Facility Plan

Water Reclamation Facility

City of Rapid City Project No. 14-2214

HDR Project No. 222360

Prepared for:

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& Water Reclamation Facility

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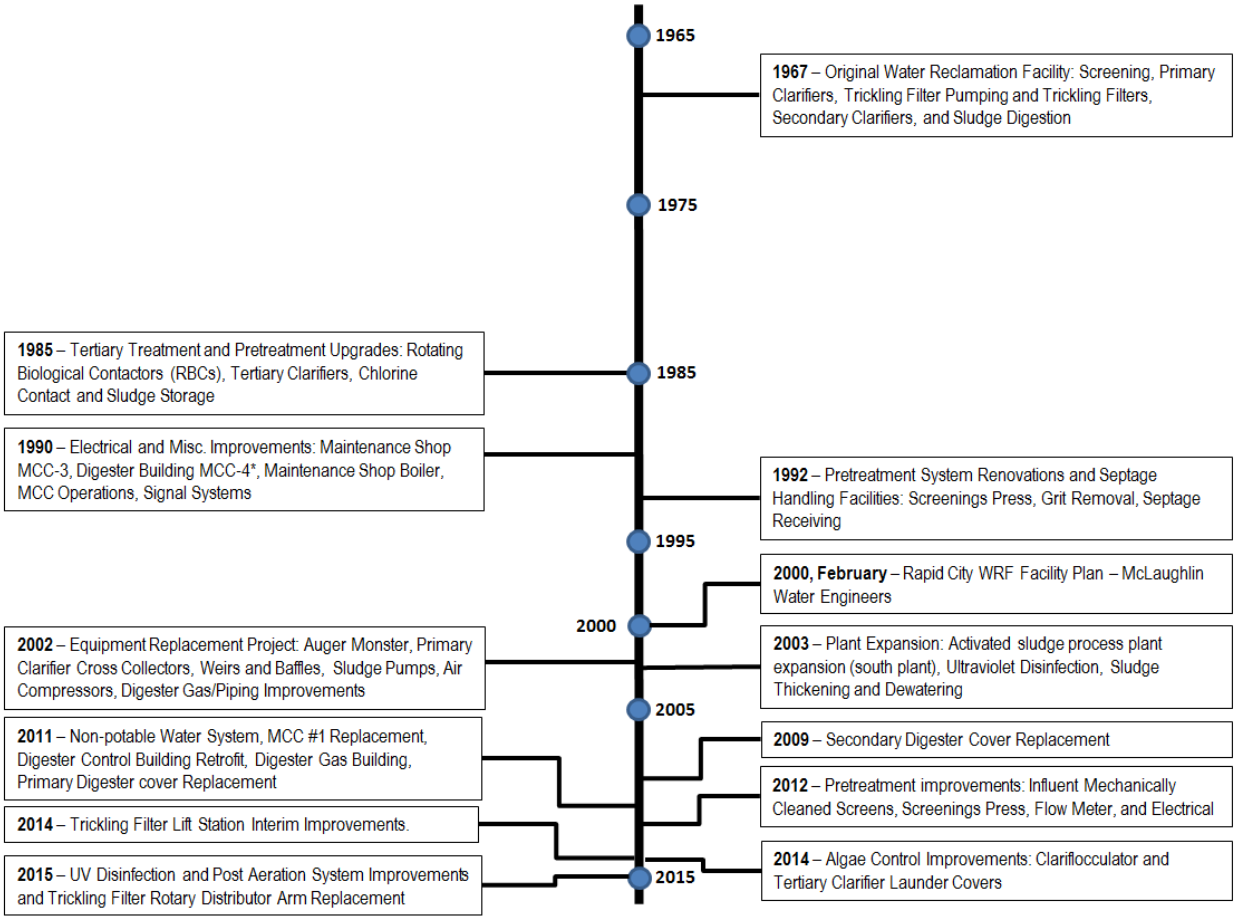
Executive Summary

Introduction

The City of Rapid City (City) Water Reclamation Facility (WRF) is located 5 miles east of the City in Pennington County, South Dakota. Rapid City provides wastewater treatment for all residential, commercial, and current industrial customers in the City of Rapid City and several regional customers. The WRF uses both a fixed film system (North Plant) and an activated sludge system (South Plant) that operate in parallel to treat wastewater from the facility's service area. The WRF is facing more restrictive discharge limits to Rapid Creek and serves a steadily increasing population base.

The original fixed film facility, referred to as the North Plant, was designed in 1965 and construction was completed in 1967. Improvements and upgrades have occurred regularly to replace worn equipment and to keep up with more restrictive effluent water quality requirements. Refer to Figure E.1 for the timeline of these major improvements.



MCC – Motor Control Center

Figure E.1. Rapid City WRF History of Major Improvements

The City last completed a WRF facility plan in 2000. Anticipated permit conditions were discussed and treatment plant equipment and processes were evaluated through the planning year 2018. The 2000 Facility Plan recommended a number of capital improvements which have been implemented. A process addition of activated sludge was completed in 2003 for additional treatment flexibility. In addition, the recommendations for construction of sludge dewatering, replacement of the gas chlorine disinfection system with an ultraviolet (UV) disinfection system and additional administration facilities have been completed. As the planning period is nearing conclusion, a number of improvements have been made to the facility, equipment condition has changed, and potential new more stringent permit modifications have been identified. This coupled with changing wastewater flows and pending operational changes at the WRF led the City to have another WRF facility plan prepared to more accurately plan for the next 20+ years.

Even at the completion of this facility plan, the upcoming facility nutrient discharge criteria for the Rapid City WRF are not certain. However impending phases of upcoming nutrient discharge criteria for total nitrogen and phosphorus criteria have been defined from which associated facility requirements can be identified. In addition to nutrient removal evaluations, this facility plan evaluated the existing facilities and structures to update the condition of the entire facility to provide reliable treatment. Plant expansion and other improvements are addressed to meet anticipated facility needs to at least the planning year 2035. Numeric nutrient criteria are a critical tool for protecting and restoring a water body's designated uses related to nitrogen and phosphorus pollution.

This Executive Summary is followed by a facility plan General Summary chapter, which further summarizes the results of the current facility analysis, and a detailed facility plan which is presented in the subsequent sections. Age and condition related needs were determined by onsite condition assessment and are reflected in Chapter 1.1 Operations and Physical Condition Assessments. Operational improvements were discussed both in terms of physical operation of the plant in Chapter 1.1 and in terms of energy consumption in Chapter 1.2 Energy Assessment. Regulatory considerations are outlined in Chapter 2.2. Capacity related needs were determined and are reflected in Chapter 3.1 Plant Hydraulic Capacity and 3.2 Plant Organic Capacity. Finally, regulatory and capacity related needs were considered and projects were identified for secondary treatment and solids handling in Chapters 4.1 and 4.2, respectively. The results have been compiled and presented in Chapter 5.1 in the form of a preliminary capital improvements plan. A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility costs is contained in Appendix 5.1.A.

Water Quality and Regulatory Requirements

The intent of this facility planning effort is to define the longer-term path forward to meet anticipated incoming capacity and regulatory discharge requirements so that shorter term modifications are consistent with the long term plan. The driving factor in this planning effort became the anticipated regulatory requirement of more strict ammonia and nutrient removal from the facility's discharge. A wider regional focus on nutrients is occurring because of the Gulf of Mexico hypoxia. Hypoxic zones are areas in the ocean of such low oxygen concentration

that animal life suffocates and dies, and as a result are sometimes called "dead zones. The focus on solving these environmental endangerments is driving efforts to reduce nutrient discharges throughout the Missouri River watershed, which includes discharges from the Rapid City WRF. In fact, due to the lack of progress on the part of the states, legislation has begun pushing the EPA to take primacy and implement these new nutrient standards on a federal level. To avoid more stringent limits directly enforced by the EPA, surrounding states including Minnesota, Wisconsin, Montana, and Colorado are in the process of incorporating nutrient discharge limits which indicates that any municipal wastewater treatment facility, such as the Rapid City WRF, should be prepared for new and/or more stringent nutrient limits for future discharge permits.

Several significant issues influence the wastewater facilities planning and discharge limitations for the City of Rapid City:

- New and future discharge permits with the greatest affect being ammonia and nutrient discharge limits.
- Increased design flow affecting permit limits and meet anti-backsliding requirements.

  (Anti-backsliding requirements are federal regulations regarding the renewal or reissue of discharge permits (for direct dischargers) and say that the effluent limitations, standards, or conditions in the renewed/reissued permit "must be at least as stringent" as the effluent limitations, standards, or conditions in the previous permit.)

- Rapid Creek water quality
- Revised federal ammonia nitrogen criteria adopted in 2013, which will be incorporated into South Dakota water quality standards at the completion of the next triennial review in 2017 and implemented into permits.
- 40 CFR Part 503 regulation impacts on biosolids

Discussions with SD DENR and review of WRF influent and effluent data have identified the significant issues that are likely to be introduced in the new discharge permit, which include a new ammonia nitrogen discharge limit and new total nitrogen (TN) and total phosphorus (TP) limits, or nutrient limits. The ammonia limits are fairly well defined based on the new federal ammonia criteria. Many factors affect the future nutrient limits. At this time the nutrient numeric limits in the upcoming discharge permits are not definite numeric values. However, a progression of more stringent limits has been developed based on discussions with SD DENR and comparisons with how other similar Midwest states are dealing with implementing these pending EPA driven limits. The ammonia and nutrient limits have significant effects on treatment processes. The existing treatment processes will require modification/ expansion to meet these anticipated limits.

Additional monitoring will be required in the upcoming discharge permit. Requirements are likely to include more complete effluent quality data with a focus on more intensive requirements for ammonia and nutrients.

Biosolids are affected by 40 CFR Part 503 regulation if the City moves away from landfilling or Co-composting the dewatered biosolids for all or part of the year. Depending on the use of biosolids and public contact, the biosolids would need to meet Class A or Class B requirements. As it stands now, both landfilling and processing biosolids through the Materials Recycle Facility

(MRF) Co-composting Facility meet federal guidelines and Rapid City does not intend to change biosolids management methods.

The process evaluations were based on meeting a "Level 1" Total Nitrogen (TN) requirement of less than 10 mg/l and a Total Phosphorus (TP) limit of 1 mg/l for nutrient limits. Level 1 can be achieved with equitable modifications to the conventional secondary treatment processes at the Rapid City WRF.

Table E.1 presents a summary of anticipated future Rapid City WRF discharge permit renewal dates and the anticipated limitations to be included in each permit. In addition, the corresponding recommended activity for the City is listed. The permit sequence is defined as follows:

- Current permit: Permit that is expected to be issued in 2016.
- Permit #1 – Compliance Schedule for New Ammonia Standards
- Permit #2 – New Ammonia Standards
- Permit #3 – New Nutrient Criteria Standards
- Permit #4 – More Stringent Nutrient Standards

Table E.1. Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit 2016	New Ammonia Standards based on updated Rapid Creek water quality	Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability. Establish schedule for construction – assume major projects are 5 years from study completion unless other justification (i.e. Trickling Filter Pump Station type trigger).
Permit #1 2020	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project to be constructed by 2025. Ammonia standards will become part of the SD Water Quality Standards After 2017 and new treatment process is required to meet proposed Ammonia limits.
Permit #2 2025	New Ammonia Standards	Assuming required improvements for ammonia removals complete. Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2030.
Permit #3 2030	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty. Track potential for more stringent nutrient standards.
Permit #4 2035	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

Plant Hydraulic Capacity

Hydraulic capacity is defined as the ability of the treatment plant to handle the wastewater flow through the various treatment units. The hydraulic capacity of the WRF was evaluated as part of facility planning to help identify capital improvements required to meet current and long-term capacity needs at the WRF.

The hydraulic capacity of the WRF was determined through a combination of a unit process by unit process analysis and a hydraulic modeling of the entire WRF.

The current 2015 peak hour flow measured at the facility is 30.2 mgd. It is anticipated the peak hour hydraulic capacity in 2035 will be 43.5 mgd. Numerous process upgrades will be required to meet this peak flow. These improvements include: aeration basin improvements, an in-plant secondary pump station, headworks capacity improvements, south plant effluent piping improvements and additional clariflocculators.

The future influent flows shown in Table E.2 were calculated from the average per capita values multiplied by the projected wastewater service population. Industrial and commercial reserve is limited to the nature of the existing service area and was included in projected population growth loadings.

The current (2015) wastewater service population of 79,855 is expected to increase at a rate of approximately 1.9% per year to over 131,000 by 2045. The current average daily flow to the treatment facility is expected to increase from the current 9.51 mgd to nearly 16 mgd by 2045. Pollutant loadings, including BOD, TSS, ammonia and nutrients are all expected to increase from current levels in proportion to the expected wastewater flow increase in future years.

Table E.2. Projected Future Influent Flows

Parameter		Flow Projections					
	Current	2020	2025	2030	Planning Year - 2035	2040	2045
Population WW Service Population	79,855	85,560	91,205	98,195	105,184	120,674	131,018
Influent Flow Annual Average Day	MGD 9.5	MGD 10.6	MGD 11.3	MGD 12.2	MGD 13.0	MGD 14.9	MGD 16.2
Peak Hour	30.0	35.4	37.7	40.6	43.5	49.9	54.2

Treatment Capacity

The WRF's ability to remove pollutants from the wastewater, as necessary to meet regulatory limits, is the facility's treatment capacity. Note the capacity is presented based on flow; however, this represents an organic loading capacity evaluation based on the wastewater characterization. The system is limited to design flows based on the pollutant levels in the

wastewater in addition to the required improvements to allow the plant to pass peak hydraulic flows.

The existing WRF was modeled to test the critical flows and loads at which expansion of the system is needed for the system as a whole. The model results showed that the controlling regulatory condition for the organic capacity of the existing facility is based on meeting the permitted effluent ammonia concentration. Table E.3 summarizes the existing capacity analysis for both current (2016) permit limits and forthcoming Permit #2 –New Ammonia Standards based on mussel toxicity (2013 EPA Water Quality Rule).

Table E.3 indicates the total equivalent population treatment capacity is 91,155, with the current 2016 permit limitations, which would be reached in approximately year 2025. The 2000 Facility Plan projected the existing WRF had a population treatment capacity of 94,000 at the 2001 permit limits. It predicted this population would be reached in 2018. The capacity with more stringent ammonia limits is only 3.1% less from the 2000 estimate at a total equivalent population of 91,155.

At the Permit #2 –New Ammonia Standards limits, the equivalent population capacity would be 81,855, or approximately 2 years of growth from the 2014 base population of 79,855. Therefore, improvements would need to be in place and functioning when Permit #2 is issued. The existing plant cannot meet expected regulatory treatment requirements without treatment capacity expansion.

The whole plant capacity evaluation was also completed by integrating improvements to meet the Permit #2 – New Ammonia Standards. The expectation is that these limits could be incorporated into the City's permit as early as 2025.

Table E.3 Organic Capacity Summary of Existing WRF

	Current Loadings	Capacity with 2016 Current Ammonia Permit Limits	Capacity with Permit #2 – New Ammonia Limits
BOD_5, lb/day	16,600	17,600	15,900
TSS, lb/day	16,100	19,600	17,600
TKN, lb/day	2,810	3,210	2,880
Ammonia, lb/day	1,970	2,240	2,020
Population Equivalent	79,855	91,155	81,855

Treatment Alternatives

Advanced treatment techniques using biological, chemical and physical processes were evaluated for removing nutrients from wastewater. Alternatives for removing nutrients were considered including: activated sludge, side-stream treatment and trickling filter wet weather treatment.

To meet Permit #2 (2025) requirements, additional activated sludge treatment capacity with additional clarifiers will be required as the RBCs that currently provide treatment capacity will no longer be utilized due to the process limitations and age and condition. To meet the Permit #3

(2030) requirement, additional facilities for chemical phosphorus removal and capacity will be required.

The recommended alternative is the expansion of the activated sludge system for additional treatment and flow capacity. This alternative is consistent with the 2000 Facility Plan as that plan recommended the activated sludge treatment for additional capacity with provisions for denitrification. The aging trickling filter/RBC treatment processes will be phased out of service as the new alternatives are constructed.

Treatment expansion improvements are divided into the phases triggered by the permit cycles. Phase 1 includes modifications required to achieve Permit #2 – New Ammonia Standards (constructed by 2025). The combination of Phase 1 and Phase 2 includes modifications to achieve both future ammonia removals and Biological Nutrient Removal (TN 10/TP 1) to be constructed by 2030. Refer to Figure E.3 for phased improvements.

The selected alternative of activated sludge expansion without the existing trickling filters is consistently the lowest cost alternative whether it be construction cost, energy cost, chemical cost, operations and maintenance cost, or overall present value. On a total present value basis, it is approximately $6.5 million less than the next alternative.

Solids Handling Evaluation

The Rapid City WRF currently processes approximately 490,000 gallons per week of sludge during a maximum month at the solids handling facilities. The solids handling facilities currently thicken sludge to 6 percent solids and dewater sludge to 25 percent solids. However, after reviewing the current Rapid City Regional Landfill composting operations, it was determined that moving forward with dewatering only (no thickening) will not adversely impact the Rapid City MRF Co-composting operations and therefore only dewatering system alternatives were evaluated for future solids handling at the Rapid City WRF. The most notable recommended technology-based change was the evaluation of options for dewatering to improve operability and reduce cost of the sludge handling operation.

Four dewatering technologies were reviewed for upgrading the existing solids handling facilities. These four technologies included centrifuges, screw presses, rotary fan presses, and volute presses.

Solids handling improvements are recommended as an immediate need. Alternative 4B: Three Volute Presses constructed in a new building, is included in the Rapid City WRF Capital Improvements Plan. A phased approach is provided to add additional units concurrent with Permit #2 (2025) liquid process train improvements.

Age and Condition

A condition assessment of equipment and facilities was conducted to help determine the needs and timing for repair or replacement of existing facility components in the development of the long-range plans of the WRF. An operations assessment was conducted by an operations specialist, focusing on how the existing facility is being operated and maintained. A physical condition assessment was conducted by individuals with expertise in process equipment, architecture, structural engineering, mechanical engineering, electrical engineering, and

instrumentation engineering, focusing on the current physical condition analysis as a basis for estimating the remaining useful life of its components.

Each significant piece of process equipment was physically inspected and plant O&M staff was interviewed to discuss reliability and operational and condition issues. From a process equipment perspective, there are currently no major constraints on the WRF's ability to meet the current discharge permit limits under normal circumstances, due to the O&M staff's dedication to ongoing operation and maintenance of the facility.

A number of the treatment facilities are 30 to 50 years old and have reached their useful life to provide reliable service. Some plant components suffer from deteriorated condition, fail to comply with current codes or provide unsatisfactory and possibly unsafe working environments for the operations staff. The following have been incorporated as key cost components in the alternative life cycle evaluations:

- Trickling filter pumping improvements
- Sludge handling improvements
- New clariflocculator
- Aeration basin curtain replacement
- Aeration basin drain pumping
- North Plant primary scum and secondary clarifier sludge pumping replacement
- Mechanical HVAC, Structural and Architectural and Electrical Improvements

The specific improvements are designed to provide adequate capacity for the projected 20-year 2035 nominal flow of 13 mgd (peak flow of 43.5 mgd).

Summary of Recommendations

Table E.4 provides a summary of the preliminary recommendations to upgrade the Rapid City WRF to reliably meet the new permit conditions. This table provides an overview of facility requirements, driving forces, urgency/timing considerations, and order of magnitude costs.

The summary of recommendation has been separated into the following categories:

- **Short-Term Capital Improvements**
  These are improvements required to reliably continue to treat the flow to meet the current permit. Short-term improvements are anticipated to be implemented within the next five years. These improvements address items such as treatment and hydraulic capacity items, reliability, operations and energy minimization. Priority 1 items are recommended to be completed in 2016 – 2018, and Priority 2 items completed by 2020.

- **Plant Modifications to meet 2025 Permit #2**
  These are improvements that will be necessary to meet the federally adopted ammonia criteria. These ammonia limits will be included in a future permit anticipated by 2025. These improvements primarily address treatment capacity upgrades.

- **Plant Modifications to meet 2030 Permit #3**
  These are improvements that will be necessary to meet the future nutrient criteria limit of 10 mg/l TN and 1 mg/L phosphorus. These limits are planned for 2030; however these limits are the most uncertain with respect to schedule and numeric criteria. These improvements primarily focus on an expanded activated sludge system.

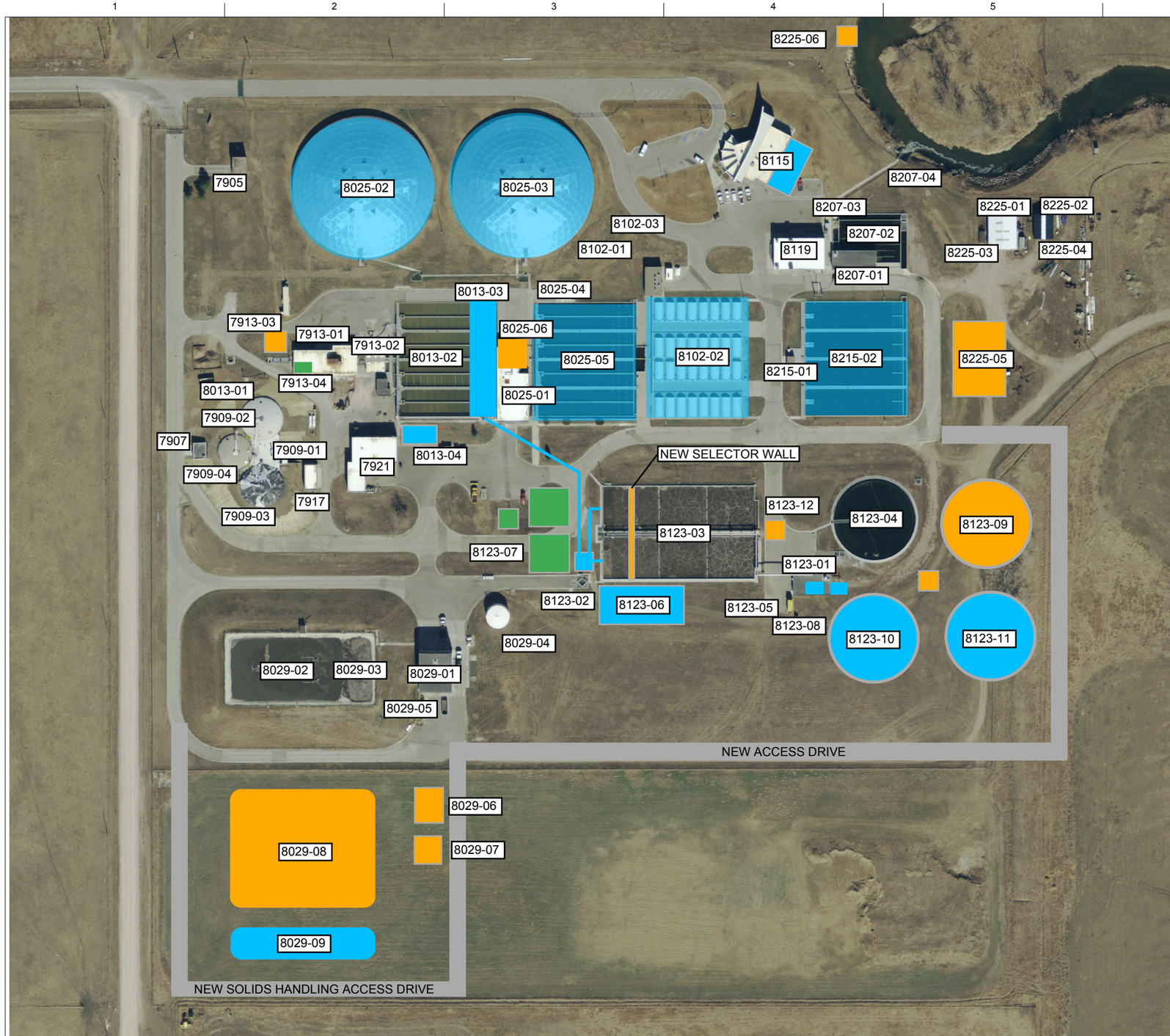
- **Plant Modifications to meet Other Needs**
  These are improvements that are necessary to continue to meet the needs for the City of Rapid City to operate effectively and meet the effluent permit limits. These items have been given Priority 3, 4 or 5 designations. Priority 3 items are planned to be completed in 2020 – 2025 and Priority 4 and 5 items are planned for completion in 2025 – 2035.

Figure E.2 illustrates the recommended WRF facility improvements.

Table E.4. Summary of Recommendations

Component	Recommended Improvements	Implementation Date	Project Cost
Short-Term Capital Improvements			
Priority 1			
Activated Sludge Improvements	One new clariflocculator, curtain wall, drain pump	Priority 1 - 2016-2018	$4,014,000
Trickling Filter Pump Sta. Improvements	New pumps with VFDs to handle flow range, and repair and recoat pump discharge piping.	Priority 1 - 2016-2018	$2,410,000
Sludge Handling Project	Provide new dewatered sludge conveyance and storage equipment.	Priority 1 - 2016-2018	$11,950,000
Misc. Preliminary Treatment Improvements	Screening bypass, septage safety and volume, misc.	Priority 1 - 2016-2019	$150,000
Misc. Digester Improvements	Roof access, chemical feed and waste gas improvements.	Priority 1 - 2016-2018	$106,000
Operations and Energy Improvement	Emergency operating plan, risk based SCADA and alarms and energy conservation measures	Priority 1 - 2016-2018	$590,000
	Priority 1 Subtotal		**$19,180,000**
Priority 2			
Site work	Roadways, plant access, Gaging Station, and water well abandonment.	Priority 2 - 2018-2020	$434,000
Primary Treatment	Scum pumps & piping, skimmers and gear boxes, sludge level sensors, pumping room HVAC, railing and misc. tuck pointing.	Priority 2 - 2018-2020	$696,000
Secondary Clarification	Humus pumps, gear boxes, and clarifier railing.	Priority 2 - 2018-2020	$264,000
RBCs and Generator	Repair RBC in-tank air piping, replace generator, and HVAC.	Priority 2 - 2018-2020	$311,000
Tertiary Clarifiers and Pumping	Costs to Maintain existing pumps, drives and HVAC.	Priority 2 - 2018-2020	$60,000
Activated Sludge Improvements	Splitter box gate actuators, Blower intakes/HVAC, generator controls and misc. architectural.	Priority 2 - 2018-2020	$156,000
UV Disinfection/Post Aeration Improvements	Generator controls and misc. architectural	Priority 2 - 2018-2020	$31,000
Digestion Area Improvements	Replace steel gas lines, boiler controls, electric modifications and misc. vac and architectural.	Priority 2 - 2018-2020	$178,000
HVAC Improvements	Upgrade Secondary Building, Water Building, Maintenance Shop, and Metals Shop HVAC.	Priority 2 - 2018-2020	$624,000
Instrumentation, Electrical and Misc. Improvements	Maintenance Shop MCC, Integration of PLCs, and Samplers.	Priority 2 - 2018-2020	$321,000
Cold Storage Building and Misc. Architectural	Construct new cold storage building.	Priority 2 - 2018-2020	$715,000
Operations and Energy Improvement	Equipment Asset Management Software Updates (EAM), O&M Manual, SCADA Integration Plan i.e. smart drive monitoring.	Priority 1 - 2016-2018	$300,000
		Priority 2 Subtotal	**$4,092,000**
Plant Modifications - 2025 Permit			

Component	Recommended Improvements	Implementation Date	Project Cost
Activated Sludge System (Phase 1 Improvements)	Construct new aeration basin, blowers (2), and secondary clariflocculators and return sludge pumping station.	2025	**$20,570,000**
Plant Modifications - 2030 Permit			
Activated Sludge System (Phase 2 Improvements)	Anoxic basins, recycle pumping	2035	**$7,800,000**
Plant Modifications - Other Needs			
Priority 3			
Sludge Handling Project	Provide Phased sludge conveyance and storage.	Priority 3	$1,220,000
Process	Includes equipment replacement and coating of the tanks.	Priority 3	$647,000
Architectural	Administration Facilities Expansion -Building addition & site improvements.	Priority 3	$990,000
Structural	Miscellaneous.		$5,000
HVAC Improvements	AB Pump Room, UV Building.	Priority 3	$37,500
Electrical, Instrumentation, and Misc. Improvements	Remote monitoring capabilities, CMMS replacement, on-line metering capabilities and Secondary standby generator.	Priority 3	$185,000
Operation & Energy Total	SCADA/Remote Operations & Computerized Maintenance Management Software (CMMS) & On-line Monitoring.	Priority 3	$290,000
	Priority 3 Subtotal		**$3,370,000**
Priority 4			
Sludge Handling Improvement	Phase 2 Sludge Handling Improvements.	Priority 4	$3,460,000
Process	Miscellaneous process equipment replacement.	Priority 4	$400,000
	Priority 4 Subtotal		**$3,860,000**
Priority 5			
Process Upgrades	Screen gear boxes, replace MCCs, grit classifier, gas flare and misc.	Priority 5	$657,000
HVAC Improvements	Replace digester boilers	Priority 5	$435,000
Electrical, Instrumentation, and Misc. Improvements		Priority 5	$1,202,000
Odor Control	Construct odor control facilities for odor-related areas. Tie to odor sources and construct new facilities.	Priority 5	$800,000
	Priority 5 Subtotal		**$3,090,000**
Total			**$62,000,000**



KEY PLAN: WATER RECLAMATION FACILITY

Pretreatment
7913-01 PRETREATMENT BUILDING
7913-02 SEPTAGE RECEIVING
7913-03 VACTOR RECEIVING STATION
7913-04 POTENTIAL NEW SCREEN

North Fixed Film Plant
8013-01 PRIMARY SLUDGE PUMP BUILDING
8013-02 PRIMARY CLARIFIERS
8013-03 PRIMARY CLARIFIER EFFLUENT IMPROVEMENTS
8013-04 IN-PLANT PEAK FLOW PUMP STATION
8025-01 SECONDARY BUILDING
8025-02 WEST TRICKLING FILTER - REPURPOSE
8025-03 EAST TRICKLING FILTER - REPURPOSE
8025-04 GENERATOR -SECONDARY
8025-05 SECONDARY CLARIFIERS - REPURPOSE
8025-06 IMPROVEMENTS TO TRICKLING FILTER PUMP STATION
8102-01 RBC BLOWER BUILDING
8102-02 RBC's - REPURPOSE, POTENTIAL SLUDGE STORAGE
8102-03 GENERATOR - RBC's
8215-01 TERTIARY PUMP PIT
8215-02 TERTIARY CLARIFIERS - REPURPOSE, POTENTIAL SLUDGE STORAGE

South Activated Sludge Plant
8123-01 AB BLOWER / PUMP BUILDING
8123-02 ACTIVATED SLUDGE - DISTRIBUTION BOX
8123-03 ACTIVATED SLUDGE - AERATION BASINS
8123-04 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-05 GENERATOR -SOUTH PLANT ACTIVATED SLUDGE
8123-06 ACTIVATED SLUDGE - AERATION BASIN WITH SPLITTER BOX
8123-07 ANOXIC BASINS WITH SPLITTER BOX
8123-08 RAS PUMPS AND AERATION BLOWERS
8123-09 ACTIVATED SLUDGE - CLARIFFLOCULATOR WITH SPLITTER BOX
8123-10 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-11 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-12 ACTIVATED SLUDGE - EFFLUENT BOX

Disinfection
8207-01 UV DISINFECTION BUILDING
8207-02 RE-AERATION BASIN
8207-03 GENERATOR UV/ADMIN
8207-04 Outfall

Digestion
7907 GAS BLOWER BLDG
7909-01 PUMP/BOILER BLDG
7909-02 NORTH DIGESTER
7909-03 SOUTH DIGESTER
7909-04 WEST DIGESTER

Solids Handling
8029-01 SOLIDS HANDLING BUILDING
8029-02 750K WEST SLUDGE HOLDING POND
8029-03 50K EAST SLUDGE HOLDING POND
8029-04 CENTRATE STORAGE TANK
8029-05 GENERATOR SOLIDS HANDLING
8029-06 SOLIDS HANDLING BUILDING
8029-07 DEWATERD SLUDGE STORAGE
8029-08 SOLIDS HOLDING POND
8029-09 SOLIDS HOLDING POND

Other
8115 ADMINISTRATION BUILDING WITH EXPANSION
7905 WATER PLANT BUILDING
7917 OIL STORAGE
7921 WASTEWATER MAINTENANCE SHOP
8119 METAL FABRICATION SHOP
8225-01 COLD STORAGE NO. 1
8225-02 SOFT SIDED COLD STORAGE NO. 2
8225-03 WEST WOODEN STORAGE SHED
8225-04 EAST WOODEN STORAGE SHED
8225-05 COLD STORAGE
8225-06 RIVER GAUGING STATION (LOCATED UPSTREAM)

NOTE: UNITS SHOWN IN BOLD ARE PROPOSED OR MODIFIED.

