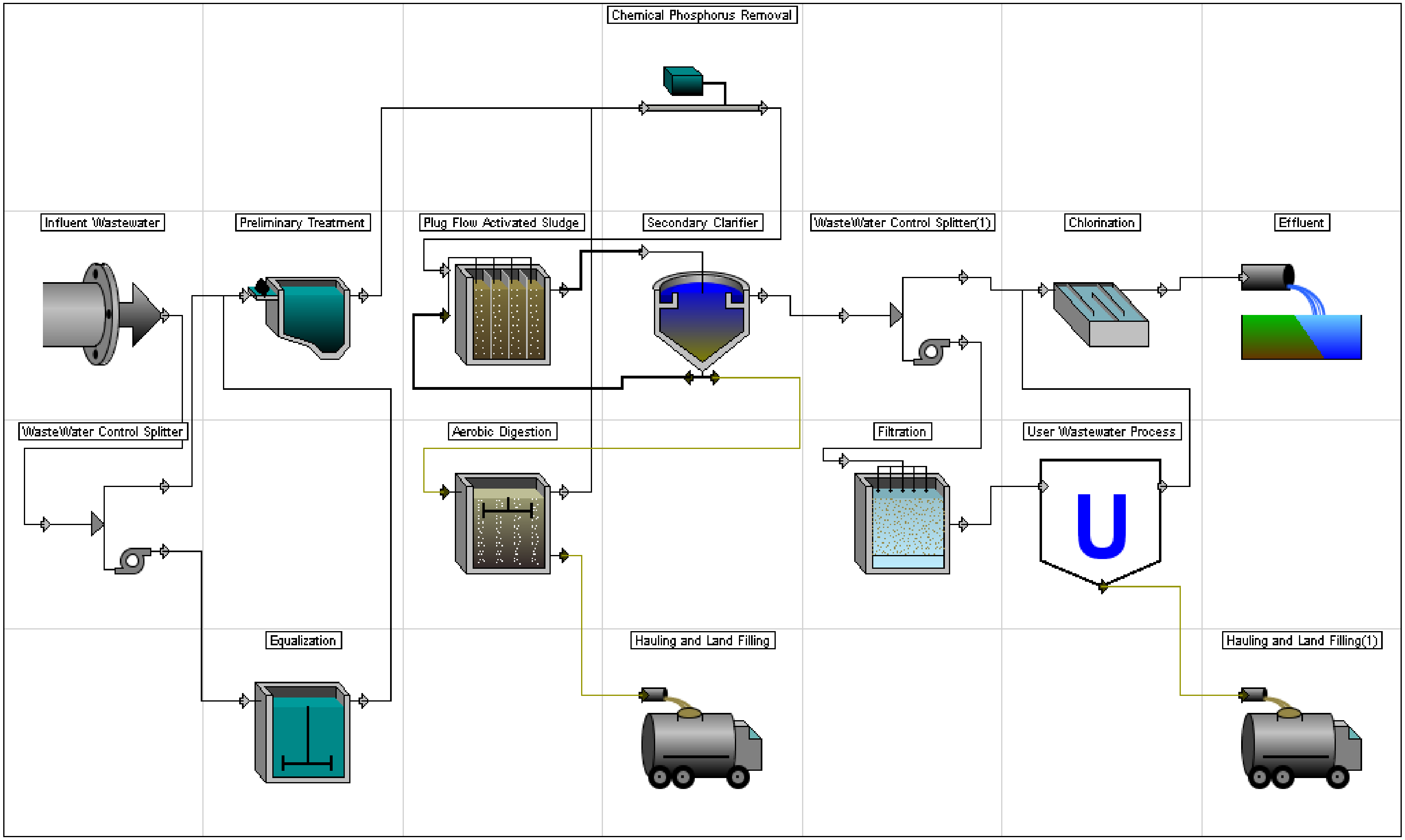

Figure D-3 Process flow diagram of potential WWTF upgrades to meet current WQBELs for Watertown

D5.0 Estimated Costs of Proposed Upgrades to Meet Current Standards

D5.1 Capital Costs

Capital costs are shown in Table D-4. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-4, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-4 Capital costs for improvements to meet current WQBELs

Process	Capital Cost ($)
Aerobic Digestion	$375,000
WasteWater Control Splitter(1)	$86,000
Filtration	$1,784,000
RO Filtration	$2,760,000
Evaporator Crystallizer	$13,406,000
Hauling and Land Filling(1)	$110,000
Iron Feed System	$262,000
Direct Costs	$2,017,000
Contingencies	$3,120,000
Construction Total	**$23,920,000**
Engineering, Legal, Admin	$4,784,000
Totals	**$28,704,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $1,938,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life
- Future replacement costs
- Expansion of existing unit processes to treat flow beyond the existing design capacity
- Collection system upgrades
- Other capital costs that are not required to meet the future WQBELs

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Aerobic Digestion costs include:
    - Expansion of the existing process
    - Concrete tank with access ladder and handrail
    - Coarse-bubble diffusers
- Wastewater Control Splitter(1) costs include:
    - Concrete splitter box
    - Duplex pumping for RO side stream
    - Gravity flow to existing chlorine contact tank
- Filtration costs include:
    - Deep-bed, dual media gravity filtration
    - Concrete basins
    - Automatic valves
    - Backwash tank and pumps
    - Process equipment building space
- RO Filtration costs include:
    - Booster pumps
    - Process piping and valves
    - Two 8 x 4 array RO membrane skids with 8" membrane modules
    - Clean-in-place equipment
    - Process equipment building space
- Evaporator/Crystallizer costs include:
    - Water feed system
    - Condenser
    - Crystallizer (evaporator not required)
    - Process equipment building space
- Hauling and Land Filling(1) costs include:
    - Salt storage shed

  - Loading equipment
  - Truck access

- Other Direct Costs include:
  - Mobilization
  - Site preparation
  - Site electrical
  - Yard piping
  - Instrumentation and control
  - Administrative building space.