KEY PLAN: FACILITY IMPROVEMENT PHASING

- IMMEDIATE NEED
- PHASE 1 IMPROVEMENTS - 2025
- PHASE 2 IMPROVEMENTS - 2035

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SCALE IN FEET

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

RECOMMENDED ALTERNATIVE A1
MAJOR IMPROVEMENTS

0 1" 2"

FILENAME ALT A1 IMPROVEMENTS.DWG
SCALE
FIGURE S.6

Consequences of Inaction

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

- Non-compliance with discharge permit requirements
- Raw sewage spills, and associated public health impacts
- Water quality impairment of Rapid Creek
- Inability to handle wastewater generated by the community

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

Facility Plan Summary

Introduction

The City of Rapid City (City) Water Reclamation Facility (WRF) is located 5 miles east of the City in Pennington County, South Dakota. Rapid City provides wastewater treatment for all residential, commercial, and current industrial customers in the City of Rapid City and several regional customers. The WRF uses both a fixed film system (North Plant) and an activated sludge system (South Plant) that operate in parallel to treat wastewater from the facility's service area. The WRF is facing more restrictive discharge limits to Rapid Creek and while serving a steadily increasing population base.

Trickling Filters and Rotating Biological Contactors (RBCs) are considered fixed film processes. Fixed film systems use media to support biological growth that treat wastewater as it passes through the media. Activated sludge systems rely on bacteria suspended in the wastewater for treatment.

Upgrades to the existing plant were substantially completed as delineated in Figures S.1 and S.2. The original fixed film facility, referred to as the North Plant, was designed in 1965 and construction was completed in 1967. Improvements and upgrades have occurred regularly to replace worn equipment and keep up with more restrictive effluent water quality requirements. The most significant changes occurred in 1985, when tertiary treatment was added to the North Plant to reduce effluent ammonia, and in 2003, when the facility was expanded for increased activated sludge treatment capacity. The 2003 expansion included construction of an activated sludge process, referred to as the South Plant, construction of sludge dewatering, and replacement of the gas chlorine disinfection system with an ultraviolet (UV) disinfection system.

The City last provided an extensive planning review of the wastewater treatment facilities in the Rapid City WRF Facility Plan, 2000 (McLaughlin Water Engineers). The treatment plant equipment and treatment process were evaluated through the planning year 2018 with a projected population of 94,000. Approximately $14.5 million in capital improvements were identified and completed including process changes to add the south activated sludge plant, ultraviolet (UV) disinfection, and sludge dewatering facilities. Since that time a number of improvements have been made to the facility, equipment condition has changed and improvements are required.

An evaluation phase report entitled Trickling Filter and Effluent Solids Reduction Improvements was completed August 2013 (HDR) which identified several WRF improvements projects. The improvements recommended included UV disinfection, post aeration, interim trickling filter pump station, and trickling filter rotary distributor improvements all of which have been completed. The final recommendation was long-term improvements for a new trickling filter pump station, which was deferred until facility planning could be conducted.

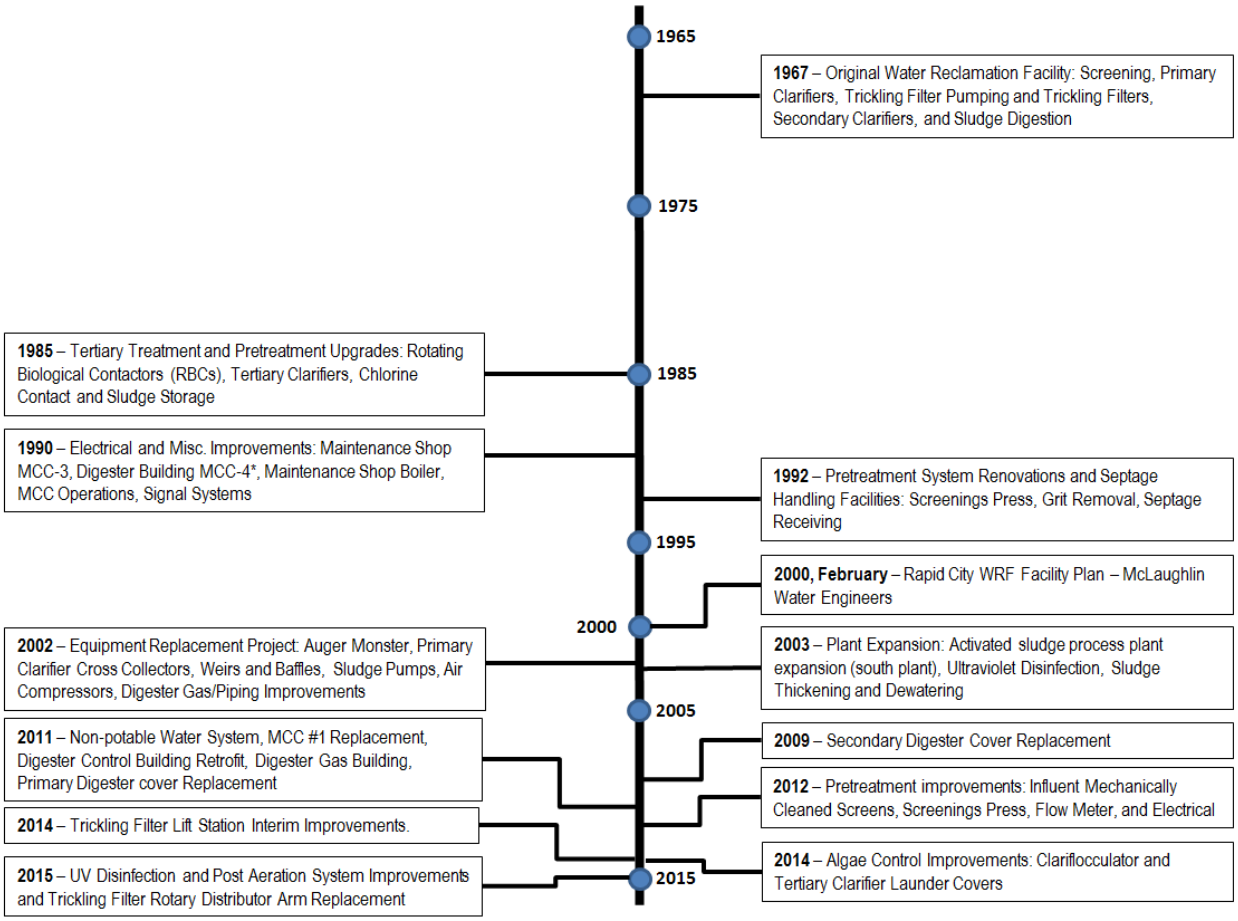

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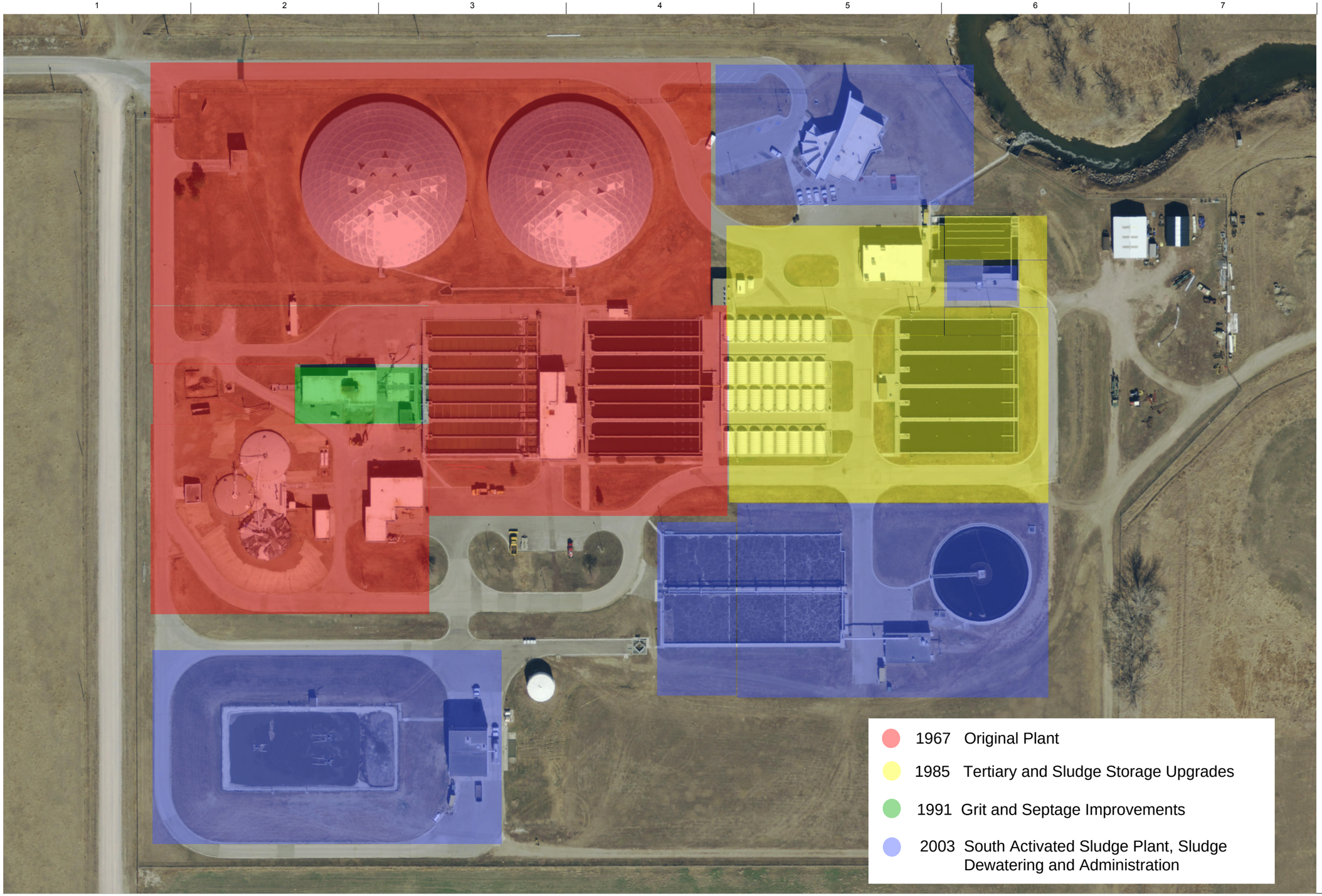
Figure S.1. Rapid City WRF History of Major Improvements

Secondly, new more stringent permit modifications have been identified. Neither more stringent ammonia discharge requirements nor more stringent nutrient limits were reviewed as part of the 2000 Facility Plan as these upcoming effluent requirements were not expected to occur in that planning horizon. In 2013, EPA implemented more stringent ammonia requirements and EPA is driving the states to implement effluent nutrient criteria for water reclamation facilities. Numeric nutrient criteria are a critical tool for protecting and restoring a water body's designated uses related to nitrogen and phosphorus pollution. Surrounding states including Minnesota, Wisconsin, Montana, and Colorado are in the process of incorporating nutrient discharge limits, which indicates that any municipal wastewater treatment facility, such as the Rapid City WRF, should be prepared for new and/or more stringent nutrient discharge limits for future discharge permits.

These factors coupled with changing wastewater flows and pending operational changes at the WRF led the City to have the WRF facility plan updated to more accurately plan for the next 20 years and beyond. The City selected the HDR/AE2S Team to complete the facility-planning task.



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SCALE IN FEET

ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

WATER RECLAMATION FACILITY

FACILITY PLAN

RAPID CITY, SOUTH DAKOTA

2015

WRF MAJOR IMPROVEMENTS

0 1" 2"

FILENAME

SCALE

FIGURE

S-2

This facility plan summary chapter describes the results of the current facility analysis and facility plan update, which is presented in detail in the subsequent sections. Components of this Facility Plan include age and condition related needs, which were determined by onsite condition assessment and are reflected in Chapter 1.1 Operations and Physical Condition Assessments. Operational improvements were discussed both in terms of physical operation of the plant in Chapter 1.1 and in terms of energy consumption in Chapter 1.2 Energy Assessment. Projected population, flow, and loading are outlined in Chapter 2.1. Regulatory considerations are outlined in Chapter 2.2. Capacity related needs were determined and are reflected in Chapter 3.1 Plant Hydraulic Capacity and 3.2 Plant Organic Capacity. Finally, regulatory related capacity needs were considered and projects were identified for secondary treatment and solids handling in Chapters 4.1 and 4.2, respectively. The results have been compiled and presented in Chapter 5.1 in the form of a preliminary capital improvements plan. A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility cost is contained in Appendix 5.1.A.

Plant Flow Scheme

As shown in Figure S.3 – Schematic of WRF Treatment Processes, wastewater enters the WRF via a 48-inch-diameter interceptor sewer and enters the headworks, where treatment includes:

- Fine screening
- Vortex grit removal

After flowing from the headworks, the flow is split into two separate treatment trains including 1) the original fixed film system and 2) the activated sludge system. The fixed film system includes the following:

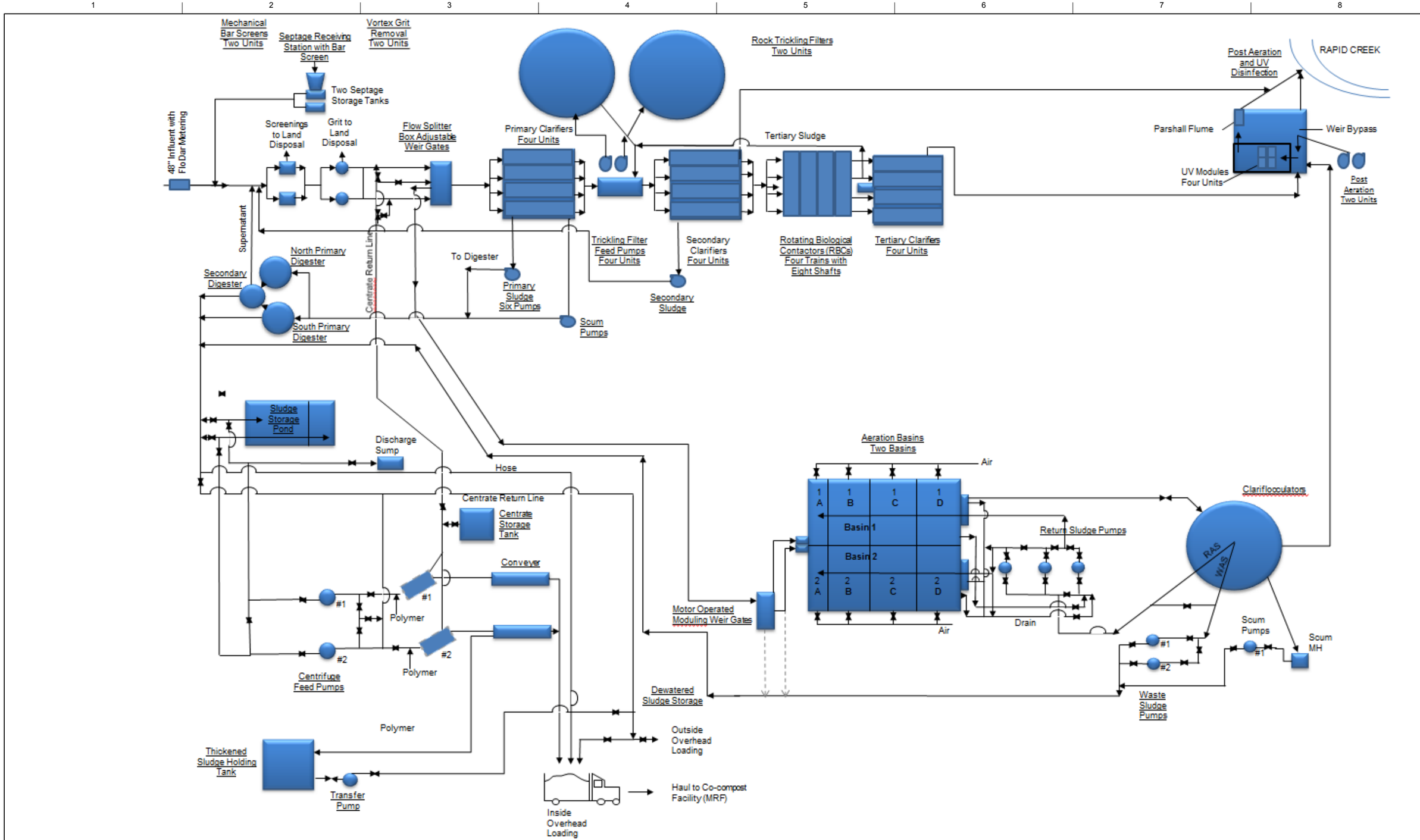
- Primary clarification
- Trickling filter pumping
- Trickling filters
- Secondary clarification
- Rotating biological contactors
- Tertiary clarification

The activated sludge system receives screened and degritted influent without primary clarification and includes the following:

- Extended aeration activated sludge
- Clariflocculator

Effluent from the two treatment trains is recombined and flows to the following:

- Post aeration with blowers and diffusers
- UV disinfection (seasonal)
- Aeration via cascade aeration steps
- Discharge to Rapid Creek.



ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

PRELIMINARY
NOT FOR CONSTRUCTION

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

SCHEMATIC OF WRF TREATMENT PROCESS

FILENAME
SCALE

FIGURE S.3

Solids from the fixed film plant are processed by the following:

- Anaerobic digestion
- Sludge storage lagoon

Waste activated sludge is pumped directly to the Sludge Storage Lagoon. Following the Sludge Storage Lagoon, sludge is further processed by centrifuges as follows:

- Sludge thickening to 6% solids (to co-compost)
- Sludge dewatering to 25% solids (to landfill or co-compost)

Triggers

Several factors drive the need for improvements at the WRF Facility. These factors include:

- Mandatory Improvements to Meet New Regulatory Requirements
- Required Capacity for Projected Peak Flows
- Required Capacity for Organic loading from Service Area Growth
- Age and condition
- Opportunities for Operations & Energy Improvements

The triggers, based on the above factors, will establish the timing for requisite improvements to have well-defined planning for essential capital improvements. The key driving forces, or triggers, behind the needed improvements are summarized below.

Regulations

Several significant issues influence the wastewater facilities planning and discharge limitations for the City of Rapid City:

- New and future discharge permits with the greatest affect being nutrient and ammonia discharge limits.
- Increased design flow affecting permit limits and meet anti-backsliding requirements.

  (Anti-backsliding requirements are federal regulations regarding the renewal or reissue of discharge permits (for direct dischargers) and say that the effluent limitations, standards, or conditions in the renewed/reissued permit "must be at least as stringent" as the effluent limitations, standards, or conditions in the previous permit.)
- Rapid Creek water quality
- Revised federal ammonia nitrogen criteria adopted in 2013, which will be incorporated into South Dakota water quality standards at the completion of the next triennial review in 2017 and implemented into permits.
- 40 CFR Part 503 regulation impacts on biosolids

Capacity for Projected Peak Flows

The hydraulic capacity of the WRF was determined through a combination of a unit process by unit process analysis and a hydraulic modeling of the entire WRF. While some peak flow reduction may be achieved through improvements to the collection system, this will not be enough to offset the need to increase the peak flow capacity of the plant. Numerous facilities will be required to meet this peak flow. These improvements include aeration basin improvements, an in-plant secondary pump station, headworks capacity improvements, south plant effluent piping improvements and additional clariflocculators.

Capacity for Organic Loading from Service Area Growth

The treatment capacity for the WRF is the ability for treatment of the wastewater to remove the pollutants necessary to meet the regulatory requirements. Note the capacity is presented based on flow; however, this represents an organic loading capacity evaluation based on the wastewater characterization. The system is limited to design flows based on the pollutant levels in the wastewater in addition to the required improvements to allow the plant to pass peak hydraulic flows. Rapid City's service population is projected to grow at an average annual rate of 1.9 percent; increasing wastewater loadings to the treatment plant (see Chapter 2). At this rate of growth, in addition to the hydraulically limited components of the plant, the capacity of several major biological treatment components will be reached in five to eight years. Without improvements, the plant could risk permit violations.

Age and Condition

A number of the treatment facilities are 30 to 50 years old and have reached their useful life to provide reliable service. Some plant components suffer from deteriorated condition, fail to comply with current codes or provide unsatisfactory and possibly unsafe working environments for the operations staff.

Operations and Energy Improvements

Some process improvements will reduce operational costs and/or delay the need for capacity expansions in other portions of the treatment systems.

Regulatory Planning (Chapter 2.2)

This section of the facility plan is to provide regulatory information to be used in planning for the City's wastewater treatment needs for the next 20 years and beyond. The goal is to best identify the physical modifications required to plan for potential future Surface Water Discharge (SWD) permit changes. Specific planning emphasis is to address ammonia limits, which are expected to be implemented in 2025, and nutrient discharge limits, which are expected to be implemented in 2030, with planning for continued treatment through year 2045.

The regulatory planning and associated dates in this section are based on the best available information from the South Dakota Department of Environment and Natural Resources (SD

DENR), United's States Environmental Protection Agency (US EPA) and surface water discharge permit development in other states within this watershed.

Anticipated Permits and Timing

Anticipated regulatory changes that will be imposed on the WRF were evaluated and their potential impact on the proposed improvements required to meet those conditions for the next 20 years and beyond. Specific planning emphasis addressed ammonia limits, which are expected to be implemented in 2025, and nutrient discharge limits, which are expected to be implemented in 2030, with planning for continued treatment through year 2045.

Table S.1 presents a summary of anticipated future Rapid City WRF discharge permit renewal dates and the anticipated limitations to be included in each permit. In addition, the corresponding recommended activity for the City is listed. The permit sequence is defined as follows:

- Current permit (2016): Permit that is expected to be issued in 2016.
- Permit #1 (2020) – Compliance Schedule for New Ammonia Standards
- Permit #2 (2025) – New Ammonia Standards
- Permit #3 (2030) – New Nutrient Standards

CURRENT PERMIT

The 2016 Current Permit became more stringent with regard to ammonia, E. Coli and Biological Oxygen Demand (BOD).

PERMIT #1

Ammonia standards will become part of the SD Water Quality Standards after 2017 and new treatment processes are required to meet proposed Ammonia limits. A compliance schedule and reporting requirements will be included with this permit.

PERMIT #2

The primary driver for reduction in ammonia in Rapid Creek is the 2013 EPA update to the 1999 and 2009 aquatic life ambient water quality criteria, most notably impacted by the presence or absence of fresh water mussels. The proposed limits are approximately half of the current 2016 ammonia permitted values. There has been little documentation regarding fresh water mussels in the waters of South Dakota and no documentation regarding these species in Rapid Creek at this time. DENR is working with the Game, Fish, and Parks regarding a mussel study and Rapid Creek is one of the sites to be investigated, however, a schedule for that study has not been developed. Given the presence of mussels in similar streams across the United States, mussels have been assumed to be present in Rapid Creek for planning purposes.

PERMIT #3

The nutrient removal treatment capacity evaluations along with the recommended improvements are based on meeting a "Level 1" Total Nitrogen (TN) requirement of less than 10 mg/l and a Total Phosphorus (TP) limit of 1 mg/l. Planning to meet Level 1 is consistent with discussions with SD DENR and limits imposed in similar U.S. states. The City should be aware there is a significant level of ongoing effort in defining nutrient numeric criteria across the U.S.

As such, future nutrient discharge limits should still be considered unpredictable. Proposed limits have been challenged in court by environmental activist groups and/or the EPA in instances where the proposed limits were considered inappropriate or untimely. In some states, legal action has greatly accelerated the implementation of more stringent discharge limits. Therefore, there is a chance that the limits may be more restrictive than Level 1.

PERMIT #4

The nutrient criteria are expected to become more stringent.

Table S.1. Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit 2016	New Ammonia Standards based on updated Rapid Creek water quality	Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability. Establish schedule for construction – assume major projects are 5 years from study completion unless other justification (i.e. Trickling Filter Pump Station type trigger).
Permit #1 2020	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project needs to be constructed by 2025. Ammonia standards will become part of the SD Water Quality Standards After 2017 and new treatment process is required to meet proposed Ammonia limits.
Permit #2 2025	New Ammonia Standards	Assuming required improvements for ammonia removals complete. Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2030.
Permit #3 2030	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty. Track potential for more stringent nutrient standards.
Permit #4 2035	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

The intent of this facility planning effort is to define the longer-term path forward to meet anticipated incoming capacity and regulatory discharge requirements so that shorter-term modifications are consistent with the long-term plan. The driving factor in this planning effort

became the anticipated regulatory requirement of more strict ammonia and nutrient removal from the facility's discharge.

Ammonia Water Quality Criteria

The primary driver for reduction in ammonia in Rapid Creek is the 2013 EPA update to the 1999 and 2009 aquatic life ambient water quality criteria, which is approximately half of the current ammonia permitted values.

In 2013, EPA updated the freshwater ammonia aquatic life ambient water quality criteria in accord with the provisions of Section 304(a) of the Clean Water Act to revise Ambient Water Quality Criteria (AWQC) to reflect the latest scientific knowledge. The largest impact for ammonia is the presence, or not, of fresh water mussels.

Nutrient Criteria

A wider regional focus on nutrients is occurring because of the Gulf of Mexico hypoxia. Hypoxic zones are areas in the ocean of such low oxygen concentration that animal life suffocates and dies, and as a result are sometimes called "dead zones. The focus on solving these environmental endangerments is driving efforts to reduce nutrient discharges throughout the Missouri River watershed, which includes discharges from the Rapid City WRF as shown in Figure S.4. In fact, due to the lack of progress on the part of the states, legislation has begun pushing the EPA to take primacy and implement these new nutrient standards on a federal level. To avoid more stringent limits directly enforced by the EPA, surrounding states including Minnesota, Wisconsin, Montana, and Colorado are in the process of incorporating nutrient discharge limits, which indicates that any municipal wastewater treatment facility, such as the Rapid City WRF, should be prepared for new and/or more stringent nutrient limits for future discharge permits.

The nutrient removal treatment capacity evaluations along with the recommended improvements are based on meeting a “Level 1” Total Nitrogen (TN) requirement of less than 10 mg/l and a Total Phosphorus (TP) limit of 1 mg/l. The City should be aware there is a significant level of ongoing effort in defining nutrient numeric criteria across the U.S. Proposed limits have been challenged in court by environmental activist groups and/or the EPA in instances where the proposed limits were considered to be inappropriate or untimely. In some states, legal action has greatly accelerated the implementation of more stringent discharge limits. Therefore, there is a chance that the limits may be more restrictive than Level 1, but Level 1 is consistent with limits imposed in similar U.S. states.

The two primary drivers for reductions in nutrients in water bodies are Total Maximum Daily Loads (TMDLs) and Numeric Nutrient Criteria.

(Source: Moving Forward on Gulf Hypoxia Annual Report 2011, Gulf of Mexico Watershed Nutrient Task Force)

Figure S.4: Missouri River and Gulf of Mexico Hypoxic Zone

TOTAL MAXIMUM DAILY LOAD

As with ammonia, changing water quality regulations for nutrients may dictate that consideration be given to modifications to improve treated wastewater effluent quality. The South Dakota Department of Natural Resources (SD DENR) is required to develop Total Maximum Daily Load Evaluation (TMDL) for all water bodies on the 303(d) list, which includes Rapid Creek. A TMDL determines the total amount of a constituent that a water body may receive from all sources without exceeding water quality standards. A TMDL may require a reduction in constituent loading to meet water quality standards.

NUMERIC NUTRIENT CRITERIA

Numeric water quality limits are intended to control excessive nutrient (nitrogen and phosphorus) pollution in streams, rivers, and lakes. The intent of numeric nutrient discharge limits is to provide water quality that protects the beneficial uses of these water bodies. Areas of the country already have numeric standards in place and others are developing them. It is not uncommon for nutrient criteria to be set below the limits of technology. In South Dakota, minimal work has been done to date on numeric nutrient criteria.

Surface Water Quality Permit Status

Currently the City is transitioning from the 2001 Surface Water Discharge (SWD) permit to the Current (2016) permit which is being processed by the SD DENR. The preliminary draft of the WRF Surface Water Discharge (SWD) Permit No: SD0023574 was received from the SD DENR in the spring of 2015 for review by the City. It is anticipated this permit will be issued to the City in 2016. This permit will be refered to as the Current (2016) Permit throughout this plan.

The most significant proposed change from the 2001 permit to the Current (2016) permit is more stringent ammonia limits. This was not identified nor anticipated during the last Facility Plan Update in 2000 and impacts the results and recommendations of that plan. The basis for this preliminary draft permit is the Total Maximum Daily Loads (TMDLs) for waters at levels necessary to achieve and maintain water quality standards.

The SD DENR has made a recommendation on the permit and Rapid City along with HDR have reviewed and commented on the permit. The DENR next reviews these comments and makes a determination on whether to incorporate the Owners comments. Following this step, SD DENR publishes the surface water quality permit limits in a local newspaper for a 30-day public comment period. If the permit is contested, the DENR decides whether or not to incorporate the comments from the public. If the comments are further disputed, a contested hearing is conducted and SD DENR considers evidence and issues a final decision with the permit changes to reflect the decision.

The following sections contain a summary of the key treatment limits including the following draft current (2016) permit parameters:

- Ammonia (NH_4)
- Biological Oxygen Demand (BOD)
- Escherichia coli (E. coli)
- Total Suspended Solids (TSS) and,
- Dissolved Oxygen (DO)

Ammonia is the key parameter which affects treatment capacity in this current (2016) permit. The draft permit and statement of basis (SOB) is attached in Appendix 2.2.A for reference.

AMMONIA

The permit will have effluent limits for ammonia which vary monthly and are calculated based on actual receiving stream and plant flow as variables. The ammonia limits include both monthly average and daily maximum ammonia calculations for determining concentration based limits. Table S.2 summarizes the draft ammonia limit equations and the resultant concentration modeled under critical flow conditions.

Critical flow conditions assume river flow is the monthly 7Q25 value and plant effluent is the monthly 80th percentile of effluent flow. The 7Q25 flow is the minimum 7-day average low flow that can be expected to occur once every 25 years in Rapid Creek. For the monthly critical

conditions simulations the 7Q25 low flow for Rapid Creek and 80th percentile effluent flows were used.

Critical conditions utilized by SD DENR to formulate the equations include using the monthly 80th percentile values for temperature, conductivity, TSS, ammonia, nitrate, total p-phosphate, alkalinity, and pH. To ensure that the ammonia standards are maintained during critical conditions, the 80th percentiles of the pH and temperature data at the water quality monitoring station upstream of the discharge point were calculated. The monthly 20th percentile values for DO were used. For the effluent, conductivity, total P-phosphate, and alkalinity were estimated from the TMDL for ammonia and dissolved oxygen in Rapid Creek (SD DENR 2000).

For downstream conditions, the South Dakota Surface Water Quality Standards (SD SWQS) are determined at the mixing zone boundary to determine if the standards are met at the end of the mixing zone as the upstream and effluent conditions are modeled. The SD SWQS for ammonia are calculated based on actual water quality data. For further reference, the Permit Statement of Basis (SOB) outlines the formulas and data utilized to calculate the coefficients for the formulas in Table S.2.

As noted, the 2016 Current Permit became more stringent with regard to ammonia. The amount ammonia lowered from the 2001 permit to the 2016 permit at critical flows is indicated in the table as a negative value. Based on analysis of historic Rapid Creek flows, the impact to the WRF's ability to meet the permit is statistically greatest in October.

Table S.2. Ammonia Limit Formulas & Limits at Critical Flows – 2016 Permit

	30-day Average	30-day Average Limits at Critical Flows	Amount 30-day Average Lowered from 2001 Permit	Daily Max Limits	Daily Max Limits at Critical Flows	Amount Daily Max Lowered from 2001 Permit Limits
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
January	$2.91 + 2.86 \frac{Qu}{Qe}$	5.7	-3.4	$5.73 + 5.68 \frac{Qu}{Qe}$	15.9	-4.6
February	$2.73 + 2.68 \frac{Qu}{Qe}$	6.1	-3.0	$5.30 + 5.25 \frac{Qu}{Qe}$	15.9	-3.9
March	$1.38 + 1.33 \frac{Qu}{Qe}$	3.2	-1.9	$4.20 + 4.15 \frac{Qu}{Qe}$	9.0	-
April	$1.43 + 1.38 \frac{Qu}{Qe}$	2.5	-2.6	$4.36 + 4.31 \frac{Qu}{Qe}$	9.0	-1.4
May	$1.36 + 1.31 \frac{Qu}{Qe}$	1.9	-0.2	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
June	$1.01 + 0.96 \frac{Qu}{Qe}$	1.3	-0.8	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
July	$1.03 + 0.98 \frac{Qu}{Qe}$	1.4	-0.7	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
August	$1.47 + 1.42 \frac{Qu}{Qe}$	1.7	-0.4	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
September	$1.54 + 1.49 \frac{Qu}{Qe}$	1.8	-0.3	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
October	$1.29 + 1.24 \frac{Qu}{Qe}$	1.6	-1.8	$3.88 + 3.83 \frac{Qu}{Qe}$	6.0	-1.2
November	$2.32 + 2.27 \frac{Qu}{Qe}$	4.4	-	$4.36 + 4.31 \frac{Qu}{Qe}$	6.0	-
December	$2.09 + 2.04 \frac{Qu}{Qe}$	4.6	-4.5	$3.88 + 3.83 \frac{Qu}{Qe}$	15.9	-7.3

Note:

[a] *Gray cells indicate that the values that do not meet anti-backsliding requirements. "Backsliding" is a term used to describe a circumstance where a facility has a permit that lists certain effluent limitations and upon renewal/reissue of the permit, the "new" effluent limitations are made less stringent then those in the previous permit. In general, "backsliding" is not allowed. The regulations that discuss "backsliding" are found at 40 CFR 122.44(l). These regulations discuss the renewal or reissue of discharge permits (for direct dischargers) and say that the effluent limitations, standards, or conditions in the renewed/reissued permit "must be at least as stringent" as the effluent limitations, standards, or conditions in the previous permit. The regulations do provide several exemptions which would allow "backsliding" (e.g., circumstances have materially and substantially changed since the time the permit was issued).*

BOD

The five-day biochemical oxygen demand (BOD5) limits are shown in Table S.3. The 2001 permitted 30-day average BOD limit was 30 mg/l year-round. The 2016 Current Permit was lowered for the 30-day average with the lowest limit at 24 mg/l during the summer months (May 1 thru September 30). The 2016 Current Permit 30-day BOD limit was also lowered to 28 mg/l for October 1 thru November 30. Planning will include a permit level for BOD consisting of discharge concentrations in Table S.3 through year 2025. At these levels, it is unlikely that BOD will drive improvements, as the more stringent ammonia limits will control treatment requirements.

Table S.3. Five-Day Biochemical Oxygen Demand (BOD5) Limits

Season	30-Day Average mg/l	7-Day Average mg/l
January 1 – January 31	30	30
February 1 – February 29	30	30
March 1 – March 31	30	30
April 1 – April 30	30	30
May 1 – May 31	24	24
June 1 – June 30	24	24
July 1 – July 31	24	24
August 1 – August 31	24	24
September 1 – September 30	24	24
October 1 – October 31	28	28
November 1 – November 30	28	28
December 1 – December 31	30	30

ESCHERICHIA COLI (E. COLI)

The 2001 permit included a monthly limit of Fecal Coliform less than 200 colonies/100ml geometric mean and a daily max of 400 colonies/100ml. This limit was effective from May 1 to September 30. The new indicator organism for the 2016 Current Permit is Escherichia coli (E. coli). The 2016 Current Permit stipulate E. coli organisms shall not exceed a concentration of 126 per 100 milliliters as a geometric mean. The draft permit requires three samples per week, with a monthly limit of less than 126 colonies/100ml geometric mean, and a daily max of 235 colonies/100ml. This limit is also effective from May 1 to September 30.

TOTAL SUSPENDED SOLIDS (TSS)

The Total Suspended Solids (TSS) concentration shall not exceed 30 mg/L (30-day average) or 45 mg/L (7-day average). This was unchanged from the 2001 permit limit.

DISSOLVED OXYGEN

The dissolved oxygen lower limits are shown in Table S.4 and did not change from the 2001 permit. Dissolved oxygen limits will be met with the current automated post aeration system followed by the final cascade aeration steps.

Table S.4. Dissolved Oxygen Limits

Season	Dissolved Oxygen (mg/l)
January 1 – January 31	5
February 1 – February 29	5
March 1 – March 31	5
April 1 – April 30	5
May 1 – May 31	6.5
June 1 – June 30	6.5
July 1 – July 31	6.5
August 1 – August 31	6.5
September 1 – September 30	6.5
October 1 – October 31	6
November 1 – November 30	6
December 1 – December 31	5

Future Permit Limits

This section contains a summary of the key future treatment limits including the following permit parameters:

- Permit #2 -Ammonia
- Permit #3 -Total Nitrogen
- Permit #3 -Total Phosphorus

The permit requirements, based on conversations with South Dakota DENR staff, are outlined in Table S.5.

AMMONIA LIMITS (PERMIT #2 -2013 EPA AMMONIA CRITERIA)

A potential regulatory driver for future SWD permits is the 2013 EPA Ammonia Criteria which lower toxicity limits. The largest impact for ammonia is the presence (or not) of fresh water mussels. The anticipated mussel toxicity criteria are significantly more stringent than those currently in place for the Rapid City WRF.

Table S.5 summarizes the current SWD permit limits along with the potential Permit #2 ammonia limits when a mussel water quality criterion is used. Per discussions with SD DENR, the potential ammonia limits are one-half of the of current ammonia limits.

Table S.5. Current (2016) and Potential Permit #2 Ammonia Limits

		Current 2016 Permit Ammonia Limits				Permit #2 New Ammonia Limits[2]	
	30-day Average	Amount 30-day Average Lowered from 2001 Permit	Daily Max	Max Day w/o Backsliding	Amount Daily Max Lowered from 2001 Permit Limits	30-day Average	Daily Max w/o Backsliding
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
January	5.7	-3.4	11.3		-4.6	2.9	5.6
February	6.1	-3.0	12.0		-3.9	3.1	6.0
March	3.2	-1.9	10.0		n/a	1.6	5.0
April	2.5	-2.6	7.6		-1.4	1.2	3.8
May	1.9	-0.2	4.6[1]	6.1	n/a	1.0	3.0
June	1.3	-0.8	4.1[1]	6.1	n/a	0.6	3.1
July	1.4	-0.7	4.4[1]	6.4	n/a	0.7	3.2
August	1.7	-0.4	3.8[1]	7.5	n/a	0.8	3.7
September	1.8	-0.3	3.8[1]	5.6	n/a	0.9	2.8
October	1.6	-1.8	4.8		-1.2	0.8	2.4
November	4.4	1.0	8.3		n/a	2.2	4.2
December	4.6	-4.5	8.6		-7.3	2.3	4.3

1. *Gray cells indicate that the values that do not meet anti-backsliding requirements.*
2. *Based on discussions between HDR and SD DENR, future ammonia limits will be one-half of the existing limits.*

There has been little documentation regarding fresh water mussels in the waters of South Dakota and no documentation regarding these species in Rapid Creek at this time. In addition, there has not been a schedule determined for Rapid Creek fresh water mussel analysis; however, there is currently a plan to conduct mussel surveys. DENR is working with the Game, Fish, and Parks regarding a mussel study and Rapid Creek is one of the sites to be investigated.

HDR met with SD DENR and it was indicated that they have recently completed their triennial review and therefore, any ammonia discharge limit changes will not be included until the next triennial review. The determination of the presence of mussels will likely occur during the next triennial review. After the next triennial review, there will be a one to two year period of rulemaking. Then, as permits are renewed, they will include the proposed ammonia limits with a compliance schedule for implementation of new facilities if necessary. This may take two permit cycles. Under the current approach, incorporation of the new ammonia limits will not take place for a minimum of 10 years.

Given that mussels are likely present, facility planning will be for treating to the new 2013 ammonia criteria with mussels present in 2025.

NUTRIENT DISCHARGE LIMITS

Over the next three SWD permit cycles point source discharges, such as the Rapid City Water Reclamation Facility, will likely be required to monitor parameters to be used to achieve biological nutrient removal, and then will be provided a moratorium with more stringent standards in place for the year 2030. As noted previously, EPA or legal action could force a more aggressive approach in South Dakota.

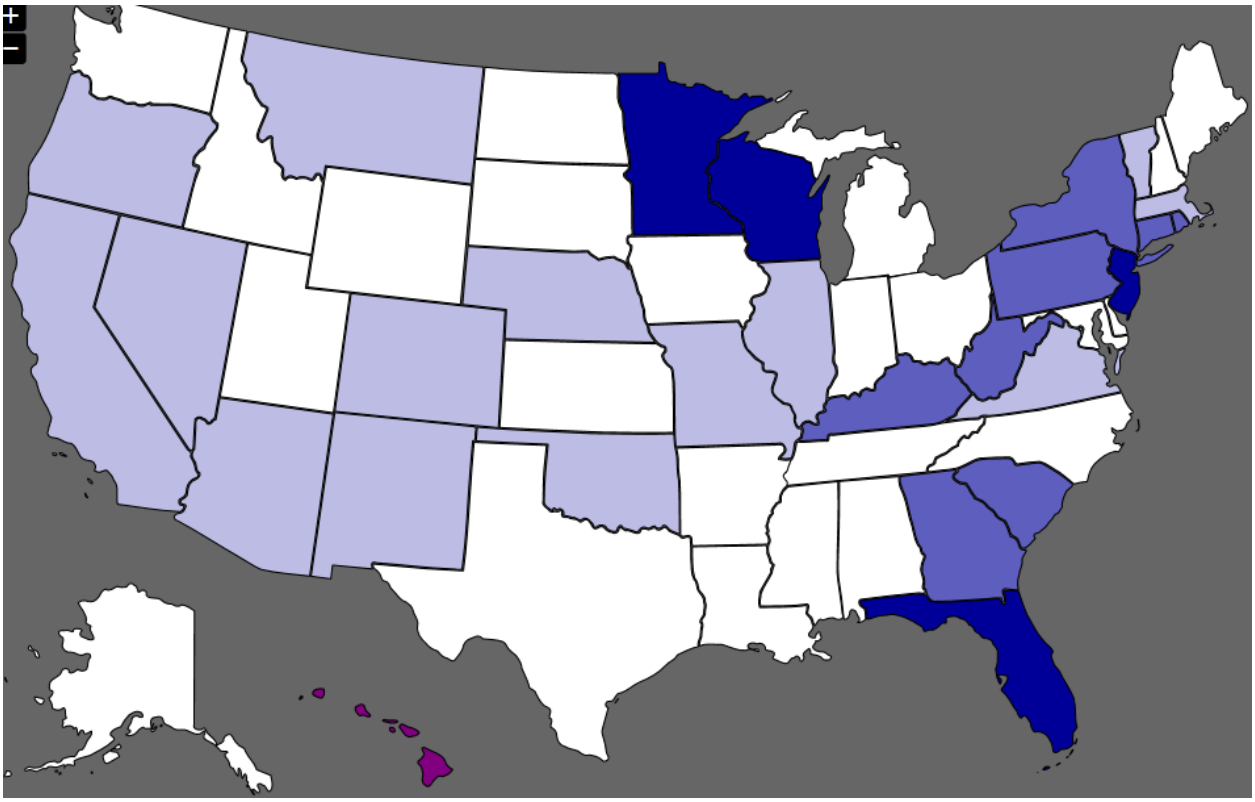
A nutrient criterion for nitrogen and phosphorus with respect to Rapid City's planning efforts was discussed with SD DENR. Based on conversations with SD DENR, there does not appear to be a current planned date for establishing nutrient criteria for South Dakota. Per the discussions, the planning team and SD DENR have agreed to a permit level for nutrients consisting of discharge concentrations in the ranges of 1.0 mg/l P and 10 mg/l TN to be met in year 2030.

For comparison purposes, Table S.6 summarizes the total nutrient goals for several other states in the region.

Table S.6. Nutrient Goals for other States in the Region

State	Total Nitrogen Goal, mg-N/L	Total Phosphorus Goal, mg-P/L
Kansas (Tier 1)	8	1.5
Iowa	10	1.0
Missouri	10	1.0
Minnesota	n/a	1.0
Wisconsin	≥ 10	1.0

Figure S.5 depicts the total nation-wide nutrient status based on the individual state's documented milestones thru year 2019. This indicates that a plan is in place to implement some form of nutrient limits within the next 3 years in these states. North Dakota has a task force in place, which is actively working to address implementing nutrient limitations.



Two or more water types with N and/or P criteria

One water type with N and/or P criteria

Waters with N and/or P criteria

Figure S.5: State-wide Nutrient Permit Limit Status

Flows & Loads (Chapter 2.1)

When planning or evaluating facilities to collect and treat wastewater, two primary wastewater characteristics are considered: (1) the quantity or volume of wastewater, expressed as "flows"; and (2) wastewater loads, which include BOD, ammonia, solids, and other physical parameters. Wastewater flow and load projections are used to evaluate the ability of existing facilities to adequately collect, transport, and treat future wastewater flows and are a measure of the organic strength of the wastewater.

The current flows and loads were evaluated and future flows and organic loads estimated for the planning period for the WRF. This information was used as the basis for the evaluation of unit process capacities in subsequent Chapters. The future average annual flows and loads to the WRF were estimated from the recent historical data presented in Table S.7.

Table S.7. Influent Flows and Loads, 5.5 Year Average, January 2010 – May 2015[a]

	Flow/Loading	Peaking** Factor	Per Capita	Concentration, mg/L
Flow, MGD* (Million Gallons Per Day)				
Average Annual	9.69	1.00	124 gpcd***	-
Maximum Month	12.51	1.29	160 gpcd	-
Maximum Day	19.00	1.96	243 gpcd	-
BOD_5, lb/d (Pounds Per Day)				
Average Annual	15,084	1.00	0.193	209
Maximum Month	16,553	1.10	0.211	1919
Maximum Day	23,267	1.54	0.297	210
TSS, lb/d				
Average Annual	16,061	1.00	.205	219
Maximum Month	18,392	1.15	.235	210
Maximum Day	32,582	2.02	.417	268
Ammonia, lb/d				
Average Annual	1966	1.00	.025	27.4
Maximum Month	2115	1.08	.027	24.5
Maximum Day	3002	1.53	.038	23.8

Notes:

[a] *The 5 ½ year average per capita flow and pollutant loading values are considered to be the best available data, more representative of conditions going forward due to recent improvements in reducing infiltration/inflow, low volume bathroom fixtures, similar water conservation measures, etc.*

* *Based on Monthly Operating Report Data (Effluent)*

** *Ratio to average annual value*

*** *Gallons per capita per day*

Influent flows from 2010 through 2015 have shown the following characteristics:

- Minimum day flow has remained relatively constant at about 6.6 MGD.
- Average day flow has varied in the range of about 8.0 MGD to 9.6 MGD with the variation attributed to variation in annual precipitation.
- Maximum day flow has varied from as low as 9.5 MGD in 2012 to 30 MGD in 2015. 2012 was an abnormally dry year and there was record rainfall during May and early June of 2015 when the maximum day was recorded.
- It was noted that potentially a siphon or other collection system bottleneck might be limiting flow to 30 MGD as the flow appears to flat-line at 30 MGD. Evaluation of the date indicates that this was not due to instrument monitoring error at the plant.

The future maximum month and maximum day flows and loads shown in Table S.8 were calculated from the average per capita values multiplied by the projected wastewater service

population. Industrial and commercial reserve is limited to the nature of the existing service area and was included in projected population growth loadings.

Table S.8. Projected Future Influent Flows and Pollutant Loading

Parameter	Loading Projections 2020	2025	2030	Planning Year 2035	2040	2045
Population						
WW Service Population	85,560	91,205	98,195	105,184	120,674	131,018
Influent Flow	MGD	MGD	MGD	MGD	MGD	MGD
Annual Average Day	10.4	11.1	12.0	13.0	14.7	16.0
Summer Average Day	11.3	12.1	13.0	13.9	16.0	17.3
Winter Average Day	9.6	10.21	11.0	11.8	13.5	14.7
Maximum Month	13.3	14.2	15.2	16.3	18.7	20.3
Maximum 7-day	17.9	19.1	20.5	22.0	25.2	27.4
Maximum Day	20.1	21.4	23.1	24.7	28.3	30.8
Peak Hour	34.0	36.2	39.0	41.8	47.9	52.0
Biochemical Oxygen Demand	lb/day	lb/day	lb/day	lb/day	lb/day	lb/day
Annual Average Day	16,563	17,651	18,997	20,343	23,326	25,318
Summer Average Day	16,419	17,502	18,843	20,184	23,157	25,142
Winter Average Day	16,355	17,435	18,771	20,107	23,068	25,045
Maximum Month	18,275	19,468	20,944	22,421	25,694	27,880
Maximum 7-day	19,802	21,108	22,726	24,343	27,928	30,322
Maximum Day	25,433	27,111	29,188	31,266	35,870	38,945
Total Suspended Solids	lb/day	lb/day	lb/day	lb/day	lb/day	lb/day
Annual Average Day	17,626	18,784	20,143	21,577	24,829	26,951
Summer Average Day	18,487	19,707	21,217	22,727	26,074	28,309
Winter Average Day	16,687	17,788	19,152	20,515	23,536	25,553
Maximum Month	20,328	21,655	23,077	24,940	28,581	31,012
Maximum 7-day	22,964	24,479	26,355	28,231	32,388	35,164
Maximum Day	35,655	38,008	40,921	43,833	50,288	54,599
Ammonia	lb/day	lb/day	lb/day	lb/day	lb/day	lb/day
Annual Average Day	2,150	2,292	2,464	2,643	3,028	3,291
Summer Average Day	2,107	2,246	2,418	2,591	2,972	3,227
Winter Average Day	2,156	2,299	2,483	2,651	3,041	3,302
Maximum Month	2,320	2,472	2,653	2,850	3,269	3,548
Maximum 7-day	2,505	2,670	2,875	3,079	3,533	3,835
Maximum Day	3,278	3,494	3,762	4,029	4,623	5,019

The current (2015) wastewater service population of 79,855 is expected to increase at a rate of approximately 1.9% per year to over 131,000 by 2045. The current average daily flow to the treatment facility is expected to increase from the current 9.51 MGD to nearly 16 MGD by 2045

with a 2035 design average flow of 13.0 mgd. Pollutant loadings, including BOD, TSS, ammonia, nitrogen, and phosphorus are all expected to increase from current levels in proportion to the expected wastewater flow increase in future years.

Plant Hydraulic Capacity (Chapter 3.1)

The hydraulic capacity, or flow component, of the WRF was evaluated as part of the facility planning process to help identify capital improvements required to meet current and long-term capacity needs at the WRF.

The objectives for this evaluation included:

- Consideration of process performance implications, if any, associated with the preliminarily identified hydraulic capacity.
- Make a preliminary assessment of the WRF hydraulic capacity.
- Identify hydraulic bottlenecks, conduct additional hydraulic analysis, and identify modifications that could potentially increase hydraulic capacity consistent with process performance implications.

The current 2015 peak hour flow measured at the facility is 30.2 MGD. The hydraulic capacity of the WRF was determined through a combination of a unit process by unit process analysis and hydraulic modeling of the entire WRF. The calculated hydraulic capacity for the individual unit processes are presented in Table S.9.

Hydraulic modeling of the entire WRF identified the limiting hydraulic capacity of the existing WRF to be 26 million gallons per day (MGD) at the Tertiary Clarifiers. The invert of the tertiary clarifier effluent weir becomes submerged at 18 MGD; the top of the weir becomes submerged at 26 MGD with 16 MGD through the North Plant and 10 MGD through the South Plant. While submerged weirs reduce the suspended solids removal efficiency, the clarifiers will continue to operate and flow will continue through the plant. At 26 MGD, hydraulic loadings on individual treatment processes are manageable, and flow can be accommodated without submerging weirs or overflowing structures when all treatment units are in operation. Because flow is split between the north and south plants, the assumption was made that the South Plant flow is limited to 10 MGD to match the South Plant basis of design.

The second most restrictive bottleneck is just upstream of the grit removal units. At 34 MGD, the freeboard in the channel directly downstream of the screens is less than 0.75 foot. Typically new plant design would provide a minimum of one foot of freeboard. To meet this restriction, it is recommended to add a curb at the upstream channel.

The third most restrictive total plant flow bottleneck is related to exceeding Recommended Ten States Standards maximum surface overflow rates. The plant flow restrictions based on Ten States' Recommendations are tertiary clarifier (16 MGD for total north and south plant flow of 26 MGD), secondary clarifier (27.3 MGD for total of 37.3 MGD), and clariflocculator (9 MGD for total north and south plant flow of 39 MGD). Refer to Table S.9 and the notes following the table, which further describe the unit process flow considerations.

Table S.9. WRF Unit Process Hydraulic Capacity Summary

Area of the Facility	Unit Process	Hydraulic Capacity, MGD		
		North Plant	South Plant	Total Plant
Pretreatment Building	WRF Influent Sewer[a]	35	10	45
	Screens[b]	43	10	53
	Grit Removal Units[c]	24	10	34
North Plant	Primary Clarifiers[d]	30	10	40
	Trickling Filter Recycle Pumps[e]	31.7	10	41.7
	Trickling Filter Rotary Distributors[f]	36	10	46
	Secondary Clarifiers[g]	27.3	10	37.3
	Rotating Biological Contactors (RBCs)[h]	38	10	48
	Tertiary Clarifiers[i]	8	10	18
		16	10	26
South Plant	Aeration Basins[j]	30	12	42
	Clariflocculator[k]	30	9	39
UV Disinfection Building	UV Disinfection	30	10	40
	Effluent Flow Measurement[l]	45	10	55

Notes:

[a] *45 MGD is the flow at which the influent sewer surcharges at the location of the WRF fence.*

[b] *Screens were assumed to be 20 percent blocked. 53 MGD is the flow at which the freeboard in the channel upstream of the screens is less than 0.75 ft.*

[c] *34 MGD is the flow at which the freeboard in the channel directly downstream of the screens is less than 0.75 ft.*

[d] *The primary clarifier effluent weirs become submerged at 40 MGD. Based on the 10 States Standards recommendations, the primary clarifiers are rated for 22.7 MGD average flow and 45.4 MG peak hourly flow.*

[e] *31.7 MGD is the firm capacity of the trickling filter pump station (two pumps in operation with two on standby). The pump station is capable of pumping approximately 45 MGD if all three pumps are in operation.*

[f] *Each trickling filter distributor system is rated for 18 MGD. Flow will begin to back into the trickling filter underdrain at 46 MGD total plant flow.*

[g] *The secondary clarifier effluent weir submerges at 40 MGD. Based on the 10 States Standards recommendations, the secondary clarifiers are rated for 27.26 MGD peak hour loading.*

[h] *The RBC effluent weir submerges at 48 MGD total plant flow.*

[i] *The invert of the tertiary clarifier effluent weir becomes submerged at 18 MGD; the top of the weir becomes submerged at 26 MGD. Based on the 10 States Standards recommendations, the peak hour capacity is 26.2 MGD.*

[j] *The aeration basin effluent weir submerges at 42 MGD total plant flow. The selector cell curtain becomes damaged at flows exceeding 4 MGD.*

[k] *The clariflocculator effluent weir submerges at a total plant flow of 39 MGD. Based on the 10 States Standards loading rates, the clariflocculator has a capacity of 11.4 MGD.*

[l] *The effluent Parshall Flume is rated for 55 MGD. At a Rapid Creek elevation of 2999.0 (the upper end of the typical range), the flume will not submerge at plant flows less than 100 MGD.*

Table S.10 contains a detailed breakdown correlating the improvements to the projected influent flow and gives the new plant capacity with the improvements incorporated.

Table S.10. Hydraulic Capacity Improvements Summary

Year	Hydraulic Limitation	Addressed
2015	Peak Hour Flow is 30.2 MGD	
	Replace the aeration basin selector curtain with a concrete wall.	Included in Age and Condition
	Add a second 48-inch pipe from the Tertiary Clarifiers to UV. (Option is allow to submerge)	This is not included due to limited treatment impact during peak event.
	Add one clariflocculator for hydraulic capacity reliability.	
2025	Peak Hour Flow is 37.7 MGD	
	Add a 10 MGD in-plant peak flow pump station to pump from grit basin effluent to the aeration basin splitter box.	Included in Regulatory - Activated Sludge Project Costs
	Increase to four (4) clariflocculators.	Included in Regulatory –Activated Sludge Project Costs
	New effluent piping to UV Disinfection.	Included in Regulatory - Activated Sludge Project Costs
	Increase the size of the wall openings in the aeration basin to accommodate anoxic recycle flows.	Included in Regulatory - Activated Sludge Project Costs
	Remove the aeration basin weir plates on the effluent launder.	Included in Regulatory - Activated Sludge Project Costs
	Increase the capacity of the influent screens (currently rated at 37 MGD total combined flow).	Not Included at this time.
2030-2035	Peak Hour Flow is 40.6 - 43.5 MGD	
	Increase capacity of grit units (current capacity is 40 MGD).	Increase upstream channel wall height. Third grit unit not Included at this time. Efficiency will be reduced but can pass flow hydraulically.
	Upgrade UV Disinfection system and effluent flow measurement (current capacity is 40 MGD).	Not included at this time.

Organic Capacity (Chapter 3.2)

The organic capacity of the facility for the current effluent limitations, the Permit #2 more stringent future ammonia and the Permit #3 nutrient effluent regulatory limitations were evaluated.

The existing WRF was modeled to test the critical flows and loads at which expansion of the system is needed for the system as a whole. The organic capacity was determined through a combination of process modeling of the entire WRF as a whole system and evaluating individual unit process capacities.

The model results showed that the controlling regulatory condition for the organic capacity of the existing facility is based on meeting the permitted effluent ammonia concentration. Table S.11 summarizes the existing capacity analysis for both current 2016 permit limits and pending Permit #2 –ammonia standards. The table indicates the total equivalent population capacity would be 91,155, with the pending 2016 Permit limitations, which would be reached in approximately year 2025.

The 2000 Facility Plan projected the existing WRF had a population treatment capacity of 94,000 at the 2001 permit limits. It predicted this population would be reached in 2018. The capacity with more stringent ammonia limits is only 3.1% less from the 2000 estimate at 91,155.

At the Permit #2 (2025) –New Ammonia Standards limits, the equivalent population capacity would be 81,855, or approximately 2 years of growth from the 2014 base population of 79,855. Therefore, improvements would need to be in place and functioning when Permit #2 is issued. The existing plant cannot meet expected regulatory treatment requirements without treatment capacity expansion.

The table does not include capacities for nutrients, total nitrogen (TN), and total phosphorus (TP) removal, since permit requirements are over 10-years into the future and the existing facility is not physically designed to treat for TN and TP.

Table S.11. Organic Capacity Summary of Existing WRF

	Current Loadings	Capacity with 2016 Current Ammonia Permit Limits	Total Equivalent Population Capacity	Capacity with Permit # 2 – New Ammonia Limits	Total Equivalent Population Capacity
BOD5, lb/day	16,600	17,600		15,900	
TSS, lb/day	16,100	19,600		17,600	
TKN, lb/day	2,810	3,210		2,880	
Ammonia, lb/day	1,970	2,240		2,020	
Overall Capacity Remaining[a] %		14.1	*91,155*	2.4	*81,855*

Note:
[a] *Capacity reduction reflects aeration capacity and reliability related to ammonia limit (nitrifier sensitivity).*

If the nature of the facility's incoming wastewater significantly changes and impacts the ratio of BOD_5 to ammonia or Total Kjeldahl Nitrogen (TKN); the modelled capacities should be rechecked. TKN is important because it is the combination of organically bound nitrogen and ammonia in wastewater and both the organic nitrogen and ammonia require treatment capacity.

Selected improvements were identified as process limitations, or “bottlenecks”, from the plant capacity modelling. The selected improvements include various south plant improvement combinations including additional aeration tankage, one additional secondary clarifier (2 total) and modifying the process to include primary clarified effluent (PE) to the south plant.

Table S.12 shows the capacity of the WRF, based on Permit #2 ammonia requirements, with select improvements. The improvements support Permit #2, with future provisions for Permit #3. The lowest capacity alternative is “Existing, Raw” using the existing system and feeding raw wastewater to the activated sludge system, and the highest capacity comes from “Additional Aeration Tankage & New Clarifier, PE to South Plant” routing primary effluent to the expanded activated sludge system with an additional clarifier. Additional clarifiers are required for peak hydraulic flows, independent of loading.

Table S.12. Summary of Permit #2 Capacity Limitations w/ Identified Improvements

	Added South Plant Clarifiers	Added Tank Volume, MG	Limiting Factor	South Plant Flow*, MGD MM = Max. Month MD = Max. Day	Total Plant Flow*, MGD MM = Max. Month MD = Max. Day	Total Equivalent Population Capacity
Existing, Raw (Matches Current Operation)	None	---	Clarifier Surface Area	MM = 8.0 MD = 8.0	MM = 12.8 MD = 19.4	84,000
PE to South Plant	None	---	Clarifier Surface Area	MM = 10.8 MD = 10.8	MM =16.0 MD = 24.2	97,100
Additional Aeration Tankage & New Clarifier, Raw to South Plant	One added	1.1	Clarifier	MM = 10.0 MD = 10.0	MM = 14.8 MD = 22.4	105,000
Additional Aeration Tankage & New Clarifier, PE to South Plant	One added	1.1	None (2035) Aeration + Clarifier (2045) Anoxic (TN removal)	MM = 14.7 MD = 17.3	MM =16.8 MD = 25.5	110,200

*Note: * Capacity presented based on flow; however, this represents an organic loading capacity evaluation based on the wastewater characterization previously described. While the plant can pass additional flow hydraulically, the system is limited to these design flows based on the pollutant levels in the wastewater.*

Assessment (Chapter 1.1)

A condition assessment of equipment and facilities was conducted to determine the needs and timing for repair or replacement of existing facility components in the development of the long-range plans of the WRF. An operations assessment was conducted by an operations specialist, focusing on how the existing facility is being operated and maintained. A physical condition assessment was conducted by individuals with expertise in process equipment, architecture, structural engineering, mechanical engineering, electrical engineering, and instrumentation engineering, focusing on the current physical condition analysis as a basis for estimating the remaining useful life of its components.

Each significant piece of process equipment was physically inspected and plant O&M staff was interviewed to discuss operational and condition issues. From a process equipment perspective, there are currently no major constraints on the WRF's ability to meet the current discharge permit limits under normal circumstances, due to the O&M staff's dedication to ongoing operation and maintenance of the facility. Estimating remaining useful life for process equipment is a subjective estimate and relies heavily on ongoing maintenance and continued availability of repair parts.

In addition to the process evaluation, site conditions were also evaluated which included site/civil, mechanical, electrical, architectural and controls and tabulated by discipline.

Table S.13 provides a summary of the preliminary recommendations to upgrade the Rapid City WRF to provide reliable treatment. This table provides an overview of facility requirements, driving forces, urgency/timing considerations, and order of magnitude costs.

The summary of age and condition recommendations has been separated into the following categories:

Short-Term Capital Improvements

These are improvements required to continue to reliably treat the flow to meet the current 2016 permit. Short-term improvements are anticipated to be implemented within the next five years. These improvements address items such as treatment and hydraulic capacity items, reliability, operations and energy minimization. Priority 1 items are recommended to be completed in 2016 – 2018, and Priority 2 items completed by 2020.

Plant Modifications to meet Other Needs

These are longer-term improvements that are necessary to continue to meet the needs for the City of Rapid City to operate effectively and meet the effluent permit limits. These items have been given Priority 3, 4 or 5 designations. Priority 3 items are planned to be completed in 2020 – 2025 and Priority 4 and 5 items are planned for completion in 2025 – 2035.