- Indirect Costs include:
  - Contingencies at 15% of construction costs
  - Engineering, legal, and administrative at 20% of construction cost

D5.2 Annual Costs

Annual costs shown in Table D-5 reflect the projected change in costs incurred from adding pretreatment filtration, RO, and evaporator/crystallizer treatment of the side stream.

Table D-5 Annual costs for improvements to meet the current WQBEL for Watertown

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Plug Flow Activated Sludge	$5,700	$3,400	$13,900	$0	$6,400	$29,400
Chemical Phosphorus Removal	$0	$0	$0	$56,600	$0	$56,600
Secondary Clarifier	$800	$1,300	$0	$0	$100	$2,200
Aerobic Digestion	$1,800	$1,000	$17,000	$0	$3,000	$22,800
Hauling and Land Filling	$12,900	$0	$17,700	$0	$0	$30,600
WasteWater Control Splitter(1)	$20,800	$13,000	$500	$0	$1,700	$36,000
RO Filtration	$37,600	$2,700	$3,000	$38,600	$12,200	$94,100
Evaporator Crystallizer	$150,400	$5,000	$19,700	$17,600	$351,500	$544,200
Hauling and Land Filling(1)	$1,700	$0	$77,300	$0	$0	$79,000
Iron Feed System	$33,400	$0	$4,300	$0	$0	$37,700
Totals	**$265,100**	**$26,400**	**$153,400**	**$112,800**	**$374,900**	**$932,600**

Annual cost clarifications:

- The activated sludge process would incur additional costs due to additional solids from the chemical phosphorus removal process.

- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item.
- The secondary clarifier is an existing process, but would require more operation and maintenance costs due to additional solids from the chemical phosphorus removal process.
- The aerobic digestion process would incur additional costs due to additional solids from the chemical phosphorus removal process.
- Land application of sludge would increase due to additional solids from the chemical phosphorus removal process.
- Wastewater control splitter(1) includes the cost of pumping to the new filtration train.
- Filtration costs would be offset by the costs of not operating the existing filtration system.
- RO filtration and evaporator/crystallizer would include costs for additional staffing, process testing, membrane replacement, cleaning chemicals, and energy.
- Hauling and land filling(1) would include the cost of hauling salt waste to a landfill. The salt waste is assumed to be non-hazardous.
- Power costs for the blower system are included in the activated sludge process line item.
- This estimate is intended to be added to existing operation and maintenance costs.

D5.3 User Costs

User costs were evaluated as an annual cost per equivalent residential unit (ERU). The ERU includes all domestic strength wastewater from residential, commercial, and industrial sources. Commercial users pay a connection fee based on their maximum potential water use and wastewater generation.

The estimated ERU, shown in Table D-1, was provided by the City.

User costs are calculated as follows.

$$User\ Cost = \frac{Annual\ Capital\ Cost\ Loan\ Payment + Annual\ Costs}{Equivalent\ Residential\ Units}$$

The increase in user cost for upgrades necessary to meet the current WQBEL would be approximately $1,426/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover Capital Costs) and volume-of-use fees (typically applied to recover Annual Costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate more than three times to $2,063/year per ERU, which is 2.8% of the median household income.

D6.0 Proposed Upgrades to Meet Future Standards

D6.1 Upgrades to Meet Nutrient Limits

The existing activated sludge process should be capable of meeting the ammonia future WQBELs, but does not have the capacity to remove nitrate to the future WQBELs, so the secondary treatment system would need to be replaced.

An activated sludge system capable of meeting the ammonia WQBEL would include the following:

- 5-stage biological nutrient removal activated sludge process
  - New mixed anaerobic tank
  - 2 new mixed anoxic tanks
  - 2 new aeration tanks
  - New aeration diffusers
  - Reuse existing blower system
  - Reuse existing return activated sludge pumps and pipes
  - New recirculation pumps
  - Reuse existing waste sludge pumps
  - Existing secondary clarifiers can be reused
- Sludge processing
  - Additional sludge hauling facilities are required

The existing facility is capable of meeting the phosphorus limits with the addition of chemical phosphorus removal; however, there would be a reduction in chemical use if the new activated sludge system is designed to incorporate biological nutrient removal (BNR) and supplemented with chemical phosphorus removal. This estimate assumes that in addition to nitrate, the activated sludge system would remove phosphorus to less than 1 mg/L. Chemical addition for removal of phosphorus would continue, but at a lower chemical usage applied primarily to recycle streams high in phosphorus. The chemical phosphorus removal system would be moved to the digester supernatant return to tie up phosphorus released during aerobic digestion. Tertiary filtration is not required to meet the future WQBEL phosphorus limit.