Table S.13. Summary of Age and Condition Recommendations

Component	Recommended Improvements	Implementation Date
Short-Term Capital Improvements		
Priority 1		
Activated Sludge Improvements	One new clariflocculator, curtain wall, drain pump.	Priority 1 - 2016-2018
Trickling Filter Pump Sta. Improvements	New pumps with VFDs to handle flow range, and repair and recoat pump discharge piping.	Priority 1 - 2016-2018
Sludge Handling Improvements	Provide new dewatered sludge conveyance and storage equipment.	Priority 1 - 2016-2018
Misc. Preliminary Treatment Improvements	Screening bypass, septage safety and volume, misc.	Priority 1 - 2016-2019
Misc. Digester Improvements	Roof access, chemical feed, and waste gas improvements.	Priority 1 - 2016-2018
Priority 2		
Site work	Roadways, plant access, Gaging Station, water well abandon.	Priority 2 - 2018-2020
Primary Treatment	Scum pumps & piping, skimmers and gearboxes, sludge level sensors, pumping room HVAC, railing, and misc. tuck-pointing.	Priority 2 - 2018-2020
Secondary Clarification	Humus pumps, gearboxes, and clarifier railing.	Priority 2 - 2018-2020
RBCs and Generator	Repair RBC in-tank air piping, replace generator, HVAC	Priority 2 - 2018-2020
Tertiary Clarifiers and Pumping	Costs to Maintain existing pumps, drives and HVAC	Priority 2 - 2018-2020
Activated Sludge Improvements	Splitter box gate actuators, Blower intakes/HVAC, generator controls, and misc. architectural.	Priority 2 - 2018-2020
UV Disinfection/Post Aeration Improvements	Generator controls and misc. architectural.	Priority 2 - 2018-2020
Digestion Area Improvements	Replace steel gas lines, boiler controls, electric modifications and misc. vac and architectural.	Priority 2 - 2018-2020
HVAC Improvements	Upgrade Secondary Building, Water Building, Maintenance Shop, and Metals Shop HVAC.	Priority 2 - 2018-2020
Instrumentation, Electrical and Misc. Improvements	Maintenance Shop MCC, Integration of PLCs, and Samplers.	Priority 2 - 2018-2020
Cold Storage Building and Misc. Architectural	Construct new cold storage building.	Priority 2 - 2018-2020
Plant Modifications - Other Needs		
Priority 3		
Sludge Handling Project	Provide Phased sludge conveyance and storage.	Priority 3
Process	Includes equipment replacement, including paddles and drives, and coating of the tanks.	Priority 3
Architectural	Administration Facilities Expansion -Building addition & site improvements.	Priority 3
Structural	Miscellaneous Structural.	
HVAC Improvements	AB Pump Room and UV Building.	Priority 3
Electrical, Instrumentation, and Misc. Improvements	Remote monitoring capabilities, CMMS replacement, on-line metering capabilities, and secondary standby generator.	Priority 3
Operation & Energy Total	SCADA/Remote Operations & Computerized Maintenance Management Software (CMMS) & On-line Monitoring.	Priority 3

Component	Recommended Improvements	Implementation Date
Priority 4		
Sludge Handling Improvement	Phase 2 Sludge Handling Improvements.	Priority 4
Process	Miscellaneous process equipment replacement.	Priority 4
Priority 5		
Process Upgrades	Screen gear boxes, replace MCCs, grit classifier, gas flare and misc.	Priority 5
HVAC Improvements	Replace digester boilers.	Priority 5
Electrical, Instrumentation, and Misc. Improvements		Priority 5
Odor Control	Construct odor control facilities for odor-related areas. Tie to odor sources.	Priority 5
Priority 5 Subtotal		Priority 5 Subtotal

Energy Audit (Chapter 1.2)

HDR conducted an energy audit for the WRF in 2011. That work was a part of a statewide audit of 16 wastewater facilities that was done for the SD DENR. The goal of the energy audit was to identify potential Energy Conservation Measures (ECMs) that could be further evaluated and implemented at the WRF. In this evaluation those results were reviewed and updated based upon current conditions. The updated recommended ECMs are summarized in Table S.14.

Table S.14. Recommended Energy Conservation Measures –Monetary Summary

ECM #	Description	Savings kW	Savings kWh/yr	Savings $/yr	Cost	Simple Payback (yrs)	Recommended For Evaluation	Trigger Point	Comments
4	Install VFDs on the lift pumps to complement the recently retrofitted trickling filter distributor arms with pneumantically controlled distributor arms.	84	803,800	$67,500	$239,000	3.5	Yes	Rotary distributor arms have already been replaced. VFDs should be included on new trickling filter pump station.	The combination of VFD's on the trickling filter pumps and the pneumatically operated distributor arms would improve operation of the trickling filters. In addition, the pumps and lift station configuration need to be addressed for future operations. Improvements to the Trickling Filter Pump Station pumps and trickling filter recirculation system in general are currently being evaluated to address both long- and short-term goals. Operational flexibility and energy efficiency should be included in any proposed improvements, including consideration of replacing all starters with VFDs.
5	Convert from propane to natural gas as a pretreatment building and shop building heat source.	NA	NA	$40,800	$25,000	0.6	Yes	As soon as NG service is extended to the WRF	Natural gas is significantly less expensive than propane and electric heat.
9	Increase size of centrate discharge lines from the centrifuges in the biosolids handling building.	NA	42,000	$3,900	$46,000	12	Yes	Within the next year or as funds are available.	This payback period for implementation of this ECM is more than 10 years. However, it is still recommended for further evaluation as it would also reduce the total annual labor hours required to operate the centrifuges by 25%.
10	Replace the Centrifuges with an alternate dewatering system that uses less energy, such as fan presses.	93	118,000	$9,922,	$963,000 (Cost difference)	97	Yes	When centrifuges require overhaul (3 - 5 Years)	ECM assumes the existing centrifuges will need to be overhauled or replaced within the next 3 to 5 years. The cost is the difference between replacing the centrifuges with three screw presses verses replacement in-kind with new centrifuges. With other factors considered such as biosolids hauling, labor, maintenance costs, polymer usage, and equipment replacement costs, the payback period would be less than 6 years. Pilot testing and futher investigation is recommend before making a final selection of dewatering technologies.
11	Maximize the use of digester gas by using excess biogas to heat buildings at the WRF, such as the Pretreatment Building and the Shop Building.	NA	NA	$68,300	$210,000	3.1	Yes		The waste gas burner piping needs to be repaired to eliminate the wasting of excess biogas through the digester covers. The use of excess digester gas to heat one or more of the buildings, such as the pretreatment building and shop building would help in maximizing the use of biogas and reduce the amount of propane required for heating purposes.
	Total for Recommended ECMs	**177**	**963,800**	**$190,422**	**$1,483,000**	**7.8**			

*Kw – Kilowatts: Instantaneous power usage.
** Kw-hr – Kilowatt-hours: Power consumption equivalent to 1,000 watts for 1 hour.

Treatment Alternatives (Chapter 4.1)

Treatment alternatives were evaluated to meet Permit no. 2 and Permit No.3 discharge requirements to determine those that have the highest potential for implementation based on their effectiveness from both a treatability aspect as well as monetarily.

After initial screening to select the most applicable process modifications for the WRF, the following long-term expansion alternatives were evaluated:

- Alternative A1 - Activated Sludge: Convert Plant to Only Activated Sludge, Blend Raw Influent with Primary Effluent
- Alternative A2 - Activated Sludge, with Biological Nutrient Removal: Convert Plant to Only Activated Sludge with full Biological Nutrient Removal
- Alternative B - Activated Sludge, Trickling Filter Peaking: Activated Sludge with Trickling Filter Peaking Alternative, Blend Raw Influent with Primary Effluent
- Alternative C – Activated Sludge with Prenitrification with Trickling Filter Peaking: Prenitrification Activated Sludge with Trickling Filter Peaking Alternative, Blend Raw Influent with Primary Effluent (Prenitrification is treatment for ammonia in side-stream tankage)

The treatment process alternatives included the ammonia design target as well as the TN design target level (< 10 mg-N/L). Only Alternative A2 included a design component for biological phosphorus removal. The remaining alternatives included chemical phosphorus removal. Chemical phosphorus removal is usually accomplished with the addition of metal salts (aluminum sulfate or ferric chloride) dosed ahead of the primary clarifier or the secondary clarifier and precipitated solids settle out in the clarifiers.

Table S.15 shows projected additional tank needs, limiting factors, and flow capacities. In summary:

- Alternative A1 meets treatment objectives for ammonia and total nitrogen; chemical addition is used for TP removal.
- Alternate A1 is consistent with the 2000 Facility Plan as this plan recommended expanding the activated sludge treatment for additional capacity with provisions for denitrification and phosphorus removal.
- Alternatives B and C are less reliable for more stringent ammonia limits due to the limitation with the fixed-film process, but meet the pending 2013 ammonia and outlined nutrient criteria -10 mg/l TN, 1 mg/l TP .
- Alternative A2 also meets all treatment objectives; however, the added tankage is substantially greater than for the other alternatives.

Table S.15. Process Evaluation Summary

Alternative	Added Tanks[d]	Added Tank Volume, MG	Process Limiting Factor	AS Flow, MGD	Total Plant Flow, MGD	Total Population Capacity
Alternative A1 - Activated Sludge	Anoxic Aerobic Clarifier	1.2 0.9 4.4 (4 units)	None (2025-2045)	MM[a] = 21.0 MD[b] = 31.8	MM = 21.0 MD = 31.8	131,000
Alternative A2 - Activated Sludge, BNR	Anaerobic Anoxic Aerobic Clarifier	1.5 1.7 1.9 4.4 (4 units)	None (2025-2045) Some chemical polish may be needed to achieve TP limits.			
Alternative B - AS, TF Peaking	Anoxic Aerobic Clarifier	1.4 1.2 2.2 (2 units)	Ammonia Removal[C]	MM[a] = 18.5 MD[b] = 18.5		
Alternative C - Prenit., TF Peaking	Prenit. Anoxic Aerobic Clarifier	0.25 1.2 0.6 2.2 (2 units)	Ammonia Removal[C]			

Notes:

[a] *MM -Maximum month flows and loads result in an effluent that meets treatment objectives.*

[b] *MD -Maximum day flows and loads result in an increase in discharge BOD_5, TSS, and ammonia during the maximum day flow.*

[c] *Limited to ammonia removal efficiency of existing permit limit due to mass transfer limitations with fixed film treatment. Existing north plant does not provide equal reliability with south plant for more stringent effluent ammonia limits.*

[d] *One clarifier needs to be added immediately to provide reliable treatment in the case that one clarifier needs to be maintained.*

Improvements detailed in Table S.16 were divided into the phases triggered by the permit cycles identified. Phase 1 includes modifications required to achieve Permit #2 – New Ammonia Standards (constructed by 2025). The combination of Phase 1 and Phase 2 includes modifications to achieve both future ammonia removals and BNR (TN 10/TP 1) to be (constructed by 2030). Alternative D is the same as Alternative A for Phase 1 as the nutrient removal requirement is not yet in the permit. Tables S.17 and S.18 present the life cycle cost estimates for Phase 1 and, Phase 1 and Phase 2 improvements combined, respectively.

Table S.16. Recommended Additional Capacity Improvements

	Added Tanks*	Phase 1 Tank Volume, MG	Phase 2 Tank Volume, MG	Total Added Tank Volume, MG
Alternative A1 - Activated Sludge	Anoxic		1.2	1.2
	Aerobic	0.9		0.9
	Clarifier	2.2 (2 Units)	2.2 (2 Units)	4.4 (4 Units)
Alternative A2 - Activated Sludge, BNR	Anaerobic		1.5	1.5
	Anoxic		1.7	1.7
	Aerobic	0.9	1.0	1.9
	Clarifier	2.2 (2 Units)	2.2 (2 Units)	4.4 (4 Units)
Alternative B – AS, TF Peaking	Anoxic		1.4	1.4
	Aerobic	1.2		1.2
	Clarifier	2.2 (2 Units)		2.2 (2 Units)
Alternative C - Prenit., TF Peaking	Prenit.	0.25		0.25
	Anoxic		1.2	1.2
	Aerobic	0.6		0.6
	Clarifier	2.2 (2 Units)		2.2 (2 Units)

Note:

* One clarifier needs to be added immediately to provide reliable treatment in the case that one clarifier needs to be maintained.

Table S.17. Phase 1 Life Cycle Analyses

Description	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Total Construction Cost	$23,200,000	$23,200,000	$23,500,000	$23,500,000
Operations & Maintenance - 20 Year Present Value, 3%	$20,300,000	$20,300,000	$24,200,000	$25,100,000
Construction & Operations & Maintenance Present Value	**$43,500,000**	**$43,500,000**	**$47,700,000**	**$48,600,000**

Table S.18. Phase 1 & 2 Life Cycle Analyses

Description	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Total Construction Cost	$31,000,000	$38,300,000	$31,400,000	$31,100,000
Operations & Maintenance - 20 Year Present Value, 3%	$38,600,000	$35,200,000	$44,300,000	$45,000,000
Construction & Operations & Maintenance Present Value	**$69,600,000**	**$73,500,000**	**$75,700,000**	**$76,100,000**

The existing trickling filters are very efficient for BOD and ammonia removal and have served the City of Rapid City well in terms of permit compliance for the last 50 years. Likewise, it is a familiar technology to operations staff and reduces the impact of future biosolids production. However, fixed film is not effective for nutrient removal without chemical addition (methanol). Secondly, the trickling filters were evaluated as a peaking facility and the advantages of keeping the trickling filters do not outweigh the disadvantages.

Costs for the four alternatives with two options to achieve the effluent limits for Permit #2 and #3 for both future ammonia and Level 1 nutrient control of 10 mg/l TN and 1 mg/l TP indicate the following:

- Alternative A1 without the existing trickling filters is ultimately the lowest cost alternative whether it be construction cost, energy cost, chemical cost, operations and maintenance cost, or overall present value. On a total present value basis, it is approximately $6.4 million less expensive than the next alternative.
- Alternatives B, C and A2 are approximately the same on a present worth basis.
- Alternative A2 with biological phosphorus removal has the highest cost with respect to initial capital cost.
- Alternate A1 is consistent with the 2000 Facility Plan as this plan recommended expanding the activated sludge treatment for additional capacity with provisions for denitrification and phosphorus removal.

The non-monetary evaluation for the four alternatives indicates that the activated sludge based alternatives were rated highest.

Alternative A1, activated sludge, has the lowest comparative present value at approximately $69.6 million and is 6% less than Alternative A2 and has the lowest total construction cost at $31 million.

Therefore, the activated sludge Alternative A1 is the recommended alternative.

Solids Handling Evaluation (Chapter 4.2)

Waste activated sludge and anaerobically digested primary sludge from the treatment processes are pumped to a holding cell for temporary storage prior to dewatering or thickening in the solids handling building. The Rapid City WRF uses two centrifuges to either thicken or dewater biosolids. Dewatered biosolids are delivered either to the Rapid City Regional Landfill for direct disposal or to the Rapid City Material Recovery Facility (MRF) for co-composting. Thickened biosolids are delivered to the MRF for co-composting. The centrifuges are operated 10 to 14 hours per day, 4 to 5 days per week, and require continuous monitoring during operation. The centrifuges require frequent overhauls, with each overhaul costing $80,000 per unit. Maintenance requires the centrifuges to be disassembled and sent to the manufacturer for service.

The Rapid City WRF currently processes approximately 490,000 gallons per week of sludge during a maximum month at the solids handling facilities. At an average solids concentration of 1.6 percent this calculates to a maximum solids loading of 67,700 pounds per week. Following discussions with Staff at the MRF Co-composting Facility, the WRF agreed that centrate water could be substituted for thickened biosolids in the co-compost operation. This would result in easier material handling for both facilities. Dewatered solids will continue to be processed either through the MRF Co-composting Facility or disposed of in the landfill.

Based on future wastewater flows and loads, and the proposed long-term treatment alternative, the 20-year projected sludge loading to dewatering is 133,000 pounds per week during a maximum month scenario and the sludge volume is projected to be 990,000 gallons per week.

Four dewatering technologies were reviewed for upgrading the existing solids handling facilities. These four technologies include centrifuges, screw presses, rotary fan presses, and volute presses. Each of the technologies has operational advantages and disadvantages over the others. However, centrifuges use a considerable amount of power to operate in comparison to the other alternatives and require more maintenance and operator supervision. These four technologies were evaluated as part of the following solids handling upgrade alternatives:

- Alternative 1A: Two Centrifuges/One Operating and One Standby
- Alternative 1B: Three Centrifuges/Two Operating and One Standby
- Alternative 2A: Two Screw Presses/One Operating and One Standby
- Alternative 2B: Three Screw Presses/Two Operating and One Standby
- Alternative 3A: Four Rotary Fan Presses/Three Operating and One Standby
- Alternative 3B: Six Rotary Fan Presses/Five Operating and One Standby
- Alternative 4A: Two Volute Presses/One Operating and One Standby
- Alternative 4B: Three Volute Presses/Two Operating and One Standby

A summary of the costs for the alternatives is shown in Table S.19.

Table S.19 Summary of Costs for Solids Handling Alternatives

Description	Alt 1A: Two Centrifuges-Dewater Only	Alt 1B: Three Centrifuges-Dewater Only	Alt 2A: Two Screw Presses-Dewater Only	Alt 2B: Three Screw Presses-Dewater Only	Alt 3A: Four Fan Presses-Dewater Only	Alt 3B: Six Fan Presses-Dewater Only	Alt 4A: Two Volute Presses-Dewater Only	Alt 4B: Three Volute Presses-Dewater Only
Total Construction Cost	$10,250,000	$11,520,000	$9,670,000	$10,980,000	$13,610,000	$17,400,000	$11,310,000	$13,400,000
Total Project Cost	$12,710,000	$14,280,000	$11,990,000	$13,620,000	$16,880,000	$21,580,000	$14,020,000	$16,600,000
Total Annual O&M Cost	$683,500	$643,900	$575,200	$562,000	$650,000	$713,900	$568,300	$589,700
Life Cycle Cost	$22,592,000	$23,599,000	$20,325,000	$21,754,000	$26,438,000	$31,892,000	$22,235,000	$25,135,000
Total Equivalent Annual Cost	$1,561,000	$1,631,000	$1,404,000	$1,503,000	$1,827,000	$2,204,000	$1,536,000	$1,737,000

Solids handling improvements are recommended as an immediate need. Alternative 4B: Three Volute Presses constructed in a new building, is included in the Rapid City WRF Capital Improvements Plan. A phased approach is provided to add additional units concurrent with Permit #2 (2025) liquid process train improvements.

Phasing Options

Table S.20 shows three options for phasing implementation of the volute press alternative of dewatering.

Option 1 includes three dewatering units and all the improvements required for the 20-year planning period and would be implemented in a single phase by 2020 at an estimated total project cost of $16.6 million.

Under Option 2, two dewatering units would be installed and additional liquid sludge storage constructed initially to meet immediate needs. Drying cake sludge storage would not be constructed as part of the immediate needs. The remaining improvements including liquid sludge storage, a third dewatering unit, and dry cake storage would be constructed in two phases based on capacity and operational requirements.

Phasing Option 3 would be similar to Option 2 in that two dewatering units would be installed and additional liquid sludge storage constructed initially to meet immediate needs. However, under Option 3 dry cake storage would also be constructed as part of the initial project. Option 3 differs from Option 2, in that it would be assumed the two dewatering units would be operated continuously and therefore a third unit would not be planned for a future phase.

Table S.20. Solids Handling Facilities Improvements – Volute Presses – Phasing Option 2

Phasing Options	Immediate Needs	Phase I	Phase II
1	**By 2020 (No Phasing)** Install all three dewatering units. Construct 1.5 MG of additional liquid sludge storage. Construct dry cake storage building. Complete all age & conditions improvements. Project Cost: **$16.6 million.**		
2 (Selected)	**By 2020 (Phasing)** Install two dewatering units – Two units operated 40 hours per week will provide dewatering capacity to 2033 or equivalent population 102,388. Constructed 1.2 MG of additional liquid sludge storage. No dry cake storage building. Implement age & condition improvements scheduled for 1- 5 years. Project Cost: **$11.95 million**.	**By 2025** Construct 300,000 gallons of additional liquid sludge storage. Implement scheduled age & condition improvements. Project Cost: **$1.22 million.**	**By 2033** Install third dewatering unit- Three units operated at 28 hours per week, will provide dewatering capacity beyond 2035. Construct dry cake storage building. Implement scheduled age & condition improvements Project Cost**:** **$3.46 million.**
3	**By 2020 (Phasing)** Install two dewatering units – One unit operated continuously for up to 85 hours per week will provide dewatering capacity beyond 2035 or equivalent population 105,184. Construct dry cake storage building. Construct 1.2 MG of additional liquid sludge storage. Implement age & condition improvements scheduled for 1–5 years Project Cost: **$12.92 million**.	**By 2025** Construct 300,000 gallons of additional liquid sludge storage. Implement scheduled age & condition improvements. Project Cost: **$0.93 million.**	Assume volute press operation is 24/7, 5 days per week.

Phasing Option 2 is recommended for implementation of the solids handling improvements. A detailed breakdown in the estimated costs for Phasing Option 2 is shown in Table S.21.

Table S.21.Solids Handling Facilities Improvements– Recommended Phasing Option Costs

Item Description	Immediate Needs	Phase I	Phase II
Division 1 - General Requirements (Included in contingencies)			
Division 2 - Site work			
2.1. New Building Site and Piping Work	$202,000		
2.2. Driven Piles	$70,000		
2.3. Additional liquid sludge storage	$402,000	$70,000	
Division 3 - Concrete			
3.1. Grade Beams/Footings/Base Slab	$435,500		
3.2. Precast Roof Panels	$25,000		
3.3. Intermediate Floor Slab	$89,000		
Division 4 - Masonry			
4.1. New Building Exterior Masonry Walls	$86,500		
4.2. New Building Interior Masonry Walls	$23,000		
Division 5 - Metals	$33,333		$16,667
Division 7 - Thermal & Moisture Protection			
7.1. New Building Roof System	$75,600		
Division 8 - Doors & Windows	$20,000		
Division 9 - Finishes	$21,000.00		$11,000.00
Division 11 - Equipment			
11.1. Three Volute Presses (2 initial, 1 phased)	$1,477,000		$738,500
11.2. Mixing equipment for new liquid sludge storage	$204,000		$36,000
11.3. New Sludge feed pump and grinder for third volute press			$91,000
11.4. Replace mixing/aeration system & add decant pumps in existing west sludge holding pond	$405,440		
11.5. Sludge feed pumps and grinders	$182,000		
11.6. Polymer feed system	$140,420	$24,780	
11.7. Replace compressor and valves		$123,000	
11.8. Polymer feed system for third volute press		$82,600	
Division 13 - Special Construction			
13.1. Controls for new equipment	$252,229	$8,590	$85,840

Item Description	Immediate Needs	Phase I	Phase II
13.2. Automate controls for centrate flow	$5,000		
13.3. Add centrate flow metering from sludge storage ponds	$10,000		
13.4. Replace failing ultrasonic level sensor in centrate tank	$3,000		
13.5. Dry cake sludge storage building			$267,000
Division 14 - Conveyance Systems			
14.1. Conveyors from volute presses to sludge load out	$135,000		$67,501
14.2. Solids load out crossover hopper and conveyor	$609,000		
14.3. Conveyor to dry cake storage building			$140,000
14.4. New Building Monorail & Hoist	$100,000		
Division 15 - Mechanical			
15.1. New Building HVAC and Plumbing	$125,000		
15.2. Sludge feed pump piping	$175,000		$87,500
Division 16 - Electrical			
16.1. New Building Electrical and Equipment MCC	$335,286	$10,738	$107,300
16.2. Replace sludge holding pond control panel	$35,000		
16.3. Replace the solids handling building standby generator and ATS		$250,000	
Subtotal - Direct Costs	**$5,680,000**	**$570,000**	**$1,670,000**
Undeveloped Design Details (25%)	$1,420,000	$140,000	$420,000
Cons. Subtotal w/Cont.	**$7,100,000**	**$710,000**	**$2,090,000**
General Conditions, Mobilization (5%)	$360,000	$40,000	$100,000
Sales Tax (Allowance) (5%)	$370,000	$40,000	$110,000
Overhead & Profit (15%)	$1,170,000	$120,000	$350,000
Bonds & Insurance (2%)	$180,000	$20,000	$50,000
Construction Subtotal	**$9,180,000**	**$930,000**	**$2,700,000**
Construction Contingency (5%)	$460,000	$50,000	$140,000
Total Construction Cost	**$9,640,000**	**$980,000**	**$2,840,000**
Engineering, Admin, Legal, Permitting (24%)	$2,310,000	$240,000	$680,000
Total Project Cost	**$11,950,000**	**$1,220,000**	**$3,460,000**

Recommended Facilities

Overview

The recommended plan includes a long-term plan of expanding the South Plant treatment technology to treat all of the flow. All of the recommended improvements involve conventional, commonly used wastewater treatment technologies. The most notable technology-based change was the evaluation of options for dewatering to improve operability and reduce cost of the sludge handling operation. The recommended Alternate A1 is consistent with the 2000 Facility Plan as this plan recommended expanding the activated sludge treatment for additional capacity with provisions for denitrification and phosphorus removal.

Anticipating that regulatory requirements will change in the future, the plan provides flexibility to incorporate future process changes such as effluent filtration or alternative methods for Class A sludge production. However, no costs are allocated in this long-term improvement program for these potential future needs.

Figure S.6 presents a simplified site plan for the proposed system improvements and Figure S.7 represents the recommended facility flow schematic.

The following sections describe recommended facilities for each unit process. In each case, the long-term recommendation is presented, followed by a listing of improvements needed to address age and condition, current capacity deficiencies, as well as effluent quality requirements dictated in the plant's current NPDES permit.

The specific improvements are designed to provide adequate capacity for the projected 20-year nominal flow of 13 MGD (peak flow of 43.5 MGD).

General Civil/Site

Civil and site improvements include the following:

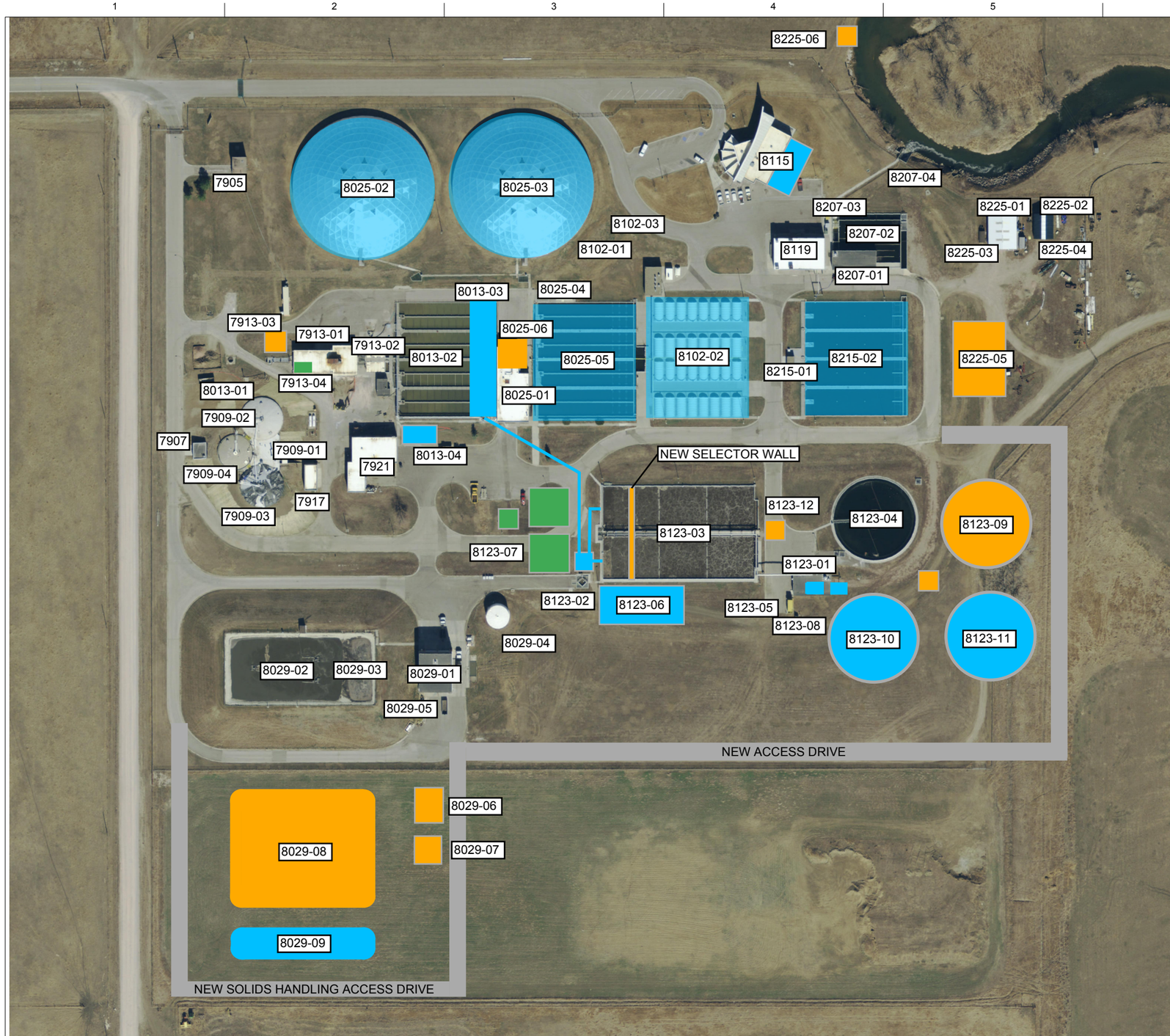
- Update main gate to provide for a remote-access security style gate.
- Mill and resurface plant access drives.
- Properly abandon water well.
- Provide Odor Control (described in more detail in later section)

Influent Sampling

Influent sampling will be modified to be flow proportional and will be removed and replaced as part of normal maintenance.

Influent Flow Metering

For influent flow metering, the long-term plan is to continue use of the current FloDar system.



KEY PLAN: WATER RECLAMATION FACILITY

Pretreatment
7913-01 PRETREATMENT BUILDING
7913-02 SEPTAGE RECEIVING
7913-03 VACTOR RECEIVING STATION
7913-04 POTENTIAL NEW SCREEN

North Fixed Film Plant
8013-01 PRIMARY SLUDGE PUMP BUILDING
8013-02 PRIMARY CLARIFIERS
8013-03 PRIMARY CLARIFIER EFFLUENT IMPROVEMENTS
8013-04 IN-PLANT PEAK FLOW PUMP STATION
8025-01 SECONDARY BUILDING
8025-02 WEST TRICKLING FILTER - REPURPOSE
8025-03 EAST TRICKLING FILTER - REPURPOSE
8025-04 GENERATOR -SECONDARY
8025-05 SECONDARY CLARIFIERS - REPURPOSE
8025-06 IMPROVEMENTS TO TRICKLING FILTER PUMP STATION
8102-01 RBC BLOWER BUILDING
8102-02 RBC's - REPURPOSE, POTENTIAL SLUDGE STORAGE
8102-03 GENERATOR - RBC's
8215-01 TERTIARY PUMP PIT
8215-02 TERTIARY CLARIFIERS - REPURPOSE, POTENTIAL SLUDGE STORAGE

South Activated Sludge Plant
8123-01 AB BLOWER / PUMP BUILDING
8123-02 ACTIVATED SLUDGE - DISTRIBUTION BOX
8123-03 ACTIVATED SLUDGE - AERATION BASINS
8123-04 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-05 GENERATOR -SOUTH PLANT ACTIVATED SLUDGE
8123-06 ACTIVATED SLUDGE - AERATION BASIN WITH SPLITTER BOX
8123-07 ANOXIC BASINS WITH SPLITTER BOX
8123-08 RAS PUMPS AND AERATION BLOWERS
8123-09 ACTIVATED SLUDGE - CLARIFFLOCULATOR WITH SPLITTER BOX
8123-10 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-11 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-12 ACTIVATED SLUDGE - EFFLUENT BOX

Disinfection
8207-01 UV DISINFECTION BUILDING
8207-02 RE-AERATION BASIN
8207-03 GENERATOR UV/ADMIN
8207-04 Outfall

Digestion
7907 GAS BLOWER BLDG
7909-01 PUMP/BOILER BLDG
7909-02 NORTH DIGESTER
7909-03 SOUTH DIGESTER
7909-04 WEST DIGESTER

Solids Handling
8029-01 SOLIDS HANDLING BUILDING
8029-02 750K WEST SLUDGE HOLDING POND
8029-03 50K EAST SLUDGE HOLDING POND
8029-04 CENTRATE STORAGE TANK
8029-05 GENERATOR SOLIDS HANDLING
8029-06 SOLIDS HANDLING BUILDING
8029-07 DEWATERD SLUDGE STORAGE
8029-08 SOLIDS HOLDING POND
8029-09 SOLIDS HOLDING POND

Other
8115 ADMINISTRATION BUILDING WITH EXPANSION
7905 WATER PLANT BUILDING
7917 OIL STORAGE
7921 WASTEWATER MAINTENANCE SHOP
8119 METAL FABRICATION SHOP
8225-01 COLD STORAGE NO. 1
8225-02 SOFT SIDED COLD STORAGE NO. 2
8225-03 WEST WOODEN STORAGE SHED
8225-04 EAST WOODEN STORAGE SHED
8225-05 COLD STORAGE
8225-06 RIVER GAUGING STATION (LOCATED UPSTREAM)

NOTE: UNITS SHOWN IN BOLD ARE PROPOSED OR MODIFIED.

KEY PLAN: FACILITY IMPROVEMENT PHASING

- IMMEDIATE NEED
- PHASE 1 IMPROVEMENTS - 2025
- PHASE 2 IMPROVEMENTS - 2035

80 0 80 160
SCALE IN FEET

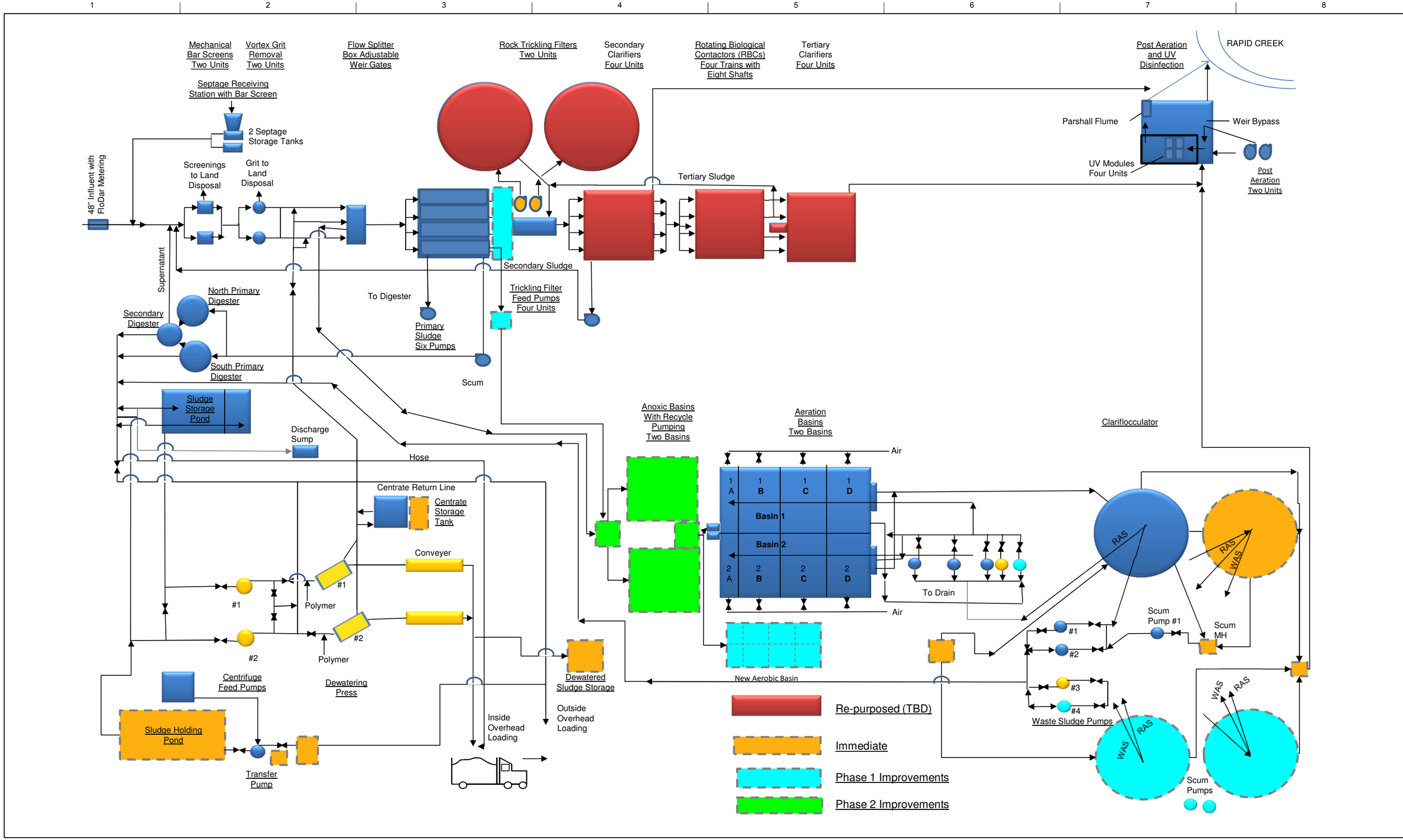
WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

RECOMMENDED ALTERNATIVE A1
MAJOR IMPROVEMENTS

0 1" 2"

FILENAME ALT A1 IMPROVEMENTS.DWG
SCALE
FIGURE S.6



ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

RECOMMENDED FACILITY FLOW SCHEMATIC

FILENAME

SCALE

FIGURE S.7

Vactor Receiving Station

The City Vactor trucks are used to clean out rocks and sediment from storm sewers and remove accumulated solids from sewage manholes and lift stations in the City's collection system.

The trucks used for cleaning lift stations often have concentrated loads of fats, oil, and grease (FOG). FOG can coat analytical probes, plug process equipment, and generally increase the maintenance requirements at treatment plants. Large rocks and debris removed from storm drainage systems can have devastating effects on pumps and screens and increase the maintenance frequency needed for downstream equipment. To avoid damaging equipment and minimize excess maintenance demands, it is recommended to separate the handling of this material from the main treatment processes. A simple and inexpensive removal system consists of a concrete drying bed, sloped to open mesh grating that drains into a shallow sand bed. Vactor trucks can dump debris directly into the drying beds. The rocks, sediment, and scum are retained on the drying bed and the liquid passes through the sand filter and then to the treatment plant processes. The sediment and scum are allowed to dry and then disposed of in a sanitary landfill. A new Vactor receiving station is recommended with the following design criteria:

- Type: Sloped Concrete Slab with sand drying bed
- Vactor Load Receiving Capacity: One
- Size (L x W x H): 20' x 20' x 5'

Septage Receiving Station

The existing septage receiving station was originally constructed by retrofitting an existing pre-aeration basin. The problems with the current system identified by haulers and WRF staff are primarily associated with the limited hours of operation, inconvenient access for large vehicles and general housekeeping issues with the open gravity dump basin and screen. Smaller rocks and gravel are not effectively removed by the current screening system thus Collections Department wastes and others with gravel components can result in unpumpable build up in storage tanks. A significant amount of operator time is needed for waste sampling, record keeping and overall monitoring, supervision, and clean-up activities.

A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility cost is contained in Appendix 5.1.A.

The long-term plan is to conduct informational meeting(s) with the local septage haulers and determine if there is a need for an improved Septage Receiving Station that can be addressed in a feasible and cost effective manner.

In the meantime, the following improvements are recommended:

- Repair immediate safety concerns including access hatch covers and fall protection.
- Include level sensor via SCADA with volume calculation to determine the amount of septage received.

Fat, Oil, and Grease (FOG) Receiving

The amount of biogas produced could be increased by feeding FOG to the anaerobic digesters. The excess biogas could then be used for cogeneration, which would reduce the electrical costs at the WRF. At an assumed typical 30% increase in biogas production from feeding FOG, an annual savings of over $80,000 in power costs could be realized. This would increase to over $293,000 in annual savings at future loading conditions. However, the cost of FOG receiving and cogeneration facilities would be approximately $6.8 million. The payback period would be over 23 years and therefore FOG receiving and cogeneration facilities are not recommended from an economic standpoint. The decision to construct FOG receiving and cogeneration facilities would be based on the City's need to provide a place for customers do dispose of FOG waste.

Pretreatment Building

Influent Screening and Disposal

The recommendation for influent screening is to:

- Renovate the bypass to include an option for an unscreened bypass complete with alarming to SCADA. This is a critical reliability issue.
- Long-term plan includes connection to the plant-wide odor control system.

The existing influent mechanically cleaned screens and compactors will continue to be serviced for long-term use.

Grit Removal

For grit removal, the long-term plan is to continue use of the current vortex grit removal system. Efficiency will be reduced at 40 MGD, but units can pass flow up to the projected 2035 peak hour. The following improvements are planned:

- Vortex grit removal equipment replacement, including paddles and drives, and coating of the tanks should be included in the 10-15 year plan.
- Raise upstream channel walls.

Primary Treatment

The existing, conventional, rectangular clarifiers will continue to be used to provide primary treatment. The primary method of phosphorus removal will be chemical precipitation, with alum fed to the wastewater flow upstream of the primary clarifiers. However, flexibility will be provided to allow future conversion to biological phosphorus removal should that become desired or cost effective. Primary sludge will continue to be withdrawn from the clarifiers in dilute form and discharged directly to anaerobic digestion. At some point, the existing clarifiers may also need to be covered, although this is not included as a near-term activity.

Required improvements for the projected 20-year nominal design flow of 13 MGD are as follows:

- Sludge Pumping improvements
    - Replace sludge pump air compressors.
    - Replace isolation valves.
- Primary Clarifiers
    - Replace sludge collector gearboxes.
    - Replace skimmers and gearboxes.
    - Provide safe access on existing tanks -replace metal railing and walkways.
    - Repair concrete walkway damage.
    - Replace the effluent trough bypass gate.
- Replace Sludge Blanket Level Detectors in Primary Clarifiers.
- Items included as part of secondary treatment alternative.
    - Build a primary effluent junction structure with pipeline from the primary effluent to discharge to an aeration basin influent splitter structure.

North Plant – Secondary Building

Improvements are planned for the following processes as follows:

- Scum Pumping
    - Install primary scum pump & repair piping to digester.
- The trickling filters and trickling filter pump station are not part of the long-term recommended improvements for the Rapid City WRF. The trickling filter process will be eliminated at Permit #2 which is estimated to by year 2025. As part of provisional improvements to maintain the process for another 10+ years before the north plant is phased out of the process scheme, trickling filter pumping recommended improvements include:
    - New pumps with VFDs to handle flow range.
    - Replace valves.
    - Repair and recoat pump discharge piping.
    - No repairs are recommended to the wetwell at this time.
- Replace secondary clarifier humus pumping and valves.
- Process Water System
    - Replace pumps and discharge check valves.
- Trickling Filters
    - Tie VFD control to pneumatically driven arms as this is expected to pay for itself in energy savings.

North Plant -Secondary Clarifiers

The sludge collector gearbox for unit Nos. 1, 3, and 4 are planned for replacement.

Rotating Biological Contactor (RBC)

The RBCs will be phased out within approximately 10 years and firm capacity is available; therefore, wholesale replacement is not recommended. The blowers, motors, and variable speed drives should continue to be maintained and replaced as required. The air piping in the basins is in poor shape and planned to be repaired as required.

Tertiary Clarifiers and Pumping

The tertiary clarifiers will be phased out within approximately 10 years; therefore, wholesale replacement is not recommended. The pumps and clarifier drives should continue to be maintained and replaced as required.

South Plant -Secondary Treatment

The process recommendation for secondary treatment is to operate new activated sludge facilities and phase out the trickling filter and RBC facilities, Alternative A1. This configuration provides the lowest-cost approach to reliably meet the pending ammonia and nutrient discharge limits. The approach also provides the best flexibility for future process modifications to achieve total nitrogen removal (denitrification), biological phosphorus removal, or both, while maintaining reliable ammonia removal. The proposed treatment is sized for and can include means for Simultaneous Nitrification and Denitrification (SND).

The aeration basin curtain should be refurbished as soon as possible. The existing diffusers and drain pumping will also be replaced in the near term.

The activated sludge process will be implemented in two modular expansions. However, at the completion of Phase 1, 100 percent of the flow will be treated through the activated sludge process.

Priority 1 required facilities prior to Phase 1:

- New clariflocculator – one new, two total.

Required facilities for Phase 1, Permit #2:

- New primary effluent junction box and flow control structure.
- New flow metering.
- New aeration basin - additional 0.9 million gallons.
- New clariflocculators – two new, four total.
- New clariflocculator influent junction box and flow control structure.
- New aeration blowers.
- New secondary effluent piping to disinfection facilities.
- RAS/WAS pumping improvements to serve four clarifiers.
- WAS piping from RAS/WAS pumping station extended to new WAS storage pond.
- Refurbish existing clariflocculator drive unit.

Required additional facilities for Phase 2, Permit #3:

- New anoxic basin splitter box and flow control structure.
- New anoxic basins complete with mixing at 0.9 million gallons.
- New recycle pumping and associated piping.

For Phase 2, the option will still be available to explore Biological Nutrient Removal for phosphorus, which is Alternative A2.

Tertiary Treatment

Tertiary treatment facilities other than disinfection are not required to meet permit conditions for conventional pollutants and nutrients. In the future, effluent limits for phosphorus may become more stringent and additional polishing steps such as effluent filtration or ballasted flocculation will be needed if the required effluent concentration drops to 0.7 mg/L or lower.

Given these potential requirements, it is recommended that the WRF treatment process be designed to allow future incorporation of a tertiary process and that adequate space be preserved for such a process in the preliminary design site planning. The appropriate type of tertiary process (if needed at all) must be determined once the specific treatment objectives have been defined.

UV Disinfection

Based on flow projections, the hydraulic capacity of the current UV disinfection is reached in year 2030. Beyond 40 MGD, it is recommended that the City revisit peak flow, bulb technology, and actual system performance. Actual system performance may improve with the selected activated sludge alternative as the existing UV system was sized for a trickling filter effluent, which has a lower transmissivity. In addition, the trend has been that flows are decreasing on a per capita basis. The potential for decreased peak flows, better quality effluent along with the continuing UV technology advancements lead to a recommendation of continued use of UV thru 2035.

Replacement of the UV effluent control gate actuators is planned with in the next 5-10 years.

On-line instrumentation including the Isco sampler, Hach pH meter, and dissolved oxygen sensors are planned for replacement as part of the normal maintenance program.

Effluent Pumping and Outfall

The plant currently discharges by gravity to Rapid Creek with no means to isolate or pump effluent. Effluent pumping capacity may be necessary to protect against flooding at the treatment plant as the 500-year flood elevation encroaches on the hydraulic profile. There has been no recorded event in the past 30-years that has impacted the ability to discharge. A number of factors will influence the design of future facilities including regulatory requirements guiding the definition of critical facilities. **Given the uncertainty regarding these factors,**

determination of long-term effluent discharge facilities should be deferred and the City should continue to monitor for final Executive Order requirements.

Two approaches to convey peak flows associated with the 2035, 43.5 MGD peak hour design condition are to 1) build a new effluent pump station 2) equalize flows during the 500-year event.

In either case, an embankment would need to be extended to protect the facility to the 500-year event. Refer to Figure S.8. With the new pump station approach, the firm capacity of the effluent pumping station will be 43.5 MGD.

Required improvements for the design condition, illustrated in Figure S.8, include:

- Outfall isolation.
- New pump station or repurpose trickling filter pump station with provision for standby power.
- Isolation berm.

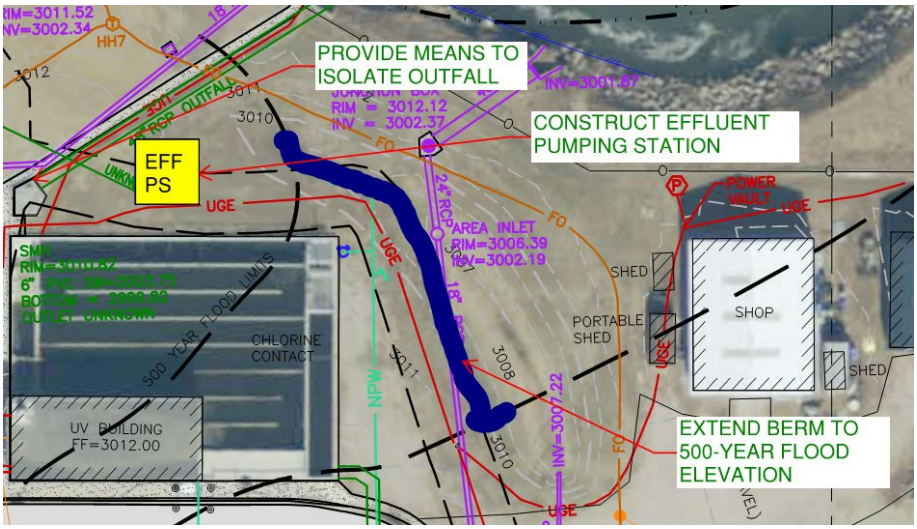


Figure S.8. 500-year Flood Protection

Sludge Digestion

For sludge stabilization, the plant should continue to use single-stage mesophilic digestion on a long-term basis, while using the subsequent composting operation to produce a Class A biosolids. Compared to other in-plant stabilization processes, this approach provides the lowest cost, least complex, easiest to operate solution.

Some near term repairs and replacements include:

- Digester roof access needs to be provided to address health and safety.
- Reinstall the waste gas flare feed piping to slope to drain.

- Remove and replace the steel portion of the boiler gas feed lines with stainless steel inside the building as they are corroded and pitted.

Additional planned replacements include:

- The sludge recirculation pumps have been recently overhauled and the expected service life is 5-10 years. The pumps should be scheduled for replacement at that time.
- The digested sludge chemical feed needs to be relocated complete with containment due to the corrosive nature of ferric chloride and the safety risks of sodium hydroxide.

Sludge Handling Facilities

The existing sludge dewatering system is failing and in need of replacement. In addition, it is recommended that additional liquid sludge storage ponds(s) be built to provide fifteen days of storage at maximum month loading between the continuously operated digestion process and the intermittently operated dewatering process. These ponds also will be equipped with new mixing.

Required improvements for the 2035 design condition include:

- New two-level solids dewatering building for housing the dewatering devices.
- New conveyors to transfer cake from the dewatering unit to the sludge load-out area, plus additional conveyors as needed for additional dewatering unit. The assumption is that each dewatering unit will have a dedicated conveyor for transfer of cake to the sludge load-out area.
- Sludge load-out conveyor to even distribution of dewatered sludge in the roll-off containers.
- New liquid polymer feed and storage system, plus additional liquid polymer feed and storage system for additional dewatering units. The assumption is that each dewatering unit would have a dedicated polymer feed system.
- New dewatering unit feed pumps, plus additional feed pumps for additional dewatering units. The assumption is that each dewatering unit would have a dedicated sludge feed pump.
- 1.5 million gallons of additional liquid sludge storage are included assuming the construction of two new lined earthen basins with new mixing and aeration equipment.
- Electrical and instrumentation costs for new equipment are estimated as a percentage of other construction costs.
- Replacement of the existing mixing/aeration equipment in the west cell of the existing sludge storage basin.
- Automation of the controls for the centrate flow; addition of a centrate flow meter; and replacement of the ultrasonic level sensor in the centrate storage tank.
- Replacement of the sludge holding pond control panel.
- Replacement of the solids handling building standby generator and automatic transfer switch (ATS).

- Dry cake storage with conveyance is included with alternatives 2A, 2B, 3A, 3B, 4A, and 4B.

The recommendation for sludge dewatering is to replace the centrifuges due to reliability and age and condition. Alternative 4B -Three Volute Presses is recommended for improvements to the solids handling facilities.

Additional investigation and pilot testing is recommended before a final decision is made on a solids dewatering alternative. Investigation and pilot testing would provide the following:

- Potential for site visits to observe the alternatives evaluation in a full-scale operation at other facilities.
- Reliability of the alternatives to consistently meet the sludge dewatering performance goals.
- Determine the ability to operate the alternatives continuously on a 24-hour basis with minimal adjustments of the polymer and operator attention.

Solids handling can be phased for maximum month 2020 and 2025, respectively as described in Table 20, Phasing Option 2.

Centrate/Supernatant Recycle Management

Compliance with the effluent limit for ammonia-nitrogen will be enhanced by improving storage for recycle flows from the sludge dewatering process and returning these flows to the liquid treatment stream during periods of low influent ammonia loading. An existing tank will continue to be used for this purpose with the following planned improvements:

- Upgraded controls and metered pumping for the recycle return system.

Materials Recycling Facility (MRF)/Co-composting

The MRF Co-composting facility equipment review was not included in the scope of this facility plan, however, improvements were reviewed that would improve both WRF and MRF Co-composting operations. The WRF delivers dewatered sludge and 12,000 to 15,000 gallons per day of unthickened sludge and or centrate to the MRF facility.

Operational improvements include:

- Approximately 50,000 gallons of liquid storage as it would be extremely beneficial to operations to provide scheduling relief for the WRF and an as-needed liquid supply for the landfill. The new tankage would allow WRF to deliver in one day and have this task complete for the week.

Costs for these improvements have not been included in the facility plan at this time.

Standby Power

The standby power planning includes provision for phased replacement of the units based on reliability, age, and condition.

Automation and Controls

The expansion alternatives include integrating the process into a uniform, plant-wide solution for automation and controls.

Administrative, Maintenance and Laboratory Facilities

Long-term requirements were reviewed for administration, laboratory, and maintenance facilities. Based on both projected staffing and limited heated garage space the following improved support facilities are recommended as part of 2025 Phase 1 improvements:

- Administration Building Addition: New 1,800 square foot expansion of both the upper and lower level, paralleling the east side of the administration building.
    - The upper level includes offices and records storage;
    - The lower level includes garage and storage space.

The pumps and control panel in the pumps station serving the building are planned for replacement.

The current operation facilities and the maintenance shop are projected to remain as is; however, a new cold storage steel building is planned for in immediate planning as follows:

- 100-foot by 60-foot steel building

Chemical Feed Facilities

The plan includes modification of the existing Oil Storage Building in the near term for storing and feeding corrosive chemicals utilized for digester pH control.

Mechanical Facilities Improvements

Planned mechanical, HVAC, and plumbing, improvements are as follows:

- Replace Maintenance Shop boiler and pump with new N+1 boiler system
- Provide ventilation system for compressor room in Primary Sludge Pump Building
- Repair/Replace roof drain piping in Digester Building
- Install permanent heater in Secondary Building restroom
- Replace unit heater in Tertiary Pump Pit
- Full renovation of Solids Handling Building Ventilation
- Replace Water Plant Building unit heater, exhaust fan and controls
- Trickling Filter Pump Room HVAC upgrade
- Replace RBC Blower Building Exhaust fans and unit heater
- Upgrade Aeration Blower Room Ventilation system/blower intakes

- Add PPU and mechanical cooling to Aeration Blower/Pump Building Electrical Room
- Replace Tertiary Pump Pit ventilation system, add dehumidifier
- Replace Primary Sludge Pump Building Ventilation System
- Replace corroded door louvers on Digester Building
- Replace old Maintenance Shop unit heaters
- Replace Maintenance Shop water heater
- Renovation of Metal Shop HVAC system
- Wall off Solids Handling electrical equipment and install PPU and mechanical cooling
- Replace AB Pump Room ventilation system
- Replace UV Building air handling unit
- Campus Wide Odor Control System
- Replace Digester boilers
- Replace Gas Blower Bldg. HVAC

Odor Control/Site Buffer

The City should develop long-term plans for the WRF site and should begin implementation of the plans as soon as possible. As surrounding properties become further developed, it will become increasingly important that the City provide an attractive visual buffer between wastewater operations and surrounding uses. The closest development will likely be to the west and potentially north. As properties become available, it may be prudent to purchase adjacent properties to buffer the site. Costs have been included as a capacity related item at 15+ years.

As growth occurs, odor control facilities should be provided for the following facilities:

- Septage/Vactor Receiving Facilities
- Pretreatment Building
- Primary Clarifiers (optional)
- Solids Handling Facilities including:
    - Sludge Storage Ponds
    - Dewatering area
    - Dewatered Storage and Loading

A plant-wide odor control system at the treatment plant would collect foul air from these process areas. The odorous air will be routed through a bio-filter bed for odor scrubbing or alternatively utilize a pre-engineered and customized packed bed odor control scrubbers and systems which utilizes hypochlorite with pH control to oxidize odorous compounds.

Planning costs have been included in Regulatory project costs for FY 2031+ totaling $800,000.

Electrical

Planned electrical improvements are as follows:

- Replace MCC-3 and any additional power panels (Maintenance Shop) along with the wooden cable pulling shed by the Maintenance Shop, possible combining into one new pre-fabricated fiberglass or concrete enclosure.
- Replace MCC-4 (located building in front of Digester Pump/Boiler Building), enlarge the building to provide adequate clearance in front of MCC-4 or possibly relocate it to the Oil Storage Building.
- Work included in Sludge Handling Project:
    - Replace the Sludge Holding Pond mixer control panel that is failing and add VFDs with turndown capability for all mixers. Possibly relocate the mixer control panel and the centrifuge control panels into their own separate, controlled space (possibly the upper level Blower Room).
    - Replace Failing Ultrasonic Level Sensor in Centrate Tank.
    - Automate controls for Centrate Flow
- Clean and inspect the three Caterpillar Standby Generation Systems (Sludge Handling, AB Blower/Pump Building and UV/Administration Building and upgrade the controls and wiring with systems enhanced for extreme use and corrosive areas (marine package), especially the generator system and near the Sludge Handling Facility and its associated ATS.
- Add air conditioning to the AB Blower/Pump Building Electrical Room to elongate the life of the ATS, VFD, MCC and control panel equipment.
- Replace the 400kW ONAN Standby Generator System that presently feeds the RBC Blower Building, Metal Fabrication Shop, and Tertiary Pump Pit. The intent would be to size the unit to be reused in another area, as these processes are not included in the long-term plan.

Longer-term items include:

- Replace MCC-2 in the Metal Fabrication Shop.
- Replace the Solids Handling Building Standby Generation System and ATS.
- Replace the Blower/Pump Building MCC-AB, dependent on how well the existing MCC holds up when air conditioning is installed to the MCC Room space. It is highly likely that this may be able to be pushed out past 15 years.
- Replace the 500kW Kohler Standby Generation System near the Secondary Building. This generator is critical as it powers the entire North side of the WRF.
- Replace Utility Company primary service cables and transformers, depending on testing and future corrosion caused by exposure.
- Replace the Pretreatment Building and UV Building MCCs.
- Replace the Caterpillar Standby generation systems installed at the AB Blower/Pump Building and the UV Building.

Instrumentation

Planned instrumentation improvements are as follows:

- Tie in site access control, Intercom and CCTV (Admin/Driveway)

- Add Septage Receiving Station volume metering
- Access Control, Intercom, CCTV and Billing Recording (New Septage Receiving Station
- Add Centrate Flow metering from Sludge Storage Ponds
- Replace Sludge Blanket Level Detectors in Primary Clarifier
- Upgrade Splitter Box Flow metering inefficiencies
- Upgrade AB SLC5 PLC Processors.

Staffing Requirements

A preliminary analysis was conducted to estimate the number of additional staff that will be required to operate and maintain the expanded plant. The first step of this analysis was to benchmark the City's current staffing for treatment functions against other publicly and privately operated wastewater utilities across the country utilizing the EPA Staffing Model. The staffing review in Chapter 1.1 provides an indication that the City is currently providing the proper number of employees as the City's staffing level matches the EPA Staffing Model.

About 45 percent (9 of 19) of WRF staff are eligible for retirement over the next 8 years.

A plan needs to be in-place to maintain trained and skilled personnel to reliably operate the WRF. Limitations in the labor force will require an on-going employee search to find and hire qualified employees in advance.

To determine future treatment staff needs, the EPA Staffing Model was used to project requirements for the projected planning year WRF employing the selected activated sludge process, and using both anaerobic digestion and dewatering. Note that the EPA Staffing Model gives a general measure of nation-wide staffing levels and the detailed breakdown of employee classifications will differ. Refer to Table S.22.

This analysis projected 24 people for a typical publicly owned utility of this size. Based on the City's current level of staffing, a staff level of 24 people would seem appropriate at year 2035. This staffing level should be built up gradually, with one additional employee added in the next couple of years and two more staff added for Phase 1 and an additional 2 staff for Phase 2.

It is recommended that the City budget for a pretreatment employee to handle the additional workload requirements for monitoring mercury best practices at dental offices. The proposed pretreatment standards apply to wastewater discharges to the WRF from offices where dentistry is performed, including institutions, permanent or temporary offices, clinics, mobile units, home offices, and facilities, including dental facilities owned and operated by federal, state, or local governments. The proposed changes to 40 CFR 403 reflect EPA's recognition that the current regulatory framework needs to be adjusted for the effective implementation and enforcement of these pretreatment requirements on the dental industry. Therefore, EPA is proposing a new classification of CIU, specifically the tailored to the proposed rule named Dental Industrial User (DIU). The extent of the impact to the WRF workload is not final and the rulemaking should continue to be monitored.

Table S.22 Rapid City WRF EPA Staffing Estimate Worksheet

Projected 2035 Nominal Daily Average Flow = 13 MGD

Unit Process	Operation (Hours/Yr.)	Maintenance (Hours/Yr.)	Supervisory & Admin. (Hours/Yr.)	Clerical (Hours/Yr.)	Laboratory (Hours/Yr.)	Yard work and Misc. (Hours/Yr.)
Screening	1416	43				
Grit Removal	803	67				
Primary Clarification	2822	553				
Activated Sludge w/ Nitrification	12,932	3,312				
Secondary Clarification	2,648	439				
Anaerobic Digestion	1056	267				
Sludge Lagoons	174	104				
Dewatering	2,000	1,175				
Disinfection	380	437				
Subtotal Hours	24231	6,397	2,728	1,169	3,587	2,621
Technology Adjustment	2,423	-640	-218	23	72	262
Total Hours / Year / Category	26,654	5,757	2,510	1,192	3,659	2,883
Workers Required / Category	14.8	3.2	1.4	0.7	2.0	1.6
Total Number of Workers Required	23.7					
Current Staffing	19					
Total Additional Workers	5					

Note: 1 worker = 1,800 hours / year

Summary of Recommendations

Table S.23 provides a summary of the preliminary recommendations to upgrade the Rapid City WRF to reliably treat the 2035 projected flows and loads. This table provides an overview of facility requirements, driving forces, urgency/timing considerations, site planning impacts and order of magnitude costs.

Table S.23. Summary of Recommendations

Priority	Treatment Component	Recommended Improvements for the Design Year	Driving Force for Improvement						Urgency/Timing	Impact on Site Planning	Cost Impact[1]
			Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	Good Neighbor			
2	Site	Repair Roads				✓			Needed within 1-5 years.		Moderate
1	Influent Screening	Renovate the bypass to include an option unscreened bypass complete with alarming to SCADA.		✓			✓		High priority – This is a critical reliability issue. Need as soon as implementable.	None	Low to Moderate
3	Grit Removal	Includes equipment replacement, including paddles and drives, and coating of the tanks.				✓			Continue to monitor condition.	None	Moderate
2	Primary Clarification	Major facilities are adequate. Replace aged equipment and improve walkways and handrails.	✓	✓					Much equipment has reached service life & failure will impact capacity. Access items are health & safety item. Scum pumping is currently not operational.	None	Low
3	Primary Effluent Flow Control	Construct new flow control structures to split flow between activated sludge basins.	✓	✓	✓		✓		Component of activated sludge system construction to meet permit limits.	Near new activated sludge basins. Coordinate with Phase 2.	Moderate
2	Clariflocculator	Build one new clariflocculator complete with appurtenant splitter box, pumps, and piping.		✓		✓	✓		Needed for reliability.	Major new facilities, but located within currently developed treatment plant area. Need to keep other clariflocculator operational.	
To meet Permit #2 and #3	Activated Sludge System (Phase 1 and 2 Improvements)	Construct new aeration basin, blowers, and clarifiers and return sludge pumping station.	✓		✓				Driven by ammonia limit. Need Phase on-line in 2025 and Phase 2 on-line in 2030 as permit schedule dictates.	New facilities would be constructed adjacent to South Plant. Major site layout impact.	High
1	Existing Activated Sludge/Trickling Filter/RBC System	Implement provisional repair of Trickling Filter Lift Station, Sec. Clarifier Gear boxes, humus pumping, aeration basin curtain, & RBC airlines.				✓	✓		High priority – This is a critical reliability issue. Need as soon as implementable.	Retrofit within existing building. No site impact.	Moderately High
3	UV Disinfection	Replace UV effluent control gate actuators			✓	✓			Needed within 5-10 years.	Retrofit within existing structures. No site impact.	Low
5	Effluent Pumping & Outfall	Add new effluent pumps to protect the facility to the 500-year event.		✓	✓				Defer and monitor for final Executive Order.	Site impact – Provide placeholder adjacent to post aeration basin.	Moderately High - TBD
n/a	Primary Sludge Thickening	None required.									
n/a	Secondary Sludge Thickening	None required.									
1	Sludge Digestion	Digester roof access. Reinstall the waste gas flare feed piping to slope to drain. .Remove and replace the steel portion of the boiler gas feed lines.				✓	✓		Roof access needs to be provided to address health and safety. Blower is currently out of service.	None	Moderate
1	Sludge Storage Pond	Build one new sludge storage pond complete with new mixing for new and existing.		✓		✓	✓		Included as part of the sludge dewatering improvements.	Major new facilities, but located within currently developed treatment plant area to south of existing Sludge Holding Pond. Need to keep other pond operational.	Moderate

Priority	Treatment Component	Recommended Improvements for the Design Year	Driving Force for Improvement						Urgency/Timing	Impact on Site Planning	Cost Impact[1]
			Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	Good Neighbor			
1	Sludge Dewatering	Install dewatering handling equipment in new building. Include new feed equipment; discharge piing and polymer feed system. Provide new dewatered sludge conveyance and storage equipment as required for the selected operating schedule.		✓		✓	✓		High priority – This is a critical hydraulic and condition reliability issue. Need as soon as implementable.	Site impact for new two-level building and dewatered sludge storage to south of existing Sludge Dewatering Building.	High
1	Centrate Storage	Improve usability of existing tankage.	✓		✓		✓		Included as part of the sludge dewatering improvements.	Continued use of existing tankage. No site impact.	Low
5	Odor Control	Construct odor control facilities for odor-related areas. Tie to odor sources and to construct new facilities.						✓	No timetable set – driven by neighboring growth.	Depends on technology selected.	Moderate
To meet Permit #2	Administration Facilities	New facilities needed for recommended staffing requirements. Heated garage are required due to lack of useable space on-site.	✓	✓			✓		Implement Phase 1 expansion.	If constructed, new facilities will be located east of the existing Administration Building.	Moderate
To meet Permit #2	Maintenance Facilities	New cold storage facility recommended. Heated garage included in Administration Building Addition.					✓		No timetable set. Currently majority of service equipment remains outside.	If constructed, new facilities will be located south of the existing cold storage building.	Moderate
n/a	Laboratory	No new facilities needed –space is adequate.							No timetable set.	No impact.	None
3,4	Treatment Plant Landscaping & Buffer	Establish landscape buffers and berms at perimeter of property.						✓	No timetable set. Desirable to establish perimeter landscaping as part of early projects.	Need to landscape interim and final property boundaries to create buffers.	Moderate
2	Compost Facility	Provide liquid sludge storage, which is used for blending.					✓		As soon as possible -extremely beneficial to operations' for both WRF and MRF Co-composting.	Not reviewed.	Low
2	HVAC Improvements	Replace bulk of HVAC equipment.							Much equipment has reached service life & failure will impact processes.	No impact.	Moderate

Cost Impact Legend
High: Over $3 million
Moderately High: $1 to $3 million
Moderate: $0.1 to $1 million
Low: Less than $0.1 million.
None: No cost anticipated for planning year

The costs are incorporated into Table S.24 and footnoted accordingly. Table S.24 includes the recommended projects for Secondary Treatment and Solids Handling Improvements, which include elements that are age and condition, operational and energy, and capacity related. The solids handling improvements will be further refined in a future study which will include pilot testing and further equipment reference review to finalize the process equipment selection.