D6.2 Summary of Proposed Upgrades

Figure D-4 shows the CapDetWorks^{TM} process flow diagram for the WWTF upgraded to meet future WQBELs. Section D7.0 provides more detail on the recommended upgrades.

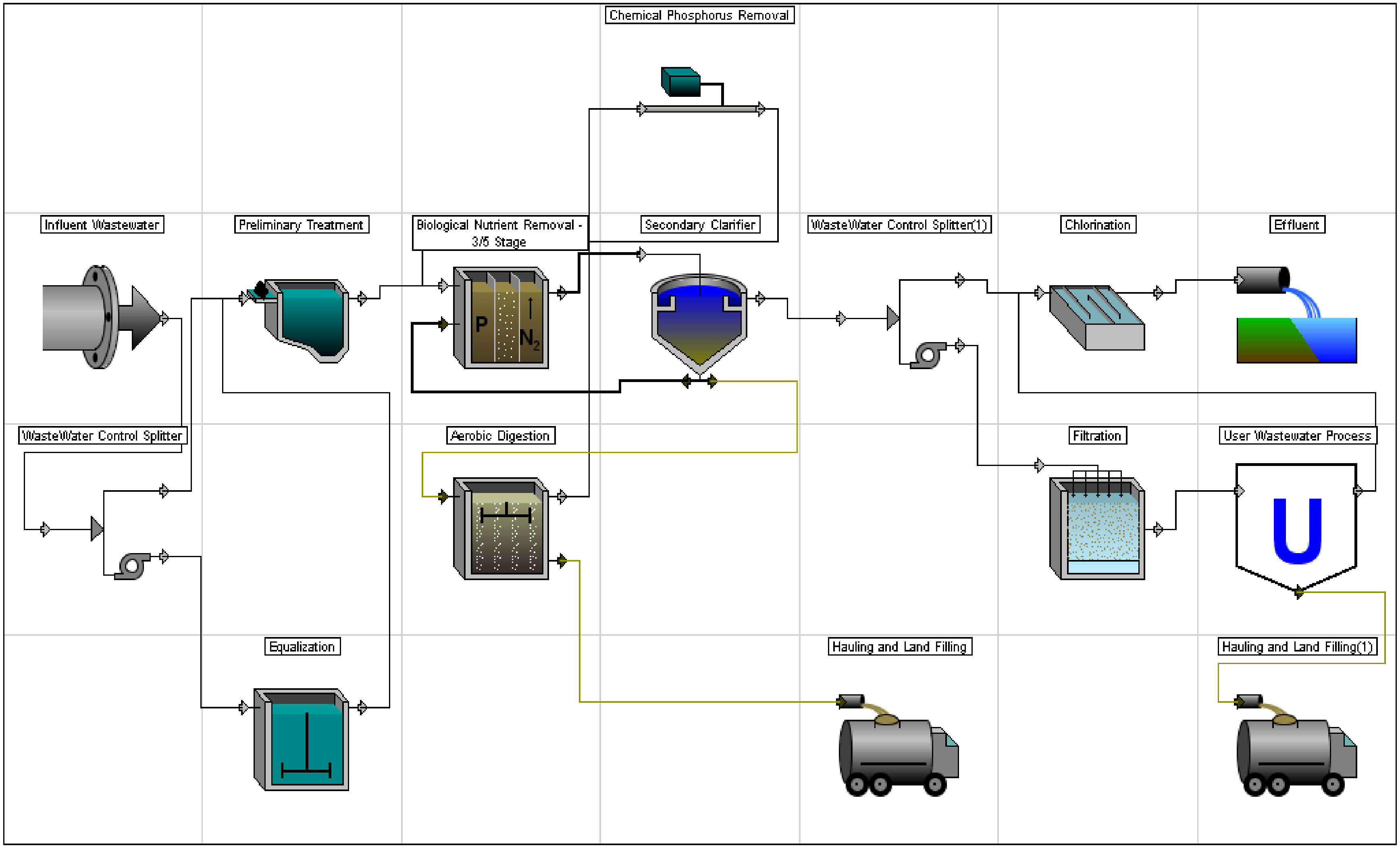

Figure D-4 **Process flow diagram of potential WWTF upgrades to meet future WQBELs for Watertown**

D7.0 Estimated Costs of Proposed Upgrades to Meet Future Standards

D7.1 Capital Costs

Capital costs are shown in Table D-6. Construction costs include costs for modifying existing facilities or constructing new facilities. For unit processes with no construction cost shown in Table D-6, the analysis assumes that the existing unit process can be reused in the proposed system.

Table D-1 Capital costs for improvements to meet future WQBELs

Process	Capital Cost ($)
Biological Nutrient Removal - 3/5 Stage	$2,148,000
Secondary Clarifier	$331,000
Aerobic Digestion	$371,000
WasteWater Control Splitter(1)	$86,000
Filtration	$1,784,000
RO Filtration	$2,760,000
Evaporator/Crystallizer	$13,406,000
Hauling and Land Filling(1)	$110,000
Iron Feed System	$262,000
Direct Costs	$2,383,000
Contingencies	$3,547,000
Construction Total	**$27,188,000**
Engineering, Legal, Admin	$5,438,000
Totals	**$32,626,000**

Note: Capital costs are calculated based on an index value of 9834.6 (source: www.enr.com, dated July 2014)

Capital costs would likely be paid with a low-interest loan available through the Minnesota Public Facilities Authority. The annual payment for a loan to cover 100% of the capital costs at a 3% interest rate for a 20-year term would be approximately $2,203,000.