Table S.24. Preliminary Capital Improvements Plan

Driving Force		Fiscal Years							Total
		FY 2016-2020		FY 2021-2025		FY 2026-2030		FY 2031+	
		Priority 1	Priority 2	Required to meet Permit No. 2	Priority 3	Required to meet Permit No. 3	Priority 4	Priority 5	
Capacity, Age & Condition	Activated Sludge Improvements	$4,014,000							$4,014,000
	Trickling Filter Pump Sta. Improvements	$2,410,000							$2,410,000
	Sludge Handling Improvements	$11,950,000			$1,220,000		$3,460,000		$16,630,000
	Misc. Improvements	$256,000	$3,790,000		$1,860,000		$400,000	$2,290,000	$8,596,000
	Age & Condition Total	$18,630,000	$3,790,000		$3,080,000		$3,860,000	$2,290,000	$31,650,000
Operation & Energy	Operation	$120,000	$300,000		$290,000				$710,000
	Energy	$470,000							$470,000
	Operation & Energy Total	$590,000	$300,000		$290,000				$1,180,000
Regulatory				$20,570,000		$7,800,000		$800,000	$29,170,000
Period Totals		$19,220,000	$4,090,000	$20,570,000	$3,370,000	$7,800,000	$3,860,000	$3,090,000	$62,000,000

Notes: All costs are reported in 2015 Dollars and include construction and engineering.
1. Priority 1 Age and Condition includes Sludge Handling Project, which is also driven by capacity
3. Priority 1 Operation and Energy includes energy conservation measures #s 4, 5, and 11.
4. Priority 1 Capacity limitation includes AB Curtain Wall (Anoxic Basin)
5. Capacity limitations are included in Regulatory project costs.
6. Odor Control is included in Regulatory project costs for FY 2031+ at $800,000.

Table S.25 provides a summary of the preliminary recommendations to upgrade the Rapid City WRF to reliably meet the new permit conditions. This table provides an overview of facility requirements, driving forces, urgency/timing considerations, and order of magnitude costs.

The summary of recommendation has been separated into the following categories:

Short-Term Capital Improvements

- These are improvements required to reliably continue to treat the flow to meet the current permit. Short-term improvements are anticipated to be implemented within the next five years. These improvements address items such as treatment and hydraulic capacity items, reliability, operations and energy minimization. Priority 1 items are recommended to be completed in 2016 – 2018, and Priority 2 items completed by 2020.

Plant Modifications to meet 2025 Permit #2

- These are improvements that will be necessary to meet the federally adopted ammonia criteria. These ammonia limits will be included in a future permit anticipated by 2025. These improvements primarily address treatment capacity upgrades.

Plant Modifications to meet 2030 Permit #3

- These are improvements that will be necessary to meet future nutrient criteria limit of 10 mg/l TN and 1 mg/L phosphorus. These limits are planned for 2030; however these limits are the most uncertain with respect to schedule and numeric criteria. These improvements primarily focus on an expanded activated sludge system.

Plant Modifications to meet Other Needs

- These are improvements that are necessary to continue to meet the needs for the City of Rapid City to operate effectively and meet the effluent permit limits. These items have been given Priority 3 or 4 designations. Priority 3 items are planned to be completed in 2020 – 2025 and Priority 4 and items are planned for completion in 2025 – 2035.

The long term recommended improvements and ultimately the capital improvements plan envisions the following:

1. No change in regulatory standards for ammonia or nutrients thru Permit #2 (2025); the existing North Plant would be maintained in service with relatively major provisional improvements to trickling filter pumping and RBC aeration.
2. More stringent permit in 2025 in response to Permit #2 ammonia criteria with no change in nutrient regulatory standards. At this point, the North plant would no longer be part of the treatment process. The South Plant would need to be constructed by 2025 and will treat the entire flow to comply with promulgated ammonia standards. The North plant structures would be re-purposed as part of the predesign process to the extent possible.

3. More stringent nutrient control standards are expected for Permit #3 (2030) and nutrient removal improvements including the anoxic basins and anoxic recycle would need to be constructed by 2030 to meet promulgated nutrient control standards.
4. Solids handling improvements are recommended as an immediate need. Alternative 4B: Three Volute Presses, is included in the Rapid City WRF Capital Improvements Plan. A phased approach is provided to add additional units concurrent with Permit #2 (2025) liquid process train improvements.
5. The trickling filter pump station will be improved to provide service through Permit #2 issuance.

Table S.25. Summary of Recommendations

Component	Recommended Improvements	Implementation Date	Project Cost
Short-Term Capital Improvements			
Priority 1			
Activated Sludge Improvements	One new clariflocculator, curtain wall, drain pump	Priority 1 - 2016-2018	$4,014,000
Trickling Filter Pump Sta. Improvements	New pumps with VFDs to handle flow range, repair, and recoat pump discharge piping.	Priority 1 - 2016-2018	$2,410,000
Sludge Handling Project	Provide new dewatered sludge conveyance and storage equipment.	Priority 1 - 2016-2018	$11,950,000
Misc. Preliminary Treatment Improvements	Screening bypass, septage safety and volume, misc.	Priority 1 - 2016-2019	$150,000
Misc. Digester Improvements	Roof access, chemical feed, and waste gas improvements.	Priority 1 - 2016-2018	$106,000
Operations and Energy Improvement	Emergency operating plan, risk based SCADA and alarms and energy conservation measures	Priority 1 - 2016-2018	$590,000
	Priority 1 Subtotal		**$19,180,000**
Priority 2			
Site work	Roadways, plant access, Gaging Station, water well abandon	Priority 2 - 2018-2020	$434,000
Primary Treatment	Scum pumps & piping, skimmers and gearboxes, sludge level sensors, pumping room HVAC, railing, and misc. tuck-pointing.	Priority 2 - 2018-2020	$696,000
Secondary Clarification	Humus pumps, gear boxes, and clarifier railing	Priority 2 - 2018-2020	$264,000
RBCs and Generator	Repair RBC in-tank air piping, replace generator, HVAC	Priority 2 - 2018-2020	$311,000
Tertiary Clarifiers and Pumping	Costs to Maintain existing pumps, drives and HVAC	Priority 2 - 2018-2020	$60,000
Activated Sludge Improvements	Splitter box gate actuators, Blower intakes/HVAC, generator controls and misc. architectural	Priority 2 - 2018-2020	$156,000
UV Disinfection/Post Aeration Improvements	Generator controls and misc. architectural	Priority 2 - 2018-2020	$31,000
Digestion Area Improvements	Replace steel gas lines, boiler controls, electric modifications and misc. vac and architectural	Priority 2 - 2018-2020	$178,000
HVAC Improvements	Upgrade Secondary Building, Water Building, Maintenance Shop, and Metals Shop HVAC.	Priority 2 - 2018-2020	$624,000
Instrumentation, Electrical and Misc. Improvements	Maintenance Shop MCC, Integration of PLCs, and Samplers	Priority 2 - 2018-2020	$321,000
Cold Storage Building and Misc. Architectural	Construct new cold storage building.	Priority 2 - 2018-2020	$715,000

Component	Recommended Improvements	Implementation	Project Cost
Operations and Energy Improvement	Equipment Asset Management Software Updates (EAM), O&M Manual, SCADA Integration Plan i.e. smart drive monitoring.	Priority 1 - 2016-2018	$300,000
		Priority 2 Subtotal	**$4,092,000**
Plant Modifications - 2025 Permit			
Activated Sludge System (Phase 1 Improvements)	Construct new aeration basin, blowers (2), and secondary clariflocculators and return sludge pumping station.	2025	**$20,570,000**
Plant Modifications - 2030 Permit			
Activated Sludge System (Phase 2 Improvements)	Anoxic basins, recycle pumping	2035	**$7,800,000**
Plant Modifications - Other Needs			
Priority 3			
Sludge Handling Project	Provide Phased sludge conveyance and storage.	Priority 3	$1,220,000
Process	Includes equipment replacement, including paddles and drives, and coating of the tanks.	Priority 3	$647,000
Architectural	Administration Facilities Expansion - Building addition & site improvements	Priority 3	$990,000
Structural			$5,000
HVAC Improvements	AB Pump Room, UV Building, Secondary standby generator	Priority 3	$37,500
Electrical, Instrumentation, and Misc. Improvements	Remote monitoring capabilities, CMMS replacement, on-line metering capabilities	Priority 3	$185,000
Operation & Energy Total	SCADA/Remote Operations & Computerized Maintenance Management Software (CMMS) & On-line Monitoring	Priority 3	$290,000
	Priority 3 Subtotal		**$3,370,000**
Priority 4			
Sludge Handling Improvement	Phase 2 Sludge Handling Improvements	Priority 4	$3,460,000
Process	Miscellaneous process equipment replacement	Priority 4	$400,000
	Priority 4 Subtotal		**$3,860,000**
Priority 5			
Process Upgrades	Screen gear boxes, replace MCCs, grit classifier, gas flare and misc.	Priority 5	$657,000
HVAC Improvements	Replace digester boilers	Priority 5	$435,000
Electrical, Instrumentation, and Misc. Improvements		Priority 5	$1,202,000
Odor Control	Construct odor control facilities for odor-related areas. Tie to odor sources.	Priority 5	$800,000
	Priority 5 Subtotal		**$3,090,000**
Total			**$62,000,000**

Consequences of Inaction

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

- Non-compliance with discharge permit requirements
- Raw sewage spills, and associated public health impacts
- Water quality impairment of Rapid Creek
- Inability to handle wastewater generated by the community

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

Chapter 1.1 Operations and Physical Condition Assessments

1.1.1 Introduction

1.1.1.1 General

The operations and physical condition assessments are one of the initial tasks of the long-range facility planning efforts performed by the HDR/AE_2S evaluation team. These assessments helped determine the needs and timing for repair or replacement of existing facility components in the development of the long-range plans of the facility. Interviews and site visits with Rapid City WRF staff were conducted on May 27–29 and June 16–18, 2015, and are the basis for the operations and physical condition assessments.

The operations assessment was conducted by an operations specialist and focused on how the existing facility is being operated and maintained, including items such as the following:

- Current operations responsibilities and protocols
- Operational modes
- Side-streams
- Instrumentation
- Reliability issues
- Possible flexibility improvements
- Maintenance responsibilities and protocols
- Maintenance issues

The physical condition assessments were conducted by individuals with expertise in process equipment, architecture, structural engineering, mechanical engineering, electrical engineering, and instrumentation engineering. These assessments focused on the physical condition of the existing facility as a basis for estimating the remaining useful life of its components. The physical condition assessment focused on the following:

- Reliability issues
- Maintenance issues
- Condition evaluation
- Remaining useful life
- Failure mode

1.1.1.2 WRF Flow Scheme

Flow enters the WRF through a 48-inch-diameter interceptor sewer which carries wastewater to the plant, where flow is measured by a Hach Flo-Dar which is a digital Doppler radar velocity-

sensing technology, along with ultrasonic level-sensing. Influent wastewater is then received at the headworks, where it undergoes the following:

- Fine screening
- Vortex grit removal

Following grit removal, flow is split between the original fixed film system and the activated sludge system. The fixed film system includes the following:

- Primary clarification
- Trickling filter pumping
- Trickling filters
- Secondary clarification
- Rotating biological contactors
- Tertiary clarification

The activated sludge system receives screened and degritted influent without primary clarification and includes the following:

- Extended aeration activated sludge
- Clariflocculator

Effluent from the two plants is recombined and flows to the following:

- Post aeration
- UV disinfection (seasonal)

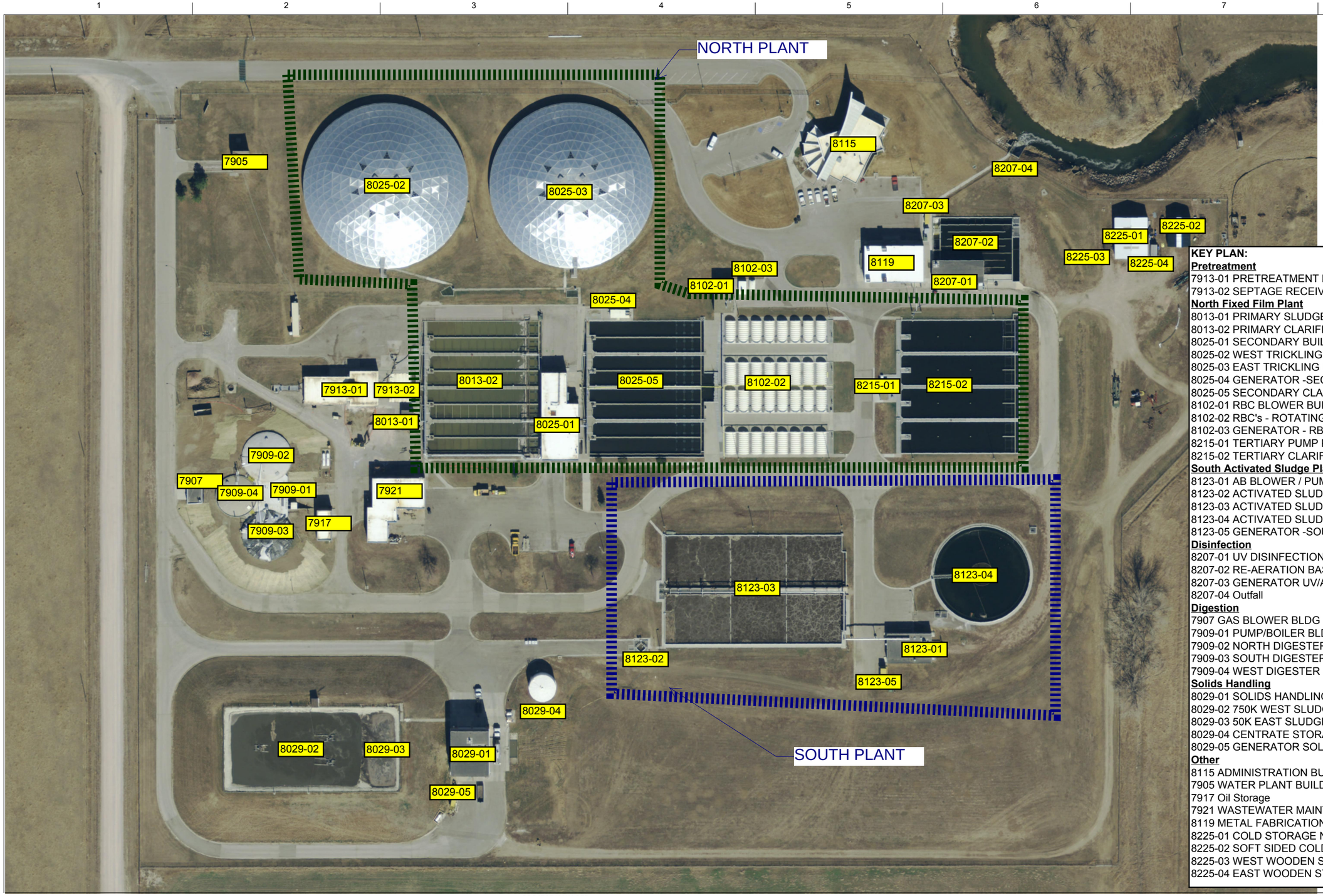
Then the effluent is further aerated via cascade aeration steps and discharged to Rapid Creek. Solids from the fixed film plant are processed by the following:

- Anaerobic digestion
- Sludge storage lagoon

Waste activated sludge is pumped directly to the Sludge Storage Lagoon. Following the Sludge Storage Lagoon, sludge is further processed by centrifuges as follows:

- Sludge thickening (to co-compost)
- Sludge dewatering (to landfill)

Figure 1.1.1 is a generalized site plan of the treatment plant structures with building numbers which will be used throughout this chapter. This figure can be referenced throughout as an aid to locate and identify the respective facilities.



KEY PLAN:

Pretreatment
7913-01 PRETREATMENT BUILDING
7913-02 SEPTAGE RECEIVING

North Fixed Film Plant
8013-01 PRIMARY SLUDGE PUMP BUILDING
8013-02 PRIMARY CLARIFIERS
8025-01 SECONDARY BUILDING
8025-02 WEST TRICKLING FILTER
8025-03 EAST TRICKLING FILTER
8025-04 GENERATOR -SECONDARY
8025-05 SECONDARY CLARIFIERS
8102-01 RBC BLOWER BUILDING
8102-02 RBC's - ROTATING BIOLOGICAL CONTACTORS
8102-03 GENERATOR - RBC's
8215-01 TERTIARY PUMP PIT
8215-02 TERTIARY CLARIFIERS

South Activated Sludge Plant
8123-01 AB BLOWER / PUMP BUILDING
8123-02 ACTIVATED SLUDGE - DISTRIBUTION BOX
8123-03 ACTIVATED SLUDGE - AERATION BASINS
8123-04 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-05 GENERATOR -SOUTH PLANT ACTIVATED SLUDGE

Disinfection
8207-01 UV DISINFECTION BUILDING
8207-02 RE-AERATION BASIN
8207-03 GENERATOR UV/ADMIN
8207-04 Outfall

Digestion
7907 GAS BLOWER BLDG
7909-01 PUMP/BOILER BLDG
7909-02 NORTH DIGESTER
7909-03 SOUTH DIGESTER
7909-04 WEST DIGESTER

Solids Handling
8029-01 SOLIDS HANDLING BUILDING
8029-02 750K WEST SLUDGE HOLDING POND
8029-03 50K EAST SLUDGE HOLDING POND
8029-04 CENTRATE STORAGE TANK
8029-05 GENERATOR SOLIDS HANDLING

Other
8115 ADMINISTRATION BUILDING
7905 WATER PLANT BUILDING
7917 Oil Storage
7921 WASTEWATER MAINTENANCE SHOP
8119 METAL FABRICATION SHOP
8225-01 COLD STORAGE NO. 1
8225-02 SOFT SIDED COLD STORAGE NO. 2
8225-03 WEST WOODEN STORAGE SHED
8225-04 EAST WOODEN STORAGE SHED

ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

WATER RECLAMATION FACILITY

FACILITY PLAN

RAPID CITY, SOUTH DAKOTA

2015

WRF KEY PLAN

FILENAME

SCALE

FIGURE 1.1.1

1.1.1.3 Current Operation

The existing Rapid City WRF treatment process and typical operations sequence for each portion of the WRF are described in the following sections.

PRETREATMENT OPERATION

Influent wastewater entering the plant is metered in a manhole directly upstream of the Pretreatment Building and screened in the Pretreatment Building. Two mechanically cleaned fine screens with ¼-inch bar spacing operate automatically based on the differential level through the screens. Screenings are discharged to a screenings trough, which transfers the screenings to two screening washers/compactors. The washed and compacted screenings are discharged to a roll-off dumpster.

Bypass channels with manually cleaned bar screens are located adjacent to the mechanically cleaned screens. The bypass channels are intended to be used if the mechanical screens are out of service or are not keeping up with the incoming flow.

The screened wastewater enters two ¾-horsepower (HP) vortex grit removal units. The grit removed from each unit is pumped to a grit classifier. The grit classifier discharges the grit into the roll-off dumpster with the screenings. Grit and screenings are periodically removed from the building and disposed of at the municipal landfill.

Effluent from the grit units flows to either the North Fixed Film Plant or the South Activated Sludge Plant. Weir gates downstream of the grit units are lowered to allow a portion of the wastewater to flow to the South Plant, and the weir gates are raised to decrease or stop flow to the South Plant. All wastewater not directed to the South Plant enters the North Plant for treatment.

The Pretreatment Building also contains two septage receiving tanks. Septage is screened through coarse bar screens, stored in the receiving tanks, and then pumped to the head of the plant for treatment. The septage flow rate is currently not monitored.

SOUTH ACTIVATED SLUDGE PLANT OPERATION

A 48-inch-diameter pipe conveys wastewater from the Pretreatment Building to the aeration basin splitter box. Motorized gates in the splitter box regulate the amount of flow to the South Plant and to two aeration basin trains (basins 1 and 2). The motorized gates are controlled automatically, and the flow to the South Plant is measured by an ultrasonic level transducer located over the weir gates.

Each aeration basin is divided into four cells: the Selector Channel and cells A, B, and C. Each cell contains fine bubble diffusers that can be individually controlled for dissolved oxygen (DO) concentration. In each aeration basin train, the selector channel cell is separated from cell A by movable curtains. Currently, the curtains limit the flow into the aeration basins to 4 MGD.

Three 300 HP centrifugal blowers, located in the AB Blower/Pump Building, supply air to the fine bubble diffusers in the aeration basins. The South Plant aeration system has the capability to operate under automatic DO control in addition to blower header pressure control (inlet valve control of blower output). However, both control loops are deactivated, and the system is run in manual.

Concrete effluent channels at the end of each aeration basin train collect the flow. A 48-inch-diameter pipe connected to the aeration basin effluent channel conveys flow to a 110-foot-diameter clariflocculator. Activated sludge settles to the bottom of the clariflocculator, and clarified water flows over the effluent weir to the effluent launder. The effluent launder empties into an effluent box. A 48-inch-diameter pipe conveys flow from the effluent box to the UV Disinfection Building. The flow can be directed to the selector zone, or it can be step-fed to the selector zone and Zones A and B by the use of downward opening gates.

Return activated sludge (RAS) is drawn off the bottom of the clariflocculator and transferred by gravity to the return sludge well at the center of the clariflocculator. The RAS flow rate can be adjusted by using tubular telescopic valves. RAS flows from the sludge well through an 18-inch-diameter pipe to the AB Blower/Pump Building. Three 20 HP screw centrifugal RAS pumps are used to convey RAS back to the aeration basins. The RAS flow rate is measured by a magnetic flow meter in the RAS pump discharge pipe.

Waste activated sludge (WAS) is pushed to the WAS sludge pit at the center of the clariflocculator by metal squeegee blades attached to the truss sweep. A 6-inch-diameter pipe connects the WAS sludge pit to the AB Blower/Pump Building. Two air diaphragm WAS pumps then transfer the WAS to sludge holding lagoons.

Scum is collected from the top of the clariflocculator by a surface scum skimmer. The scum is collected in a scum pit and then flows by gravity to the AB Blower/Pump Building, where a 5 HP non-clog pump transfers it to the sludge holding lagoons.

NORTH FIXED FILM PLANT OPERATION

All wastewater that is not diverted to the South Plant flows to the North Plant. The first process in the North Plant is conducted by the primary clarifiers. Four, 140-foot-long by 40-foot-wide rectangular primary clarifiers are used to settle solids out of the wastewater. Each clarifier has its own influent channel, and flow is controlled to each basin by adjustable plates at the outlet of each influent channel. Clarified water flows over V-notch weirs and into effluent launders. The effluent launders transfer flow to the effluent channel, which conveys the primary clarifier effluent to the Trickling Filter Pump Station in the Operations Building. Scum is collected off the top of the primary clarifiers. Primary scum was originally transferred to the primary digesters by three 3 HP piston pumps that are not currently operational. Instead, sludge is pumped with the Vactor truck and transferred to the secondary clariflocculator scum box which then is pumped to the sludge storage pond.

Longitudinal sludge scrapers push settled primary clarifier sludge to sumps on the inlet side of the clarifiers. A chain and flight cross collector transfers sludge to one end of the sump for feed

to sludge pumps where it is removed through a pipe by six (two on standby) air diaphragm primary sludge pumps located in the North Sludge Pump Pit. Air is supplied to the pumps by two 15 HP air compressors. The primary sludge pumps transfer primary sludge to the primary anaerobic digesters.

Currently three vertical turbine pumps with one on standby in the Trickling Filter Pump Station transfer wastewater to two 200-foot-diameter trickling filters. Air flow is induced though the trickling filters media by natural draft. Effluent from the trickling filters flows to a recirculation pit adjacent to the trickling filter wetwell. The recirculation pit is a concrete cell with openings that allow some of the flow to go back to the Trickling Filter Pump Station wetwell to be recycled back to the trickling filters. This recycle flow allows for proper media-wetting and biofilm thickness control. The remainder of the trickling filter effluent flow travels through openings in the recirculation pit to the secondary clarifiers.

The four secondary clarifiers are identical in size to the primary clarifiers. Secondary sludge settles to the bottom of the clarifiers, and the clarified water flows over V-notch weirs into launders and then into the secondary clarifier effluent channel.

The secondary clarifiers have longitudinal sludge scrapers that push the settled secondary sludge to a sump at the influent end of the clarifiers. Chain-driven, fiberglass cross collectors serve to transfer the secondary sludge to the sumps. The sludge is then returned to the Pretreatment Building to be removed by the primary clarifiers.

From the secondary clarifier effluent channel, flow enters the rotating biological contactors (RBCs). There are four banks of RBCs, each with eight units. The RBCs are air-driven units, with the air being provided by four rotary lobe positive displacement blowers.

After traveling through the RBCs, the flow enters the four tertiary clarifiers. The sludge removal and collection mechanisms are similar to the secondary clarifiers. Tertiary sludge is returned to a trickling filter effluent box by five centrifugal 5 HP humus pumps. There, the humus mixes with trickling filter effluent before flowing to the Trickling Filter Pump Station recirculation pit. The clarified tertiary effluent flows over V-notch weirs into launders and then into concrete effluent channels. A 48-inch-diameter pipe conveys the tertiary clarifier effluent from the effluent channels to the UV Disinfection Building.

DISINFECTION AND POST AERATION OPERATION

The North Plant and South Plant flows combine in a concrete channel upstream of the Ultraviolet Disinfection (UV) Building. The flow travels over a series of post aeration diffusers in the bottom of the channel. Air from the diffusers increases dissolved oxygen (DO) concentration of the effluent flow. The flow then travels through two parallel Trojan Signa UV units for disinfection. The intensity of UV disinfection applied to the water varies based on plant flow and the UV transmittance of the effluent.

Effluent flow measurement is achieved by a Parshall flume, located downstream of the UV units. Downstream of the flume, the flow travels through a 48-inch-diameter pipe and then down a cascade aerator to final discharge in Rapid Creek.

SOLIDS HANDLING OPERATION

The solids handling process at the Rapid City WRF consists of anaerobic digestion, centrifugal sludge dewatering/thickening, a sludge holding tank, sludge holding ponds, and pumping.

Primary sludge is pumped to two 60-foot-diameter anaerobic digesters. Primary digested sludge flows by gravity to a 50-foot diameter secondary anaerobic digester.

Two 5 HP chopper pumps are used to circulate sludge from the primary digesters, through spiral heat exchangers, and back to the digesters to maintain the desired temperature. Two boilers provide heated water for the heat exchangers. Digester gas is used as the fuel source for the boilers, with propane as a backup source.

The two primary digesters and secondary digester are mixed using a gas mixing system. Positive displacement blowers are used to recirculate digester gas through the mixing system.

Two 7.5 HP rotary lobe pumps transfer digested sludge from the digesters to the 800,000-gallon raised berm sludge storage reservoir. Three 25 HP Aero2 Triton mixers/aerators run continuously to keep the sludge in the reservoir completely mixed. The digested sludge in the reservoir has a solids concentration of 2 to 3 percent. A portion of the sludge is thickened to approximately 6 percent solids and hauled off site to Rapid City's Materials Recovery Facility (MRF) for use in co-composting. The rest of the sludge is thickened to approximately 25 percent solids and disposed of in the municipal landfill. Thickened sludge may be stored in a 13,000-gallon holding tank. From the holding tank, the thickened sludge is eventually transferred to the haul truck by a transfer pump.

Digested sludge thickening is achieved by two centrifuges. Each centrifuge has a 25 HP back drive and a 100 HP bowl drive. Sludge is fed into the centrifuges by two 20 HP feed pumps. The concentration of the thickened sludge is adjusted by changing the polymer feed rate and centrifuge speed.

The original flow scheme was to store centrifuge centrate in the 10,000-gallon storage tank and evenly meter it back to the Pretreatment Building for treatment. Due to the limited hydraulic head and flat slope on the return line, the line regularly plugged. Consequently, centrate is returned just downstream of the grit units.

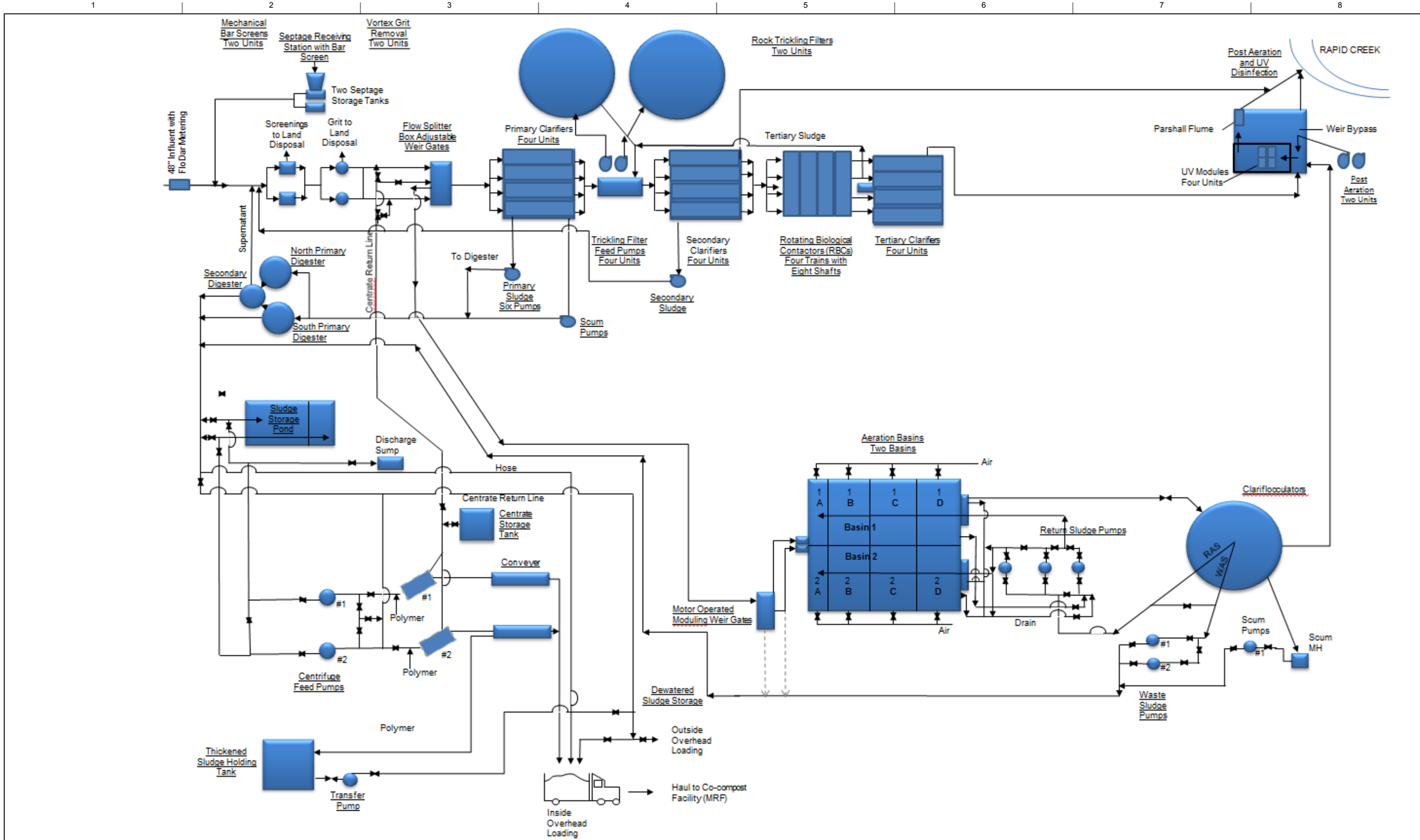
SUPPORT SYSTEMS

Nonpotable water is available throughout the WRF. Three 15 HP vertical multistage pumps draw process water from either the South Plant clariflocculator effluent box or the North Plant secondary clarifier effluent. Nonpotable water is disinfected with sodium hypochlorite and transferred nonpotable water is filtered through an automatic back wash filter throughout the

WRF. Variable speed drives on the nonpotable water pumps are Gould's Aquavar smart drives, which maintain system pressure.

The WRF facility is controlled by a supervisory control and data acquisition (SCADA) system, which has recently undergone significant improvements.

Figure 1.1.2 is a simplified flow schematic of the WRF liquid and solids treatment processes.



ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

PRELIMINARY
NOT FOR CONSTRUCTION

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

SCHEMATIC OF WRF TREATMENT PROCESS

FILENAME
SCALE

FIGURE
1.1.2

1.1.1.4 Sampling

Regulatory compliance for the facility is governed by a permit issued under the National Pollution Discharge Elimination System (NPDES). Sampling of effluent wastewater for NPDES compliance is accomplished with an automatic composite sampler just upstream of UV Disinfection. Fecal and E Coli grab samples are taken on a daily basis just upstream of the effluent Parshall Flume from the combined flow from the UV disinfection process.

Influent and effluent 24-hour composite samples are collected on a daily basis. Both the influent and effluent samplers have been reprogrammed to provide flow proportional sampling.

Additional sampling is conducted to provide WRF process control. Process sampling is performed by automatic samplers at the following locations:

- Combined Flow -North and South Plants
    - Raw Influent
- North Plant
    - Primary Clarifier Effluent
    - West Trickling Filter Effluent
    - East Trickling Filter Effluent
    - Secondary Clarifier Influent
    - Secondary Clarifier Effluent
    - RBC Bank No. 3 Effluent
    - Tertiary Clarifier Effluent
- South Plant
    - Clariflocculator Effluent
- Combined Flow -North and South Plants
    - Disinfection Influent

Of the automated sampling points listed above, the raw influent and disinfection influent stations are sampled 7 days per week including holidays. All of the other sampling points are tested 5 days per week except holidays.

All 10 of the automatically collected samples are tested for Total Suspended Solids (TSS), biochemical oxygen demand (BOD), and ammonia-N. In addition to these samples, the primary clarifier effluent, secondary clarifier effluent, and the RBC Bank No. 3 effluent samples are analyzed for soluble BOD.

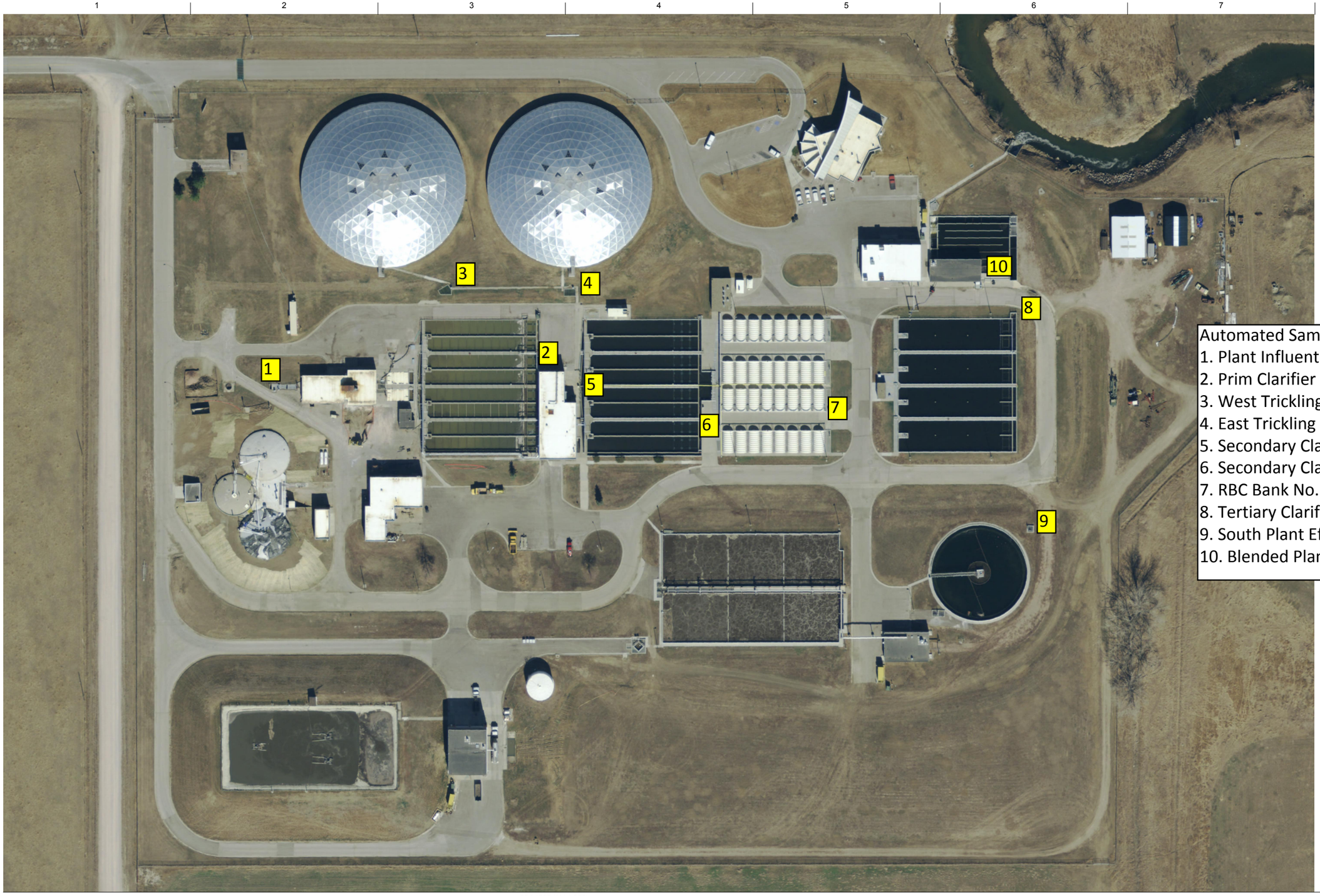
Primary clarifier influent parameters (TSS and BOD) are calculated based on samples collected at the plant influent and the secondary clarifier return flow (secondary clarifier influent values minus secondary clarifier effluent values).

Grab samples are collected from the following locations at the noted frequency:

- Primary clarifier sludge: The primary clarifier sludge is sampled 1 day per week. The sludge is analyzed for total solids and total volatile suspended solids.
- Activated sludge: Activated sludge samples are collected 7 days per week. On 5 of the 7 days, the samples are tested for TSS, volatile suspended solids, and sludge volume index. A settleometer test is conducted on the activated sludge 7 days per week.
- RAS and WAS flow: RAS and WAS flows are tested for TSS 5 days per week, and they are tested for volatile TSS 1 day per week.
- Digester sludge: The digested sludge is sampled 1 day per week and tested for total solids, volatile solids, carbon dioxide, volatile acids, alkalinity, and pH.
- Centrifuge feed, centrate, and product: Samples are collected on the centrifuge feed, product, and centrate streams. The samples are collected 5 days per week and are analyzed for total solids and TSS.

Current sampling equipment is incapable of producing alarm messages that can be monitored by SCADA.

Figure 1.1.3 identifies the locations of the automated sampling locations at the Rapid City WRF.



N

80 0 80 160
SCALE IN FEET

Automated Sampler Locations
1. Plant Influent
2. Prim Clarifier Effluent
3. West Trickling Filter Effluent
4. East Trickling Filter Effluent
5. Secondary Clarifier Influent
6. Secondary Clarifier Effluent
7. RBC Bank No. 3 Effluent
8. Tertiary Clarifier Effluent
9. South Plant Effluent
10. Blended Plant Effluent

HDR

ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

RAPID CITY INCORPORATED 1882 SOUTH DAKOTA
2015

AUTOMATED SAMPLER LOCATIONS

0 1" 2"
FILENAME
SCALE

FIGURE
1.1.3

1.1.2 Assessments

An extensive process review was conducted for the existing Rapid City WRF by a team consisting of civil, process, architectural, structural, mechanical, electrical, and instrumentation and controls engineers.

The asset evaluation was conducted to determine the condition and remaining useful life of the facility equipment and components. Based on the findings of this assessment the estimated expenditure and prioritized scheduling for repair, replacement or upgrade of the equipment and components was determined. In addition, based on the corresponding hydraulic and treatment capacity and the efficiency and capabilities of each unit was determined and summarized. The team assessed the site/civil, unit process equipment, structures and electrical components throughout the facility and summarized reliability, maintenance issues, condition, remaining useful life and critical failure modes. The result of the asset evaluation and capacity evaluation is a prioritized capital improvements plan sorted by type of need i.e. age and condition, organic capacity or hydraulic capacity.

This on-site evaluation and operations and maintenance staff interviews were conducted on May 27–29 and June 16–18, 2015. The documentation of the visual observations and interviews are included in Appendix 1.1.A.

The following sections organize the evaluation of the treatment facility by the associated area or building (if applicable) and include a description, condition and operational issues, and results of the evaluation.

1.1.2.1 Process – Condition and Operations

GENERAL CIVIL/SITE

Access Roads

The roads were evaluated as follows:

- The drives are in poor condition, with extensive cracking and miscellaneous drainage issues.
- The drainage is poor south of administration building garage areas and needs to be regraded.
- The biosolids and septage outdoor load-out areas require curb replacement.
- Minor sidewalk repair is required at aeration basin exterior walk areas.

It is recommended to mill and resurface plant access drives.

Access Gates

The main access gate #1 should be removed and replaced with a remote-access, upward swing security gate.

In general, the remaining gates, listed below, appear to be in satisfactory condition and should continue to be maintained:

- #2 and #3 – west gates to administration building
- #4 – east gate at administration building
- #5 – personnel gate
- #6 – east end of WRF to fields
- #7 – northeast end of WRF to fields

Rapid Creek Bank Stabilization

A riprap bank stabilization project on Rapid Creek near the Administration Building was completed to protect the property and infrastructure in the summer of 2015.

Water Well

As part of the 1967 facility, the WRF was intended to have water provided for seal water, fire protection and other in-plant uses supplied by on-site wells due to the remoteness from the City's potable water system. The wells are not used due to poor water quality. Since that time the potable water system has expanded closer to the WRF and is being extended to the facility. Potable water will be available in the near future to meet those needs and the well should be properly abandoned.

Odor Control

There is currently no odor control at the WRF, and there is potential for housing to the south and west of the WRF. Odor control needs to be provided for in future planning.

Rapid Creek Flow Gaging

There is currently a downstream flow gaging station but no there is no gaging station immediately upstream of the WRF. It is recommended to add an USGS flow gaging station upstream of WRF for Rapid Creek. The station will provide valuable background Rapid Creek flow data as the effluent discharge permit limits are highly dependent on flow in Rapid Creek.

A panel box that would hold all the instrumentation would be about 1ft x 3ft x 3ft in size. Establishment of a gaging station is somewhat site specific and for an exact cost a site visit is needed. The installation with all the instrumentation would be approximately $24,000. This would include all the instrumentation, data logger, pressure transducer, and re-establishing the original datum. Stage and discharge would be collected on a 15-minute interval transmitted by satellite and available to the public on the "web" near real-time. This would be a one-time cost for gage installation. There would also be a yearly operational cost of $15,500. This would cover developing and maintaining a stage/discharge rating, record processing, and quality assurance of data, data transmission and publication. Installation cost is typically shared with USGS. Who would pay the annual operational cost is to be determined.

Influent Flow Metering – Flo-Dar

A Flo-Dar, a flow meter sensor manufactured by Hach, was installed in 2012 for influent flow measurement. The system operates by measuring the flow velocity and depth in an open channel. Achieving good flow results is very dependent on accurate calibration of the flow channel and laminar flow. Evaluation of the Flo-Dar is as follows:

- Since installed in 2012, there has been some difference in flow between the influent Flo-Dar and effluent Parshall Flume flow meters.
- The Flo-Dar meter has been recently calibrated with carefully measured dimensions and resultant flows are closer, but there is still some differential.
- The Flo-Dar has been dependable, and there were no other reported issues.
- The original influent Parshall flume was abandoned in place and is no longer continuously monitored. Influent Parshall flume no longer used for continuous influent flow measurement, but flume level is checked manually by staff at high and low flow rates and compared to FloDar readings to confirm accuracy.
- The Flo-Dar meter should continue to be maintained and calibrated.

Influent Sampling

Isco automatic samplers are used throughout the WRF. Sampler heads and refrigeration units are mixed and matched as needed throughout the WRF. The plant has an ongoing program for maintenance of the samplers, and samplers are on an annual replacement schedule. The samplers need to be set to take flow proportional samples.

Influent Mechanically Cleaned Bar Screens

Influent screening consists of two traveling-rake Huber Rakemax multi-rakes. The bar screens are capable of being continuously cleaned by multiple rakes mounted on a chain. Evaluation of the bar screens is as follows:

- The units were installed in 2012, with new gear boxes installed in 2013.
- The units are in excellent condition.
- There are issues with emergency restart after power outages because manual restart is required.
- Rocks can lock up multi-rake screens.
- Failure causes channels to overflow and damages the grit pumping equipment in the lower level.
- An emergency unscreened bypass is required. It is recommended to provide a tip-up mechanism for manual bar screens or remove manual screens completely for an emergency situation where the screens cannot be returned to service. In addition, an

automatic restart function after a power outage needs to be added to provide for immediate restarting capabilities.
- A hardwire for the floats for level alarming should be provided due to critical function.
- The programming should be verified as providing proper screen reversing during jamming events.

Screening Washer Compactors and Sluice

There are two Huber Rotamat WAP 2-L washing presses that receive screenings directly from a water sluice conveyance device. Screenings enter an inlet hopper where an auger transports them into a washing zone. Wash water is introduced, and the screenings continue into a compaction zone where they are dewatered. The screw then typically reverses, allowing the material to expand, and the wash cycle is repeated. Evaluation of the washer compactors and sluice is as follows:

- Units were installed in 2012.
- Auma flush valves have been an issue and are being replaced with standard solenoid valves by the City. Auma valves were originally installed to address water hammer, which has not been an issue.
- The washer and sluice units are in excellent condition with no other issues since installed in 2012.

Grit Removal Units

Vortex-type Jones and Atwood mechanically stirred grit chambers were constructed in 1992. The system has generally functioned well. The 16-foot-diameter grit basins, paddles, drives, and motors are all in operable condition. Evaluation of the mechanically stirred grit removal units is as follows:

- Units were installed in 1992. All equipment is 23 years old and has reached the end of its expected service life.
- The Owner reported that sand seems to bypass if the grit units are heavily loaded. This is evident when the sludge ponds are cleaned and a slug of grit is returned.
- Vortex grit removal equipment replacement, including paddles and drives, and coating of the tanks should be included in the 10-15 year plan.

Grit Classifier and Cyclone

The grit classifier consists of one Lakeside 30-degree Type L unit complete with a Krebs model 845 cyclone. Evaluation of the grit classifier is as follows:

- Units were installed in 2012, with new shaft screw and trough in 2013.
- Units are in good condition and should continue to be maintained.
- The cyclone pressure gage needs to be replaced.

Grit Pumps

The grit pumps consist of two units complete with a Krebs model 845 cyclone. Evaluation of grit pumps is as follows:

- Units were installed in 2012, with new motors in 2013.
- Units are in good condition and should continue to be maintained.
- Check valves have been problematic.
- Pumps are susceptible to flooding if the influent screening blinds off which needs to be addressed as noted previously.

7913-02 – SEPTAGE RECEIVING

The existing septage receiving system evaluation is as follows:

- Immediate safety concern is that the access hatch covers on septage storage cells have non-functioning hinges and latches with no secondary device such as a coarse grating to prevent falls into septage cells when hatch is open.
- The fiberglass covers are in poor condition and need to be replaced.
- The septic cell pump is a new Vaughn chopper-style pump that was being installed in May 2015, at the time of the inspection, and is in good condition.
- There is no means to monitor the level or volume to determine the amount of septage received. This should be added via SCADA.
- The septage receiving system is not ideally located for receiving regular septic hauling because the drive is restricted by the trickling filters.
- There is no automated screening.
- High-strength loads are dumped without pretesting.
- Dumping is limited to WRF hours of operation.
- Delivery requires WRF staff to be present for manual sampling from the beginning, middle, and end of the load.
- Security is limited.
- There are no controls or ability to send loads to the digester.

A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility cost is contained in Appendix 5.1.A.

The long-term plan is to conduct informational meeting(s) with the local septage haulers and ultimately make a determination if the cost of service and need for septage disposal match up.

In the meantime the following improvements are recommended:

- Repair immediate safety concerns including access hatch covers and fall protection.
- Include level sensor via SCADA with volume calculation to determine the amount of septage.

8013-01 – PRIMARY SLUDGE PUMP BUILDING

The Primary Sludge Pump Building houses two Sullair ES8 air compressors complete with a Premier brand air dryer which supplies air for six Gorman Rupp Ramparts air diaphragm primary sludge pumps. This type of air diaphragm pump is robust and has relatively few moving parts, with primary maintenance being controller repairs and diaphragm and ball valve replacement. The controllers and diaphragm are normal maintenance service items addressed as needed by maintenance staff. The existing primary sludge pumping evaluation is as follows:

- Sludge pumps were installed in 2002. They are in good condition and should continue to be maintained.
- Check valve repair and replacement is required.
- Isolation valves need to be replaced.
- Sullair ES8 air compressors were installed in 2002. According to the vendor these units are obsolete and these two units are scheduled for replacement in 2016.

8013-02 – PRIMARY CLARIFIERS

The primary clarifiers consist of weirs and baffles, and sludge collector, skimmer, cross collector drive equipment, with the evaluation as follows:

- Sludge collector complete with gearbox: The gear boxes' main drives are original 1965 equipment and need to be removed and replaced. Chains and sprockets have been updated to plastic and are in good condition.
- Skimmer complete with gearbox drive chains and sprockets: Gear boxes and skimmers are original 1967 equipment and need to be removed and replaced. Chains and sprockets have not been updated on grease skimmers and need to be replaced.
- Cross collector complete with gearbox: Gear boxes and cross collector units were replaced in 2002 and are in good condition. Chains and sprockets have been updated to plastic and are in good condition.
- Fiberglass-Reinforced Plastic (FRP) weirs and baffles: FRP weirs and baffles were replaced in 2002 and are in good condition. FRP replacement included prefabricated collector troughs with weirs and new scum troughs with baffles.
- Isolation gates: The primary clarifier effluent trough bypass gate has broken free of its mountings and is in poor condition and needs to be removed and replaced. The remaining isolation gates are in good condition and should continue to be maintained.

8025-01 – SECONDARY BUILDING

The Secondary Building is the old Operations Building. This building houses the following:

1. Primary clarification scum pumping
2. Trickling filter lift pumping
3. Secondary clarifier humus pumping
4. Process water system

The Secondary Building equipment evaluation is discussed in the following sections.

Primary Clarification Scum Pumping and Piping to Digester

The pumps are the original 1967 Watson Marlow PE-81W plunger pumps. The pumps are in poor condition and are no longer serviceable. The scum/grease piping to the digester needs to be removed and replaced because it is plugged and efforts to unplug it have been unsuccessful. It is recommended to remove existing pumps and replace with one Gorman Rupp 40p Air Diaphragm Pump with automated suction valving, and new suction and discharge piping, to be run off new compressed air. Improvements should include replacing buried primary scum piping since it is plugged with grease. Scum is currently transferred from primary clarifiers to grease sump in clariflocculator by means of Vactor; all scum goes to the sludge holding pond.

Trickling Filter Lift Pumping

The lift pumping was constructed as part of the original 1967 facility. The trickling filter lift pumping process has high vulnerability, as follows, and needs to be addressed:

- The configuration of the existing wetwell is not ideal, making the pumps susceptible to adverse hydraulic conditions. The existing pumps are maintenance intensive and have been replaced frequently due to these adverse hydraulic conditions and excess wear caused by the presence of snails.
- The pumps are difficult to maintain due to overhead clearance limitations. The pump motor needs to be removed using two hoists and the pump lifted and shimmed for re-gripping. This, coupled with the inadequate clearance around the pumps, limits the functionality of the above-grade structure.
- Currently, only three of the four Trickling Filter Pump Station pumps are in operation:
    - Pump No. 4 was recently replaced with a 75 hp Peerless 24MF -1 stage assembly with 316 stainless steel mixed flow impeller and is in good condition. However, the pump installed has limited life due to wear caused by a combination of snails and cavitation. A spare 416 stainless steel impeller has been provided. The pump should be monitored and the impeller replaced with the more durable 416 stainless steel impeller as required.
    - Pump Nos. 2 and 3 are Cascade models 6310 and were replaced in 2002 and remain in service. Pump No. 2 has a 75 HP motor and discharges to the East Trickling Filter. Pump No. 3 has a 100 HP motor and discharges to the West Trickling Filter.
        - The bowl assembly on Pump No. 2 was replaced in 2010.
        - Pump No. 3 required a new bowl and propeller in 2006 and a new propeller again in 2011.
        - The existing piping is original from 1965 and has corroded and developed pinholes. Pumps are exhibiting noise, which is anecdotal to impeller pitting and imbalance; consequently, process reliability is compromised.
    - Pump No. 1 was removed from service due to wear and pump component corrosion, and needs to be removed and replaced.

The trickling filters and trickling filter pump station are not part of the long-term recommended improvements for the Rapid City WRF. The trickling filter process is expected to be eliminated at Permit #2 which is estimated to by year 2025. As part of provisional improvements to maintain the process for another 10+ years before the north plant is phased out of the process scheme, trickling filter pumping recommended improvements include:

- New pumps with VFDs to handle flow range.
- Repair and recoat pump discharge piping.
- No repairs are recommended to the wetwell at this time.

Secondary Clarifier Humus Pumping

The Chicago non-clog pumps were installed in 1967 and associated valves and piping are in poor condition and are virtually unserviceable. They have reached the end of their expected service life and should be removed and replaced.

Process Water System

Evaluation of the process water system is as follows:

- The hypochlorite day tank was installed in 2011 is in good condition and should continue to be maintained.
- The pressure gauges are in good condition and should continue to be maintained.
- Three Gould's SM1D1E5C1VA process water pumps are as follows:
    - Plastics in the system are causing wear on the impellers, and one pump has been refurbished.
    - Plastics have also caused plugging issues downstream, and a self-cleaning strainer is being installed on the discharge.
    - An option for a strainer on the pump suction header should be considered to protect the pumps. The pumps could be replaced with a different type of pump with harder impeller options.
- The Eclipse yard hydrants were installed in 2011 and are less than 5 years old and need to continue to be maintained.
- A new Forsta B6-90 Discharge Filter was installed on the discharge in summer 2015 to address seal water filter plugging issues downstream.
- The hypochlorinator system, complete with two Prominent brand diaphragm metering pumps, was installed in 2011 has been operating fine mechanically. However, frequent air lock issues have made the system labor intensive to keep operational. If air lock issues continue, modification of the suction piping to provide flooded suction would be recommended.
- Gate valves are in good condition and should continue to be maintained.
- The Process Water Pump Apco model 603 Check Valve has been problematic with the plastics present. It is recommended that the check valve be replaced with three Tide flex valves, or similar.

8025-02 AND 03 – WEST AND EAST TRICKLING FILTERS

The trickling filters receive effluent from the primary clarifiers. The equipment consists of 6-feet of rock media and pneumatically controlled rotary distributors. The trickling filters were installed in 1967. The existing trickling filter evaluation is as follows:

- The rock media appears to be in good condition.
- The distributors have been replaced, summer of 2015, and functioning well.
- The entrance doors showed deterioration, with an accumulation of growth in the interior door panels. The doors are in poor shape need to be replaced.
- The Owner reported that there are periods of odor from the trickling filters which should continue to be monitored as the new distributors could improve the situation.

8025-05 – SECONDARY CLARIFIERS

The secondary clarifiers were installed in 1967 and consist of weirs and baffles, and sludge collector and skimmer drive equipment, with the evaluation as follows:

- Sludge collector Nos. 1, 3, and 4 complete with gearbox: The gear boxes' main drives are original from 1967 and need to be removed and replaced. Chains and sprockets have been updated to plastic and are in good condition.
- Sludge collector No. 2: The sludge collector No. 2 drive has been replaced complete with gearbox. Chains and sprockets have been updated to plastic and are in good condition.
- FRP weirs and baffles: FRP weirs and baffles are in good condition and should continue to be maintained.
- Isolation gates: Isolation gates are in good condition and should continue to be maintained.

8102-01 – ROTATING BIOLOGICAL CONTACTOR (RBC) BLOWER BUILDING

The RBC Blower Building was constructed in 1985 and houses four tri-lobe blowers complete with motors and variable frequency drives. The blower units and motors have been replaced piecemeal over the years, and there is a variety of units, including one Gardner Denver Sutorbilt, one Roboshi, and two Blower Engineering units. The RBC Blower Building equipment evaluation is as follows:

- The RBCs are expected to be phased out within approximately 10 years and firm capacity is available; therefore, the following actions are recommended.
    - The blowers, motors, and variable speed drives should continue to be maintained and replaced as required.
    - The damaged air drive piping in the RBC tanks should be selectively replaced. The replacement is estimated at about 25% of the total piping.

8102-02 – ROTATING BIOLOGICAL CONTACTORS (RBCS)

The RBCs at the Rapid City WRF were installed in 1985 to achieve the permitted level of nitrification. The RBCs are currently 30 years old and have reached the end of their expected service life. Due to the RBCs' limitations in meeting stringent ammonia limits and the need to provide add-on processes for the expected total nitrogen and total phosphorus limits, the RBCs have not been considered for future treatment alternatives. The RBCs will eventually be phased out but should continue to be maintained until the recommended alternative improvements are made. The RBC equipment evaluation is as follows:

- The stainless steel air headers are in poor condition. The stainless steel diffuser piping needs to be removed and replaced to maintain the RBCs' air drive capability. Damaged headers may be causing additional blower energy because air is not properly directed.
- One isolation valve is nonfunctional and needs to be replaced.
- Media "air cups" are delaminating and coming off, which affects both the treatment surface area and the number of remaining air cups. The primary observation is the air cups for the drive are deteriorating which in turn has increased the air requirements over the years.
- Inlet and outlet gates are in good condition.

8215-01 – TERTIARY PUMP PIT

The Tertiary Pump Pit was constructed in 1985 and contains the tertiary clarifier solids/humus removal pumps. The tertiary humus pumping equipment evaluation is as follows:

- Wholesale replacement is not recommended as this process is not included in the selected long term plan.
- The pumps and valves are original 1985 equipment and have reached the end of their expected service life. Valves have been purchased and will be installed by the Owner. The five pumps should continue to be maintained and replaced as required.

8215-02 – TERTIARY CLARIFIERS

The tertiary clarifiers were constructed in 1985 and consist of weirs and baffles, and sludge collector and skimmer drive equipment, with the evaluation as follows:

- Wholesale replacement is not recommended as this process is not included in the selected long term plan.
- Chains and sprockets have been updated to plastic and are in good condition.
- FRP weirs and baffles: FRP weirs and baffles are in good condition.
- Isolation gates: Isolation gates are in good condition and should continue to be maintained.
- Sludge collector drives complete with gearbox: The gear boxes' main drives are original from 1985 to be maintained and replaced as required.

7907 – GAS BLOWER BUILDING

The Gas Blower Building was constructed in 2011 and includes three Tuthill 5507-67L3 helical blowers rated for gas service for gas mixing of the digesters. The gas mixing blowers were evaluated as follows:

- The blower life has been reduced due to moisture and gas quality. Initial investigations of the manufacturer's literature do not show helical gear material options. However, this should be investigated further prior to replacement.
- The Gas Blower No. 1 (south) was recently replaced and should continue to be maintained.
- The Gas Blower #2 (middle) compressor should continue to be maintained.
- Gas Blower #3 (north) was recently replaced and should continue to be maintained.

7909-01 – PUMP / BOILER BUILDING

The Digester Pump Boiler building includes the following components:

1. Digester Gas Components
    a. Flame Arresters
    b. HP and standard Manual Drip Traps
    c. Vacuum/ Pressure Relief Valves
    d. Blower Flame Trap Assemblies
    e. Boiler Flame Arresters
    f. Sediment Traps
    g. Thermal Valve
    h. Metering
    i. Cover Gas Lines
    j. Waste Gas Flare
    k. Boiler Gas Lines and Valves
2. Digested Sludge Pump
3. Sludge Recirculation Pumps
4. Digester Heat Exchangers
5. Digested Sludge Chemical Feed

These components are evaluated in the following sections.

Digester Gas Handling Equipment

The digester gas handling equipment was evaluated as follows:

- Digester gas handling items a-j above were replaced in 2011 as part of the digestion improvements project and are in good condition and should continue to be maintained.
- The steel portion of the boiler gas feed lines need to be removed and replaced with stainless steel inside the building as they are corroded and pitted.

- The waste gas flare feed piping needs to be reinstalled with slope to drain as it has developed a sag and is currently plugged with liquid and the waste gas burner is not functioning.

Digested Sludge Pump

The two Boerger model PL300 rotary lobe digested sludge pumps were replaced in 2011 and are in like new condition and should continue to be maintained.

Sludge Recirculation Pumps

The sludge recirculation pumps have been recently overhauled but the expected service life is 5-10 years and should be scheduled for replacement at that time.

Digester Heat Exchangers

The heat exchangers were replaced in 2011 and are in like new condition and should continue to be maintained.

Digested Sludge Chemical Feed

The digested sludge chemical feed needs to be relocated complete with containment due to the corrosive nature of ferric chloride and the safety risks of sodium hydroxide.

7909-02 – NORTH PRIMARY DIGESTER

The North Primary Digester was constructed as part of the 1967 improvements. Improvements to the associated gas handling piping and equipment were completed in 2002 and 2011. No equipment rehabilitation recommended at the North Primary Digester.

7909-03 – SOUTH PRIMARY DIGESTER

The South Primary Digester was constructed as part of the 1967 improvements. Improvements to the associated gas handling piping and equipment were completed in 2002 and 2011. No equipment rehabilitation recommended at the South Primary Digester.

7909-04 – SECONDARY DIGESTER

The secondary digester was constructed as part of the 1967 improvements. Cover replacement and improvements to the associated gas handling piping and equipment was completed in 2009. No piping or equipment rehabilitation is recommended at the Secondary Digester.

8123-01 – AB BLOWER/PUMP BUILDING

The AB Blower/Pump Building was constructed in 2003 and equipment includes three multistage aeration blowers on the at-grade level and three centrifugal screw RAS pumps, two air diaphragm WAS pumps, and one scum pump on the lower level. Two rotary screw compressors complete with air dryers provide dedicated air for the air diaphragm WAS pumps are also located on the lower level.

AB Blower

The three aeration blowers were installed in 2003 and are 300 HP Hibon Model 350.7 units rated at 5200 cubic feet per minute each at 8.5 pounds per square inch. Inlet vanes are used to control the blower. The blowers have throttling limitations because the variable inlet vanes do not control the required range and units are not able to run in automatic. Consequently, only one blower is operated at a time and DO in the basins exceeds the required levels. Blowers are a critical component to meet the NPDES permit and necessitate high priority maintenance.