The following costs are excluded from this analysis:

- Capital costs for replacement of existing equipment that has reached the end of its service life
- Future replacement costs
- Expansion of existing unit processes required to treat flow beyond the existing design capacity
- Collection system upgrades
- Other capital costs that are not required to meet the potential new WQBELs
- This estimate is not intended to be additive with the estimate in Table D-

Capital cost clarifications:

- This is a Class 5 cost estimate, as defined by AACE International's *Recommended Practice No. 17R-97: Cost Estimate Classification System*. As such, the capital cost estimate has an expected accuracy range of +50/-30% for projects with a maturity level less than 2%.
- No additional land is required.
- Biological Nutrient Removal costs include:
  - Anaerobic/Anoxic/Oxic (A2O) activate sludge process
  - Concrete basins with handrail
  - Return activated sludge pumps
  - Recirculation pumps
  - Pump building
  - Fine-bubble diffusers
  - Anaerobic basin mixers
  - Anoxic basin mixers
  - Air piping
- All other costs would be similar to Section D5.1.

D7.2 Annual Costs

Annual costs shown in Table D- reflect the projected change in average costs incurred from changing the secondary treatment process, adding RO filtration and evaporation/crystallization. Note that these costs reflect the cost of upgrading from the existing facility to a facility capable of meeting the future WQBELs.

Table D-2 - Annual costs for improvements to meet future WQBELs for Watertown

Process	Operation ($/yr)	Maintenance ($/yr)	Material ($/yr)	Chemical ($/yr)	Energy ($/yr)	Total ($/yr)
Biological Nutrient Removal - 3/5 Stage	$88,400	$49,500	$21,300	$0	$31,500	$190,700
Chemical Phosphorus Removal	$0	$0	$0	$16,200	$0	$16,200
Secondary Clarifier	$400	$1,400	$0	$0	$100	$1,900
Aerobic Digestion	$1,800	$1,000	$17,000	$0	$3,000	$22,800
Hauling and Land Filling	$5,400	$0	$0	$0	$0	$5,400
WasteWater Control Splitter(1)	$20,800	$13,300	$500	$0	$1,700	$36,300
RO Filtration	$37,600	$2,700	$3,000	$38,600	$12,200	$94,100
Evaporator/Crystallizer	$150,400	$5,000	$19,700	$17,600	$351,500	$544,200
Hauling and Land Filling(1)	$1,700	$0	$77,300	$0	$0	$79,000
Iron Feed System	$30,900	$0	$4,300	$0	$0	$35,200
Totals	**$340,300**	**$74,400**	**$170,800**	**$72,400**	**$400,500**	**$1,058,400**

Annual cost clarifications:

- The BNR system annual costs would be partially offset by existing annual costs associated with the existing activated sludge process. The BNR process would have increased costs for operation and maintenance due to a more complex process flow.
- Land application of sludge would increase because the BNR process would generate more waste sludge than the existing activated sludge process.
- The secondary clarifier is an existing process, but would require more operation and maintenance costs due to the increased sludge volume.
- Power costs for the blower system are included in the BNR process line item.
- Chemical costs for the iron feed system are included in the chemical phosphorus removal line item. Note that chemical costs would be less than chemical costs for phosphorus removal without BNR.
- Other costs are as described in Section D5.2.
- This estimate is intended to be added to existing operation and maintenance costs.

D7.3 User Costs

User costs were evaluated as described in Section D5.3.

The increase in user cost for upgrades necessary to meet the future WQBEL would be approximately $1,620/year per ERU. This cost could be recovered with a combination of connection fees (typically applied to recover capital costs) and volume of use fees (typically applied to recover annual costs).

Adding the increase to the Typical Residential Sewer Rate shown in Table D-1 would increase the typical residential sewer rate more than four times to $2,257/year per ERU, which is 3.0% of the median household income.

Appendix E

Statewide annualized cost estimate to meet future TMDL requirements

Appendix E - Statewide annualized cost estimate to meet future TMDL requirements

Municipal MS4	Has Active TMDL related to sediment or nutrients?	Major Basin	Annual pollutant load (lbs/yr) - TSS	Annual pollutant load (lbs/yr) - TP	Annual pollutant load (lbs/yr) -	Future pollutant load reduction requirement (lbs/yr) - TSS	Future pollutant load reduction requirement (lbs/yr) - TP	Future pollutant load reduction requirement (lbs/yr) - TN	Annualized cost estimate to meet future TMDL requirements ($/yr)
Albert Lea	No	Lower Mississippi	2,368,000	4,900	24,300	2,013,000	2,400	7,300	$1,855,000
Austin	No	Lower Mississippi	2,486,000	5,100	25,500	2,113,000	2,500	7,600	$1,920,000
Fairmont	Yes	Lake Pepin	1,406,000	2,900	14,400	1,195,000	1,400	4,300	$1,147,000
Grand Rapids	No	Lake Pepin	1,657,000	3,400	17,000	1,409,000	1,700	5,100	$1,529,000
Hibbing	No	Lake Superior	1,874,000	3,800	19,200	1,593,000	1,900	5,800	$1,979,000
Rochester	Yes	Lower Mississippi	10,136,000	20,800	104,000	8,615,000	10,400	31,200	$6,732,000
Alexandria	No	Lake Pepin	1,562,000	3,200	16,000	1,327,000	1,600	4,800	$1,659,000
Andover	No	Lake Pepin	2,302,000	4,700	23,600	1,956,000	2,400	7,100	$1,942,000
Anoka	Yes	Lake Pepin	1,736,000	3,600	17,800	1,476,000	1,800	5,300	$1,483,000
Apple Valley	Yes	Lake Pepin	4,378,000	9,000	44,900	3,721,000	4,500	13,500	$3,624,000
Arden Hills	No	Lake Pepin	1,554,000	3,200	15,900	1,320,000	1,600	4,800	$1,290,000
Baxter	No	Lake Pepin	1,143,000	2,300	11,700	972,000	1,200	3,500	$1,107,000
Bemidji	No	Lake Pepin	1,577,000	3,200	16,200	1,341,000	1,600	4,900	$1,581,000
Big Lake	Yes	Lake Pepin	923,000	1,900	9,500	785,000	900	2,800	$818,000
Birchwood Village	No	Lake Pepin	34,000	100	300	29,000	0	100	$28,000
Blaine	Yes	Lake Pepin	5,571,000	11,400	57,100	4,736,000	5,700	17,100	$4,723,000
Bloomington	No	Lake Pepin	8,843,000	18,100	90,700	7,517,000	9,100	27,200	$7,385,000
Brainerd	No	Lake Pepin	1,556,000	3,200	16,000	1,323,000	1,600	4,800	$1,463,000
Brooklyn Center	Yes	Lake Pepin	2,526,000	5,200	25,900	2,147,000	2,600	7,800	$2,139,000
Brooklyn Park	Yes	Lake Pepin	6,376,000	13,100	65,400	5,420,000	6,500	19,600	$5,501,000
Buffalo	No	Lake Pepin	1,457,000	3,000	14,900	1,238,000	1,500	4,500	$1,295,000

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Burnsville	Yes	Lake Pepin	5,901,000	12,100	60,500	5,016,000	6,100	18,200	$4,845,000
Cambridge	No	Lake Pepin	1,135,000	2,300	11,600	964,000	1,200	3,500	$966,000
Carver	Yes	Lake Pepin	233,000	500	2,400	198,000	200	700	$205,000
Centerville	No	Lake Pepin	324,000	700	3,300	276,000	300	1,000	$273,000
Champlin	No	Lake Pepin	1,692,000	3,500	17,400	1,438,000	1,700	5,200	$1,460,000
Chanhassen	Yes	Lake Pepin	2,618,000	5,400	26,900	2,225,000	2,700	8,100	$2,242,000
Chaska	Yes	Lake Pepin	2,534,000	5,200	26,000	2,154,000	2,600	7,800	$2,066,000
Circle Pines	Yes	Lake Pepin	278,000	600	2,900	237,000	300	900	$237,000
Cloquet	No	Lake Superior	1,390,000	2,900	14,300	0	0	0	$0
Columbia Heights	Yes	Lake Pepin	1,185,000	2,400	12,200	1,007,000	1,200	3,600	$988,000
Coon Rapids	No	Lake Pepin	4,974,000	10,200	51,000	4,228,000	5,100	15,300	$4,291,000
Corcoran	Yes	Lake Pepin	523,000	1,100	5,400	444,000	500	1,600	$471,000
Cottage Grove	Yes	Lake Pepin	3,216,000	6,600	33,000	2,733,000	3,300	9,900	$2,680,000
Crystal	Yes	Lake Pepin	1,612,000	3,300	16,500	1,370,000	1,700	5,000	$1,365,000
Dayton	No	Lake Pepin	671,000	1,400	6,900	570,000	700	2,100	$599,000
Deephaven	No	Lake Pepin	262,000	500	2,700	223,000	300	800	$225,000
Dellwood	Yes	Lake Pepin	110,000	200	1,100	93,000	100	300	$90,000
Detroit Lakes	No	Lake Winnipeg	1,131,000	2,300	11,600	0	0	0	$0
Dilworth	No	Lake Winnipeg	433,000	900	4,400	0	0	0	$0
Duluth	No	Lake Superior	8,879,000	18,200	91,100	0	0	0	$0
Eagan	Yes	Lake Pepin	7,448,000	15,300	76,400	6,330,000	7,600	22,900	$6,115,000
East Bethel	Yes	Lake Pepin	711,000	1,500	7,300	604,000	700	2,200	$600,000

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Municipal MS4	Has Active TMDL related to sediment or nutrients?	Major Basin	Annual pollutant load (lbs/yr) - TSS	Annual pollutant load (lbs/yr) - TP	Annual pollutant load (lbs/yr) -	Future pollutant load reduction requirement (lbs/yr) - TSS	Future pollutant load reduction requirement (lbs/yr) - TP	Future pollutant load reduction requirement (lbs/yr) - TN	Annualized cost estimate to meet future TMDL requirements ($/yr)
East Grand Forks	No	Lake Winnipeg	868,000	1,800	8,900	0	0	0	$0
Eden Prairie	No	Lake Pepin	6,444,000	13,200	66,100	5,478,000	6,600	19,800	$5,511,000
Edina	No	Lake Pepin	3,968,000	8,100	40,700	3,373,000	4,100	12,200	$3,312,000
Elk River	No	Lake Pepin	2,868,000	5,900	29,400	2,438,000	2,900	8,800	$2,402,000
Elko New Market	No	Lake Pepin	340,000	700	3,500	289,000	300	1,000	$289,000
Excelsior	No	Lake Pepin	182,000	400	1,900	155,000	200	600	$156,000
Falcon Heights	Yes	Lake Pepin	607,000	1,200	6,200	516,000	600	1,900	$498,000
Faribault	Yes	Lake Pepin	2,454,000	5,000	25,200	2,086,000	2,500	7,600	$2,007,000
Farmington	Yes	Lake Pepin	1,674,000	3,400	17,200	1,423,000	1,700	5,100	$1,427,000
Fergus Falls	No	Lake Winnipeg	1,310,000	2,700	13,400	0	0	0	$0
Forest Lake	Yes	Lake Pepin	1,737,000	3,600	17,800	1,477,000	1,800	5,300	$1,446,000
Fridley	No	Lake Pepin	3,416,000	7,000	35,000	2,904,000	3,500	10,500	$2,849,000
Gem Lake	No	Lake Pepin	119,000	200	1,200	101,000	100	400	$98,000
Glencoe	No	Lake Pepin	783,000	1,600	8,000	665,000	800	2,400	$686,000
Golden Valley	Yes	Lake Pepin	2,670,000	5,500	27,400	2,270,000	2,700	8,200	$2,233,000
Grant	Yes	Lake Pepin	405,000	800	4,200	344,000	400	1,200	$333,000
Greenwood	No	Lake Pepin	61,000	100	600	52,000	100	200	$52,000
Ham Lake	No	Lake Pepin	1,255,000	2,600	12,900	1,066,000	1,300	3,900	$1,070,000
Hastings	Yes	Lake Pepin	1,854,000	3,800	19,000	1,576,000	1,900	5,700	$1,574,000
Hermantown	No	Lake Superior	1,256,000	2,600	12,900	0	0	0	$0
Hilltop	No	Lake Pepin	61,000	100	600	51,000	100	200	$50,000
Hopkins	No	Lake Pepin	1,336,000	2,700	13,700	1,136,000	1,400	4,100	$1,115,000

Appendix E - Statewide annualized cost estimate to meet future TMDL requirements

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Hugo	Yes	Lake Pepin	1,148,000	2,400	11,800	976,000	1,200	3,500	$968,000
Hutchinson	No	Lake Pepin	1,938,000	4,000	19,900	1,647,000	2,000	6,000	$1,762,000
Independence	Yes	Lake Pepin	350,000	700	3,600	298,000	400	1,100	$309,000
Inver Grove Heights	Yes	Lake Pepin	3,777,000	7,700	38,700	3,211,000	3,900	11,600	$3,108,000
La Crescent	No	Lower Mississippi	529,000	1,100	5,400	0	0	0	$0
Lake Elmo	Yes	Lake Pepin	1,125,000	2,300	11,500	956,000	1,200	3,500	$916,000
Lakeville	Yes	Lake Pepin	5,664,000	11,600	58,100	4,815,000	5,800	17,400	$4,689,000
Landfall	No	Lake Pepin	33,000	100	300	28,000	0	100	$27,000
Lauderdale	No	Lake Pepin	152,000	300	1,600	129,000	200	500	$125,000
Lexington	Yes	Lake Pepin	160,000	300	1,600	136,000	200	500	$136,000
Lilydale	No	Lake Pepin	64,000	100	700	55,000	100	200	$53,000
Lino Lakes	Yes	Lake Pepin	1,885,000	3,900	19,300	1,602,000	1,900	5,800	$1,603,000
Litchfield	No	Lake Pepin	898,000	1,800	9,200	763,000	900	2,800	$817,000
Little Canada	Yes	Lake Pepin	1,025,000	2,100	10,500	871,000	1,100	3,200	$851,000
Little Falls	No	Lake Pepin	1,042,000	2,100	10,700	886,000	1,100	3,200	$1,046,000
Long Lake	No	Lake Pepin	212,000	400	2,200	180,000	200	700	$187,000
Loretto	Yes	Lake Pepin	71,000	100	700	61,000	100	200	$64,000
Mahtomedi	Yes	Lake Pepin	523,000	1,100	5,400	444,000	500	1,600	$430,000
Mankato	Yes	Lake Pepin	4,365,000	9,000	44,800	3,710,000	4,500	13,400	$3,606,000
Maple Grove	Yes	Lake Pepin	6,286,000	12,900	64,500	5,343,000	6,400	19,300	$5,531,000
Maple Plain	No	Lake Pepin	238,000	500	2,400	202,000	200	700	$209,000
Maplewood	Yes	Lake Pepin	3,921,000	8,000	40,200	3,333,000	4,000	12,100	$3,192,000
Marshall	Yes	Lake Pepin	1,867,000	3,800	19,100	1,587,000	1,900	5,700	$1,762,000
Medicine Lake	Yes	Lake Pepin	24,000	0	200	20,000	0	100	$20,000

Appendix E - Statewide annualized cost estimate to meet future TMDL requirements

Municipal MS4	Has Active TMDL related to sediment or nutrients?	Major Basin	Annual pollutant load (lbs/yr) - TSS	Annual pollutant load (lbs/yr) - TP	Annual pollutant load (lbs/yr) -	Future pollutant load reduction requirement (lbs/yr) - TSS	Future pollutant load reduction requirement (lbs/yr) - TP	Future pollutant load reduction requirement (lbs/yr) - TN	Annualized cost estimate to meet future TMDL requirements ($/yr)
Medina	Yes	Lake Pepin	848,000	1,700	8,700	721,000	900	2,600	$764,000
Mendota	No	Lake Pepin	34,000	100	300	29,000	0	100	$28,000
Mendota Heights	No	Lake Pepin	1,745,000	3,600	17,900	1,483,000	1,800	5,400	$1,434,000
Minneapolis	Yes	Lake Pepin	18,998,000	39,000	194,800	16,148,000	19,500	58,500	$16,562,000
Minnetonka	Yes	Lake Pepin	4,871,000	10,000	50,000	4,140,000	5,000	15,000	$4,166,000
Minnetonka Beach	No	Lake Pepin	62,000	100	600	53,000	100	200	$55,000
Minnetrista	Yes	Lake Pepin	558,000	1,100	5,700	475,000	600	1,700	$490,000
Montevideo	No	Lake Pepin	680,000	1,400	7,000	578,000	700	2,100	$635,000
Monticello	Yes	Lake Pepin	1,526,000	3,100	15,600	1,297,000	1,600	4,700	$1,348,000
Moorhead	No	Lake Winnipeg	2,865,000	5,900	29,400	0	0	0	$0
Morris	Yes	Lake Pepin	515,000	1,100	5,300	438,000	500	1,600	$519,000
Mound	No	Lake Pepin	626,000	1,300	6,400	532,000	600	1,900	$551,000
Mounds View	No	Lake Pepin	943,000	1,900	9,700	801,000	1,000	2,900	$799,000
New Brighton	Yes	Lake Pepin	1,865,000	3,800	19,100	1,585,000	1,900	5,700	$1,555,000
New Hope	Yes	Lake Pepin	1,766,000	3,600	18,100	1,501,000	1,800	5,400	$1,379,000
New Ulm	Yes	Lake Pepin	1,550,000	3,200	15,900	1,317,000	1,600	4,800	$1,365,000
Newport	No	Lake Pepin	680,000	1,400	7,000	578,000	700	2,100	$561,000
North Branch	Yes	Lake Pepin	934,000	1,900	9,600	794,000	1,000	2,900	$823,000
North Mankato	Yes	Lake Pepin	1,342,000	2,800	13,800	1,141,000	1,400	4,100	$1,130,000
North Oaks	No	Lake Pepin	357,000	700	3,700	304,000	400	1,100	$297,000
North Saint Paul	Yes	Lake Pepin	815,000	1,700	8,400	693,000	800	2,500	$664,000
Northfield	Yes	Lake Pepin	1,726,000	3,500	17,700	1,467,000	1,800	5,300	$1,436,000

Appendix E - Statewide annualized cost estimate to meet future TMDL requirements

Municipal MS4	Has Active TMDL related to sediment or nutrients?	Major Basin	Annual pollutant load (lbs/yr) - TSS	Annual pollutant load (lbs/yr) - TP	Annual pollutant load (lbs/yr) -	Future pollutant load reduction requirement (lbs/yr) - TSS	Future pollutant load reduction requirement (lbs/yr) - TP	Future pollutant load reduction requirement (lbs/yr) - TN	Annualized cost estimate to meet future TMDL requirements ($/yr)
Nowthen	No	Lake Pepin	344,000	700	3,500	293,000	400	1,100	$292,000
Oak Grove	No	Lake Pepin	603,000	1,200	6,200	513,000	600	1,900	$503,000
Oakdale	Yes	Lake Pepin	2,434,000	5,000	25,000	2,069,000	2,500	7,500	$1,982,000
Orono	No	Lake Pepin	963,000	2,000	9,900	818,000	1,000	3,000	$847,000
Osseo	Yes	Lake Pepin	298,000	600	3,100	253,000	300	900	$257,000
Otsego	No	Lake Pepin	1,454,000	3,000	14,900	1,236,000	1,500	4,500	$1,300,000
Owatonna	Yes	Lake Pepin	3,166,000	6,500	32,500	2,691,000	3,200	9,700	$2,514,000
Pine Springs	Yes	Lake Pepin	51,000	100	500	43,000	100	200	$42,000
Plymouth	Yes	Lake Pepin	7,063,000	14,500	72,400	6,003,000	7,200	21,700	$6,075,000
Prior Lake	Yes	Lake Pepin	2,312,000	4,700	23,700	1,965,000	2,400	7,100	$1,996,000
Proctor	No	Lake Superior	362,000	700	3,700	0	0	0	$0
Ramsey	No	Lake Pepin	2,265,000	4,600	23,200	1,925,000	2,300	7,000	$1,991,000
Red Wing	No	Lake Pepin	2,059,000	4,200	21,100	1,750,000	2,100	6,300	$1,644,000
Redwood Falls	Yes	Lake Pepin	593,000	1,200	6,100	504,000	600	1,800	$551,000
Richfield	Yes	Lake Pepin	2,264,000	4,600	23,200	1,924,000	2,300	7,000	$1,868,000
Robbinsdale	Yes	Lake Pepin	834,000	1,700	8,600	709,000	900	2,600	$706,000
Rosemount	Yes	Lake Pepin	3,125,000	6,400	32,100	2,657,000	3,200	9,600	$2,385,000
Roseville	Yes	Lake Pepin	3,901,000	8,000	40,000	3,316,000	4,000	12,000	$3,199,000
Saint Anthony	Yes	Lake Pepin	685,000	1,400	7,000	582,000	700	2,100	$571,000
Saint Bonifacius	No	Lake Pepin	201,000	400	2,100	171,000	200	600	$176,000
Saint Cloud	Yes	Lake Pepin	6,747,000	13,800	69,200	5,735,000	6,900	20,800	$6,493,000
Saint Joseph	No	Lake Pepin	603,000	1,200	6,200	512,000	600	1,900	$562,000
Saint Louis Park	Yes	Lake Pepin	3,143,000	6,400	32,200	2,671,000	3,200	9,700	$2,628,000

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Saint Michael	No	Lake Pepin	1,606,000	3,300	16,500	1,365,000	1,600	4,900	$1,448,000
Saint Paul	Yes	Lake Pepin	15,542,000	31,900	159,400	13,210,000	15,900	47,800	$14,547,000
Saint Paul Park	No	Lake Pepin	648,000	1,300	6,600	551,000	700	2,000	$540,000
Saint Peter	Yes	Lake Pepin	1,149,000	2,400	11,800	977,000	1,200	3,500	$981,000
Sartell	No	Lake Pepin	1,629,000	3,300	16,700	1,385,000	1,700	5,000	$1,520,000
Sauk Rapids	Yes	Lake Pepin	1,384,000	2,800	14,200	1,176,000	1,400	4,300	$1,301,000
Savage	No	Lake Pepin	2,781,000	5,700	28,500	2,364,000	2,900	8,600	$2,323,000
Shakopee	No	Lake Pepin	4,921,000	10,100	50,500	4,183,000	5,000	15,100	$4,223,000
Shoreview	No	Lake Pepin	2,065,000	4,200	21,200	1,756,000	2,100	6,400	$1,716,000
Shorewood	Yes	Lake Pepin	592,000	1,200	6,100	503,000	600	1,800	$519,000
South Saint Paul	No	Lake Pepin	1,979,000	4,100	20,300	1,682,000	2,000	6,100	$1,633,000
Spring Lake Park	No	Lake Pepin	645,000	1,300	6,600	548,000	700	2,000	$546,000
Spring Park	No	Lake Pepin	122,000	300	1,300	104,000	100	400	$108,000
Stillwater	Yes	Lake Pepin	1,504,000	3,100	15,400	1,279,000	1,500	4,600	$1,201,000
Sunfish Lake	No	Lake Pepin	148,000	300	1,500	125,000	200	500	$121,000
Tonka Bay	No	Lake Pepin	131,000	300	1,300	111,000	100	400	$115,000
Vadnais Heights	Yes	Lake Pepin	1,282,000	2,600	13,200	1,090,000	1,300	3,900	$1,065,000
Victoria	Yes	Lake Pepin	656,000	1,300	6,700	558,000	700	2,000	$576,000
Waconia	Yes	Lake Pepin	928,000	1,900	9,500	789,000	1,000	2,900	$815,000
Waite Park	No	Lake Pepin	1,199,000	2,500	12,300	1,019,000	1,200	3,700	$1,106,000
Waseca	Yes	Lake Pepin	1,043,000	2,100	10,700	887,000	1,100	3,200	$779,000
Wayzata	No	Lake Pepin	567,000	1,200	5,800	482,000	600	1,700	$488,000

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West Saint Paul	No	Lake Pepin	1,530,000	3,100	15,700	1,300,000	1,600	4,700	$1,258,000
White Bear Lake	Yes	Lake Pepin	1,987,000	4,100	20,400	1,689,000	2,000	6,100	$1,635,000
Willernie	No	Lake Pepin	20,000	0	200	17,000	0	100	$17,000
Willmar	Yes	Lake Pepin	2,805,000	5,800	28,800	2,385,000	2,900	8,600	$2,541,000
Winona	No	Lower Mississippi	2,694,000	5,500	27,600	0	0	0	$0
Woodbury	Yes	Lake Pepin	5,385,000	11,000	55,200	4,577,000	5,500	16,600	$4,443,000
Woodland	No	Lake Pepin	46,000	100	500	39,000	0	100	$40,000
Worthington	Yes	Des Moines	1,285,000	2,600	13,200	1,093,000	1,300	4,000	$1,175,000