The blowers were reviewed, and the evaluation is as follows:

- The blowers are functional and in fair to poor condition. The units are serviceable but require major rebuilds.
- The seals and shafts have been rebuilt.
- The potential to extend the blower inlet to the outside was discussed because inside temperature matches outside temperature during the winter.
- Replacing the blower with newer, more efficient blowers with a better turndown ratio or adding smaller jockey blower(s) should be investigated.
- If blowers are not slated for replacement, complete overhaul is required in next 5-10 years.
- The blower inlets are contained within the room and draw in exterior make-up air. Consequently, the room is near outside temperature in the winter.
- Planning costs should include extending blower inlets to the exterior complete with inlet hoods for exterior service and related HVAC improvements.

Clariflocculator Scum Pump

The centrifugal Hayward Gordon model R3-8, 5 hp non-clog scum pump was installed in 2003 with the evaluation as follows:

- The centrifugal non-clog scum pump functions properly, with no reported issues.
- The centrifugal non-clog scum pump is in fair condition, and should continue to be maintained.
- Planning costs should include complete replacement at the end of a 20-year service life as this pump used intermittently and has limited hours of operation.

Return Activated Sludge (RAS) Pumps

The RAS pumps were installed in 2003 and are Hayward Gordon model XCSJO-C screw centrifugal pumps. Each pump is rated for 2,200 gallons per minute (gpm) at 15 feet total head when operating at about 850 revolutions per minute (rpm), with efficiency at the design point of 79 percent, with a firm capacity of 6.4 MGD, and total capacity of approximately 9 MGD. The RAS flow is discharged to zones Selector 1 and Selector 2 via magnetic flow meters on each line. The RAS pumps were reviewed, and the evaluation is as follows:

- The RAS pumps are generally in good condition and should continue to be maintained.

- The current RAS pumps do not pump the tanks down far enough during the draining operation.
- A RAS/drain pump is recommended, consisting of a new self-priming pump, Gorman Rupp style, on a RAS suction header with discharge tied to a discharge header. This would drain to the other tank and could be sized to add RAS pumping capacity in the future.
- Planning costs should be included for three pumps because the expected service life is 15 to 20 years and the existing pumps are 13 years old. Because the pumps have been rotated through service, their service life will likely be able to be extended to the 20-year mark with normal maintenance.

Waste Activated Sludge (WAS) Pumps

The two Gorman Rupp model 40P air diaphragm WAS pumps were installed in 2003 and the evaluation is as follows:

- The two (2) positive displacement style WAS air diaphragm pumps are in good condition and should continue to be maintained.
- These units are robust and have few moving parts. As long as proper coatings are maintained, the units should last 25+ years.
- Planning costs should be included at the 15 year range for complete replacement of both units because the expected service life is 25 years and the existing units are 13 years old.

Waste Activated Sludge (WAS) Pumps Air Compressors

The Sullair ES8 air compressor was installed in 2003 and the evaluation is as follows:

- This unit is in the same condition as the units in the primary pump pit with repair parts limited and cost of repair running close to the cost of replacement. Planning costs should include complete replacement of one unit.

Waste Activated Sludge (WAS) Pumps Air Dryer

A Zeks Heatsink 50HSHA100 brand air dryer is installed to treat the moisture prior to the WAS pumps and has been reviewed as follows:

- The air dryer was replaced in 2014, is in good condition, and should continue to be maintained.
- This equipment should be scheduled for replacement at 15 years, and planning costs should include complete replacement of one unit.

8123-02 – ACTIVATED SLUDGE – DISTRIBUTION BOX

The aeration basin splitter box was installed in 2003 and is a concrete box located west of the aeration basins and southeast of the Pretreatment Building.

The aeration basin splitter box directs the effluent from the pretreatment splitter box into any or all of the aeration basins: No. 1 (northernmost), No. 2, No. 3 (future), or No. 4 (future, southernmost). Aluminum, motor-operated slide gates (SB-1, SB-2, SB-3 (future), and SB-4 (future)) located within the splitter box direct the process flow to each of the aeration basins.

Wastewater flows into the center of the box, and flow is measured by head over the weir via difference between sonic level measurement and gate position derived from the actuator. The SCADA system calculates flow from head over the weir and maintains a set flow while at the same time maintaining equal weir position to each aeration basin. The distribution box was reviewed as follows:

- The gates, guides, concrete, and the mechanical portion of the actuator are in good condition and should continue to be maintained.
- Weir height is obtained from the actuator position indication. The positioners are worn and need to be removed and replaced because maintaining an equal flow split requires frequent gate actuator calibration to adjust the position indication.
- South Plant flow metering should be considered because currently, flow is split based on head over the weir gate and gate position. Frequent calibration is required to maintain an equal flow split and at least semi-accurate flow.
- Metering could consist of either installing a partial full magnetic flow meter or extending the influent channel and installing a Flo-Dar meter. The gates would then match elevations, and the flow measurement would be more accurate.

8123-03 – ACTIVATED SLUDGE – AERATION BASINS

Aeration basin Nos. 1 and 2 are located on the south side of the existing plant and were installed in 2003. Aeration basin Nos. 1 and 2 are divided into four distinct zones that can be individually controlled for aeration intensity. Zones A, B, and C of each basin are separated by concrete partitions. Zone A contains a moveable (two locations for anchoring) polyethylene curtain that divides the zone into two zones: Selector Channel and Zone A. The partition walls have interconnection openings on opposite sides to minimize short-circuiting of the flow. In addition to aeration control, the Selector Channel receives RAS return flow from the clariflocculator. The RAS return flow feeds directly to the selector basin. The rate of return flow to the zones can be individually adjusted and controlled.

Each of the four zones within each train of aeration basins is equipped with a fine bubble air diffusion system. The system is a flexible-membrane fine bubble aeration system manufactured by Sanitaire.

The aeration basin components were reviewed, as discussed in the following sections.

Moveable Polyethylene Curtain

The aeration basin curtains were installed in 2003 and need to be removed and replaced with a more durable material (that is, concrete) because the existing curtain tears when flows exceed 4

MGD. This is limiting the flow capacity of the South Plant and the process flexibility and reliability of the entire facility.

Diffusers

The diffusers were installed in 2003 and are due for replacement because of their age. Sanitaire EPDM diffusers need to be replaced on a 7 to 15 year cycle and are at year 13. Given their age, planning should include all diffusers being replaced in the next 5 years.

Air Piping

The air piping was installed in 2003 and is in good condition and should continue to be maintained.

Air Control Valves (Zone)

The air control valves were installed in 2003 and have been malfunctioning. The valve actuators need to be scheduled for replacement because they have been problematic and have reached the 13-year mark of the 10 to 15 year life expectancy for electrical equipment.

Tank Drain

The tank cannot be fully drained with the existing RAS pumps. An option for improvement was described in the previous section regarding the RAS pumping.

8123-04 – ACTIVATED SLUDGE – CLARIFLOCCULATOR

The clariflocculator was installed in 2003 and is a Dorr-Oliver Eimco RSR clariflocculator having a 110-foot diameter and a 16-foot side water depth. The Eimco C40LT rake drive train consists of a ½ HP 460v, three-phase motor by SEW-Euro drive with an output speed of 1,750 rpm, connected to a parallel helical reducer, SEW-Euro drive model R47A speed reducer connected to a pinion shaft and pinion gear that drives a spur gear connected directly to the submerged truss framework.

Clariflocculator Drive Unit

The clariflocculator drive unit was installed in 2003 and the evaluation is as follows:

- The clariflocculator is generally in good condition.
- Typically, the pinion shaft and gear will last in excess of 30 years and should continue to be maintained and monitored.
- The motor and speed reducer were replaced in 2014 and should continue to be maintained.
- The clariflocculator is critical to the activated sludge process, and given that there is only one clariflocculator, a spare motor and speed reducer units along with miscellaneous manufacturer recommended spare parts should be obtained and stored on-site.

Weirs and Launder Covers

The weirs were installed in 2003 and launder covers were installed in 2014 the evaluation is as follows:

- The launder covers were installed in 2014 and are in good condition with some warranty replacement required as a result of wind damage. The covers require upgrades to the latch mechanism.
- The weirs are in good shape and should continue to be maintained.

Lower Seals

The lower seals were reviewed, and the evaluation is as follows:

- Staff replaced the lower seal in 2013 and noted an increase in WAS concentration and a decrease in pumping. Increased WAS flows are an indication that the lip seal on the main drive has failed and is allowing dilute WAS to short circuit the arms. In less than a year, the WAS flow has increased again, indicating that the seal has failed in a short period.
- The manufacturer has been contacted to determine if there is troubleshooting specific to the seal or alignment that would be recommended.
- Planning costs should include lip seal replacement.

8207-01 – UV DISINFECTION BUILDING

The UV Disinfection Building was constructed in 2003 and consists of the following components:

1. UV system complete with system control centers, hydraulic drive units, and level and transmissivity monitoring – Four Trojan UV Signa banks installed in 2015.
2. UV effluent control gates – Two EIM actuators installed in 2003.
3. Post aeration blowers – Two Kaiser model DB 236C Omega installed in 2015.
4. Parshall Flume – Fiberglass installed in 2003.
5. Effluent sampler (addressed in a separate section) – One Isco model 6712FR.

On-line instrumentation including the Isco sampler, Hach pH meter, and dissolved oxygen sensors should be planned for replacement in the 5-10 year range.

Trojan UV Signa System

The UV system was updated in 2015, and no improvements or rehabilitation is recommended. SCADA monitoring points should continue to be added and refined.

UV Effluent Control Gates

Gate actuators were installed in 2003 and have been calibrated as part of the 2015 UV improvements and are functional. Overall coliform reduction and reduction per channel should be checked periodically to verify reasonably equal treatment. Planning should include actuator replacement in 5 to 10 years.

Post Aeration Blowers

Two Kaiser Model DB 236C Omega blowers were installed in 2015 and are expected to continue to be maintained for 15 to 20 years.

Parshall Flume

The Parshall Flume was installed in 1985 and is experiencing some normal discoloration to the fiberglass. There is no wicking of the fiberglass at this time; however, bypassing could be performed and a gel coating applied for aesthetic purposes.

8207-02 – RE-AERATION BASIN

The re-aeration basin configuration was updated in 2015, and no improvements or rehabilitation is recommended. Diffusers will need to be replaced every 7-10 years.

8029-01 – SOLIDS HANDLING BUILDING

The Solids Handling Building includes the following equipment:

1. Centrifuge Feed Pump Grinders
2. Centrifuge Feed Pumps
3. Centrifuge Units
4. Centrifuge Conveyors
5. Thickened Sludge Transfer Pump
6. Solids Handling Blower
7. Solids Handling Disposal Valves
8. Polymer Pumps
9. Polymer Blending Units
10. Solids Handling Compressor
11. Pond Liner
12. Pond Mixers/Aerators
13. Pond Decant Pumps
14. Centrate Tank/ Appurtenances
15. Pond Decant Pump

Solids handling process equipment and ponds were evaluated per the following subsections.

Centrifuge Feed Pump Grinders

The two Vogelsang models RotaCut RC feed pump grinders were installed in 2015 and are in new condition. These units should be planned for replacement at 15 year mark as they are a high wear piece of equipment.

Centrifuge Feed Pumps

The two Moyno model 1H175G1 centrifuge feed pumps have been trouble free with no reported issues. The pumps were installed in 2003 and Pump No. 1 was rebuilt in 2014. Pump No. 2 is 12 years old and should be scheduled for a rebuild within the next 3 years.

These pumps are robust and expected to last 20+ years. The units should continue to be maintained and be programmed for complete replacement in 8-10 years. Given the WRF facility has grit removal, fine screening and grinding prior to the pump additional service life can be expected.

Centrifuge Units

- The Andritz model D5LLC30CHP centrifuge units were installed in 2003 and are 12 years old. The centrifuge units are a high speed, high wear, piece of equipment and maintenance costs have increased extensively over the past few years. The maintenance costs for the scrolls are $80,000 each and the units need to be shipped to California for extended service for up to 6 months.
- Reliability is an issue due to time required for shipping and repair. The WRF has regularly been limited to one centrifuge which also needed repair. When ponds are full approximately 60,000 gpd of WAS and digested sludge needs to be processed with current available storage.
- Foam in the centrate is limiting capacity in the outlet piping, in turn; the centrifuges are limited to approximately 160 gpm of the total 250 gpm capacity. The limit is both due to foaming and capacity also decreases as the centrate holding tank level increases. The design intent was to bleed the high strength side stream back to the centrate tank and equalize the return to the headworks avoiding slug loads. This function is not being used as the piping to the headworks plugs due to a combination of flat grade and limited pressure head. Centrate return rate is currently also limited by available head from centrate tank.
- Solutions considered include oversized piping in the horizontal runs (typical), defoaming or installing a sump with dual sump pumps to receive centrate gravity discharge and pump to centrate holding tank. The Owner noted that a defoaming add-on option was discussed at the time of original installation.
- Reliability needs to be addressed with an additional spare unit or alternate technology which can be serviced in-place.
- It is recommended to install a new flow meter on centrate side-stream to more accurately quantify side-stream load.
- Planning costs for centrifuge replacement is included complete with a spare scroll, flow meter and piping improvements.
- For capital improvements planning it is recommended that the total project cost for Three Volute Presses, is included in the Rapid City WRF Capital Improvements Plan.

Centrifuge Conveyors

- The centrifuge screw conveyors complete with Nord drives were installed in 2003 and are 12 years old and have been operating well with no reported issues.
- The conveyors were installed in 2003 and are 12 years old and should continue to be maintained for the next 20 years.

Thickened Sludge Transfer Pump

- The single Moyno model 2J175G2 CDO AEA thickened sludge transfer pump was installed in 2003 and is 12 years old and has been operating well with no reported issues. The pump is expected to last 20 years and the units should be programmed for replacement in 7 years. Given the WRF facility has grit removal, fine screening and grinding prior to the pump additional service life can be expected.
- The pump is critical for operations and planning costs for a loose spare should be provided for process reliability.

Solids Handling Blower

- The solids handling Hibon model SF 1.03 tri-lobe blower was installed in 2003 and is 12 years old and has been operating well with no reported issues. The blower is expected to last 15 to 20 years.
- The unit will not be scheduled for replacement because thickening will be discontinued.

Solids Handling Disposal Valves

The solids handling valves were installed in 2003 and are 12 years old and have been operating well with no reported issues. The valves are expected to last at least 20+ years and the valves should be programmed for replacement in 7-10 years.

Polymer Pumps

- The two Seepex model 805643 progressive cavity polymer feed pumps were installed in 2003 and are 12 years old and have been operating well with no reported issues.
- Given the pump is not handling grit or plastics additional service life can be expected.
- The pumps are expected to last 15-20 years and the units should be programmed for replacement in 5 years.

Polymer Blending Units

- The two USFilter Polyblend model SP60101737 units utilized for polymer mixing and feed preparation were installed in 2003 and are 13 years old and have been operating well with no reported issues.
- There are few moving parts in the units but the units are expected to last 20 years and the units should be programmed for replacement in 7-10 years.

Solids Handling Compressor

- The Henke Mfg., Pacemaker UT2R-B3 compressor unit was installed in 2003 and is 12 years old and has been operating well with no reported issues.
- The compressor has limited use and the unit is expected to last 20 years and the units should be programmed for replacement within 8 years.

Pond Liners

- The pond liner consists of a CoolPro RPP80, 80 mil scrim-reinforced polypropylene liner which was installed in 2013.
- The liner was installed recently, is in good condition and should continue to be maintained.

Mixers/Aerators

- The pond equipment includes three 25 HP Aire-O2 Triton pond mixers complete with integral power aerators and a pond decant pump which were installed in 2003.
- The pond mixing system is difficult to service and requires access via boat.
- The mixing is limited and there are significant dead zones within the storage pond requiring semi-annual to annual solids removal.
- It is recommended to install header style pumped mixing similar to Jet-Tech or Jet mix or a sanitary coarse bubble aeration system.

Decant Pump

- The pond decant pump/piping arrangement was installed by the Owner to intermittently, approximately once per month, return decant off of the pond surface if there are maintenance issues with the dewatering operation.
- It is recommended to provide permanent piping to tie into the discharge to the dewatering centrate return line complete with flow metering.

Centrate Tank/ Appurtenances

- See Centrifuge comments for operations issues.
- The Owner noted that there was no apparent damage or corrosion within the tank.
- Exterior coating is intact and was in good condition.
- Continue to monitor coatings and maintain.

8115 – ADMINISTRATION BUILDING

Process equipment pertinent to the administration building was installed in 2003 and includes the sewage lift station and was reviewed as follows:

- The pumps and electrical equipment were in fair condition and were functional with no reported issues.
- Continue to maintain remove and replace as required.

- Planning costs should include pump and panel replacement at the 7-10 year mark.

7905 – WATER PLANT BUILDING

No improvements or rehabilitation recommended at this structure. This structure would accommodate a water main connection with minimal structural improvements.

7917 – OIL STORAGE BUILDING

No improvements or rehabilitation recommended at the Oil Storage Building unless portions are repurposed for digester chemical feed or an electrical room.

7921 – WASTEWATER MAINTENANCE SHOP

No process equipment improvements or rehabilitation recommended at the Wastewater Maintenance Shop.

8119 – METAL FABRICATION SHOP

No process equipment improvements or rehabilitation recommended at the Metal Fabrication Shop.

SUMMARY OF MAJOR CONSTRAINTS

From a process equipment standpoint, there are currently no major constraints on the Rapid City WRF's ability to meet the existing NPDES Permit under normal circumstances. It should be noted that this is primarily due to the operation and maintenance staff's dedication to ongoing operation and maintenance of the facility.

Prediction of the remaining useful life for process equipment is an estimate and relies heavily on ongoing maintenance and continued availability of repair parts.

Based on this evaluation and discussions with operation and maintenance staff, the equipment replacement or renovation schedule shown in Table 1.1.1 should be implemented.

Table 1.1.1. Process Equipment Replacement or Renovation Schedule

Time Frame	Replacement or Major Renovation
0-5 Years	• Add USGS flow gaging station upstream of WRF for Rapid Creek. • Replace or renovate trickling filter lift pumps and piping • Remove and replace waste gas flare gas line with slope to building as required. • Influent Screening: An emergency unscreened bypass is required. Automatic restart after power outage needs to be added. Provide tip up mechanism for manual bar screens or removing screens completely for emergency situation where screenings cannot be returned to service. Provide hardwire floats for level alarming due to critical function. Ensure programming is providing proper screen reversing during jamming events. • Digester Boilers: Replace controls with dual controls and recoat units.

Time Frame	Replacement or Major Renovation
	• Primary clarifier effluent trough bypass gate: Broken free of its mountings and is in poor condition and needs to be removed and replaced. • AB Curtain Walls (Anoxic Basins): Remove and replace with concrete curtain walls which withstand high flows. • AB Blower: Investigate replacing blowers with newer more efficient blowers with better turndown ratio or adding smaller jockey blower(s). If blowers are not slated for replacement, complete overhaul is required in next 5 years. Include costs to extend blower inlets to exterior complete with inlet hoods for exterior service. • AB Distribution Gate Actuators: Replace actuators as units are worn and need to be recalibrated frequently. Review options for flow metering to South Plant or to each aeration basin. • AB Diffuser Grid: Inspect and replace diffusers as required. Given age replace all diffusers in next 5 years. • AB Air Supply: Investigate aeration zone header inlet valve modulation. Determine if malfunction is mechanical or a matter of loop tuning. Replace valve actuators. • RAS/Drain Pump: Add new self-priming pump on RAS suction header with discharge tied to discharge header. This would drain to other tank and could be sized to add additional RAS pumping capacity for future. • Grounds Wells: Plug wells. • Roads: Resurface plant access drives. • Laboratory Samplers: Follow through with replacement schedule of plant composite samplers. Provide flow proportional signal to composite sampler. Consider incorporating alarm monitoring features provided with the new composite samplers into SCADA. Provided cost for 3 new units to provide for improved sampling at influent, effluent and primary effluent. Assumed remaining will rotate as required. • Primary Scum Pump and Piping to Digester: Remove and replace with Gorman Rupp 40p Air Diaphragm Pump with automated suction valving, and new suction and discharge piping -To be run off of existing compressed air. Also includes replacing buried piping as is plugged from primary scum. • Primary Clarifier Skimmers: Replace skimmers and extend new grease lines. • Primary Skimmer Gearboxes: Remove and replace. • Primary Sludge Collector Gearboxes: Remove and replace. • Secondary Clarifier 1, 3, 4 Gearboxes: Remove and replace. • Clariflocculator Seal: Replace Seal. • Secondary Humus Pumps: Removed and replace. • Digester Boiler Gas Lines: Replace gas feed piping with stainless steel. • Digested Sludge Chemical Feed: Ferric and Sodium Hydroxide chemicals feed need new isolated location complete with containment. Chemical should be relocated and sealed in the meantime. • Centrifuges: Address reliability with additional spare unit or alternate technology which can be serviced in-place. Review piping rerouting and review defoaming options. Consider installing a sump with dual sump pumps to receive centrate gravity discharge and pump to centrate holding tank. Install flow meter on centrate side-stream to more accurately quantify side-stream load. • Pond Aerator/Mixers: Options are Install header style pumped mixing similar to Rotamix, Jet-Tech or Jet mix, or provide cover that can walk on.

Time Frame	Replacement or Major Renovation
	• Solids Handling Blower: Provide loose spare complete. Continue to maintain existing. • Pond Decant Pump: Provide metering. • Process Water Pump Check Valves: Replace check valves with tide flex style valve. • Hypo chlorinator Metering Pumps: Provide flooded suction. • Tertiary Clarifier Gearbox: 3 drives per clarifier need to be replaced - three shaft drives, shafts in the tanks - sprockets have been converted and are in good condition. • RBC Air Lines: Remove and replace 25% of the stainless steel headers on an as-need basis. • Tertiary Humus Pump: Continue to maintain and replace as required. • Grounds Gates: Replace main gate with automated security style gate. Continue to maintain remaining gates.
5-10 Years	• Admin Lift Station: Continue to maintain remove and replace as required. Planning costs include pump and panel replacement only. • AB Distribution Box Gates: Metering should be considered as currently flow is split based on head over the weir gate and gate position. • SCF Scum Pump: Planning costs should include complete replacement of 1 unit. • RAS Pumps: Planning costs should include pump replacement cost of 3 units. • WAS Pumps Air Compressor: Planning costs should include complete replacement of 1 unit. • WAS Pumps Air Dryer: Planning costs should include complete replacement of two units. • UV Effluent Weir Gates: Planning costs should include replacing actuators. • Grit Pump: Planning costs should include replacing check valves with Golden Anderson style 250 or potentially tide flex. • Trickling Filter Lift Pump 1: Monitor pump and replace impeller as required. • Polymer Pump: Planning costs include complete replacement of 2 units. • Centrifuge Feed Pump: Continue to maintain. Costs include complete replacement of 2 units. • Centrifuge Feed Pump Gearbox: Continue to maintain remove and replace as required. • Polymer Blending Units: Continue to maintain. Costs include complete replacement of 2 units. • Thickened Sludge Transfer Pump: Provide loose spare complete. Cost included for loose spare due to critical nature. • Process Water Pumps: Costs include pump replacement and option for strainer on the pump suction header. • RBC Blowers: Continue to replace as required as RBCs have limited life. Costs include complete replacement of 4 units. • RBCs Units: Units have reached the expected service life. Units should continue to be serviced with normal maintenance. • Grit Removal Units: Coat Interior. Remove and replace mechanisms.

Time Frame	Replacement or Major Renovation
	• Sludge Recirculation Pumps: Removed and replace.
10-15 Years	• WAS Pump: Continue to maintain. Costs include complete replacement of 2 units. • Septic Cells: Monitor level/volume to determine amount returned via SCADA. Costs include level monitoring with SCADA volume calculation. • Primary Clarifier Cross Collector Gearbox: Planning costs should include complete replacement of 4 units. • Primary Sludge Pump Compressor: Planning costs should include complete replacement. • Primary Sludge Pump: Replace check valves. • Vacuum/ Pressure Relief Valve: Refurbish or replacement cost for 4 relief valves. • Digester Boiler Equipment • Digested Sludge Pump: Continue to maintain. Costs include complete replacement of 1 pump. • Solids Handling Compressor: Continue to maintain. Costs include complete replacement of 1 compressor. • Centrifuge Conveyor: Continue to maintain. Costs include complete replacement of 1 conveyor. • Centrifuge Feed Pump Grinder: New. Continue to maintain. • Solids Handling Disposal Valves: Continue to maintain. Assumed 25 valves replaced. • Solids Handling Blower: Continue to maintain. • Process Water Pump Gate Valves: Continue to maintain. Costs include complete replacement of 3 valves. • Process Water Pressure Gauge: Continue to maintain.

15+ Years	• Disinfection Basin Blowers: Reaches service life at 15-20 years.
	• UV System: Reaches service life at 15-20 years.
	• Grit Cyclone: Reaches service life at 15-20 years.
	• Bar Screens: Reaches service life at 15-20 years.
	• Grit Classifier: Reaches service life at 15-20 years.
	• Screening Washer Compactor: Reaches service life at 15-20 years.
	• Primary Clarifier Cross Collector: Reaches service life at 15-20 years.
	• Secondary Clarifier 2 Gearbox: Reaches service life at 15-20 years.
	• Digester Gas Component Replacement Required:
	  o Flame Arresters
	  o HP and standard Manual Drip Traps
	  o Vacuum/ Pressure Relief Valves
	  o Blower Flame Trap Assemblies
	  o Boiler Flame Arresters
	  o Sediment Traps
	  o Thermal Valve
	  o Metering

Time Frame	Replacement or Major Renovation
	o Cover Gas Lines o Waste Gas Flare o Boiler Gas Lines and Valves • Waste Gas Flare: Reaches service life at 15-20 years. • Centrifuge Conveyor: Reaches service life at 15-20 years. • Centrifuge Feed Pump Grinder: Reaches service life at 15-20 years. • Odor Control: Provide for odor control for future planning. Included in HVAC.

PLANT OPERATIONS

Staffing

The WRF is currently staffed by three main work groups: Operators, Maintenance and Lab (Environmental). A total of nineteen full time and one half time employees manage, operate and maintain the Rapid City WRF. Current staffing consists of the following:

- 1 Division Superintendent
- 1 Half time Administrative Secretary
- 1 Plant supervisor
- 9 Plant operators
- 1 Plant Maintenance Specialist
- 1 Truck Driver
- 1 Industrial Electrician
- 1 Environmental Process Supervisor
- 3 Laboratory Technicians
- 1 Industrial Waste Technician

The facility is fully staffed by all three work groups Monday through Friday, eight hours per day. On weekends, three operators report to the facility each day for two hours to perform site checks and lab tests. During unattended hours the plant is monitored by SCADA and alarms are transmitted to a Dial-Out system. Callouts are reported to be about fifty per year or just less than one callout per week. Operators receive call-out pay and are paid an additional two hours minimum overtime upon a callout event.

Staffing was reviewed based on EPA staffing recommendations in Table 1.1.2. The total number of employees calculated through the staffing worksheet is very close to the existing staff numbers. The Laboratory category includes the pretreatment coordinator hours.

Table 1.1.2. Rapid City WRF EPA Staffing Estimate Worksheet

Year 2010-2015 Annual Average Flow = 9.69 MGD - Existing

Unit Process	Operation (Hours/Yr.)	Maintenance (Hours/Yr.)	Supervisory and Admin. (Hours/Yr.)	Clerical (Hours/Yr.)	Laboratory (Hours/Yr.)	Yard work and Misc. (Hours/Yr.)
Screening	955	39				
Grit Removal	686	59				
Primary Clarification	2125	497				
Trickling Filters	719	1,022				
Rotating Biological Contactors	719	1022				
Activated Sludge w/ Nitrification	6,551	2,836				
Secondary Clarification Tricking Filter	599	407				
Secondary Clarification RBCs	599	407				
Secondary Clarification Act. Sludge	1,922	407				
Anaerobic Digestion	864	218				
Sludge Lagoons	155	104				
Dewatering	2,000	1,025				
Disinfection	336	399				
Subtotal Hours	18229.5	8442	2248	823	3,066	2156
Technology Adjustment	1823	-844	-180	16	61	216
Total Hours / Year / Category	20052	7598	2068	839	3127	2372
Workers Required / Category	11.1	4.2	1.1	0.5	1.7	1.3
Total Number of Workers Required	20.0					
Current Staffing	9	6	1	0.5	3	
Total Number of Workers	19.5					

Note: 1 worker = 1,800 hours / year

The candidate pool for qualified wastewater treatment operators and mechanics is limited. The WRF has a difficult time competing with regional industries and relies mostly on transfers from other City divisions. With increasing technology and improved implementation of SCADA, WRF will require technicians with advanced skills and problem solving abilities.

About 45 percent (9 of 19) of WRF staff are eligible for retirement over the next 8 years.

A plan needs to be in-place to maintain trained and skilled to personnel to reliably operate the WRF. Due to limitations in the labor force will require an on-going employee search to find and hire qualified employees in advance.

Operations

Operators perform preventive maintenance (PM) work (referred to as recurring maintenance at the WRF). Operators also assist with lab sampling and analysis; i.e. settleometer /SVI, and reading 5-day BOD results on weekends.

Maintenance

The WRF is staffed with a maintenance technician who provides technical expertise in planning, scheduling and coordinating preventive and corrective (non-recurring) maintenance. Operators maintain mechanical and electrical process equipment that best utilizes available labor.

An industrial electrician position is assigned to the WRF staff and provides technical expertise for the maintenance of power distribution, electrical and control systems. This position is required to maintain a City Electrical Contractors license.

Laboratory

All laboratory work is performed onsite at the WRF. Environmental lab technicians are capable and willing to provide special study support as needed during any required analysis for plant upgrades. Lab staff maintain composite samplers and verify calibration of all permit related analyzers.

Operational Issues

Table 1.1.3 lists operational and maintenance issues that were assembled from consultations with WRF staff. The table also includes recommendations for addressing the issues. Several of the critical facility replacement items have been repeated in this table as they also affect plant reliability and vulnerability.

Table 1.1.3. Operational and Maintenance Issues

Type	Assessment Category	Opportunity	Opportunity	Years of Implementation (Immediate, 1–5 years, 5–10 years, 10–20 years)	Construction Cost (Does not include Engineering)
Nonmonetary	Vulnerability	Emergency Operating Plan	Update Emergency Operating Plan (EOP) to include: 1) Alternative routes to the WRF 2) City contacts for snowmobile service 3) plan for having 2 persons stay at plant if storm event is predicted.	1–5	N/A
Monetary	Vulnerability	Emergency Operating Plan	Increase fuel storage complete with containment to up to 3 days. Station fuel tanker on-site prior to anticipate blizzard/flood events.	1–5	$18,000
Nonmonetary	Vulnerability	Emergency Operating Plan	Potential for natural gas service for new generators. Included two 500 Kva generator units.	1–5	$1,500,000
Monetary	Vulnerability	SCADA	Address high risk areas for instruments via SCADA only and provide hard-wired alarms for influent screening, trickling filter pumping, aeration blowers and UV.	1–5	$102,000
Monetary	Vulnerability/ Process	Aeration Basins	Current RAS pumps do not pump the tanks down far enough and servicing aeration basins and diffusers is an issue: Provide improved means for draining tank and options included: 1) New pump on RAS suction header with discharge tied to discharge header. This would drain to other tank (recommended). 2) Add adjacent drain pump station to pump to headworks/primary clarifiers. 3) Lower the grade to limit suction lift. New pumps require higher suction lift properties.	1–5	$114,000
Monetary	Vulnerability	Sludge Dewatering[1]	Address sludge dewatering equipment reliability and time required for repair. The life cycle options for this process have been reviewed as part of the study. Preliminary options discussed included: 1) providing an additional unit shipped loose, or 2) implementing a different technology that can be repaired on-site/in-place.	1–5	Included in Sludge Handling Project Cost
Nonmonetary	Staffing	Staffing Coordination	Phase into a new staffing model over the next 10 years to reflect dual technician levels; wastewater technician 1 and 2. Technician 2 level staff are multi-skilled with the ability to perform maintenance, operations and laboratory duties with strong knowledge and problem solving skills related to automation (control and instrumentation) and wastewater treatment process control. Technician 1 level staff should be familiar with wastewater treatment and perform common semi-skilled tasks safely.	5–10	N/A
Nonmonetary	Staffing	Staffing Coordination	Identify a more structured succession plan for key positions such as the Environmental Program Manager and Plant Supervisor.	5–10	N/A
Nonmonetary	Staffing	Staffing Coordination	Share common trades between water treatment and wastewater treatment such as the industrial electrician.	5–10	N/A
Monetary	Operational Capabilities and Procedures	Operations Manuals	Development of a facility level Operation and Maintenance Manual is recommended. A digital intranet based manual should be considered to facilitate continuous update and central access to SOP's and equipment manuals.	1–5	$200,000
Nonmonetary	Operational Capabilities and Procedures	Operations Procedures	Development of SOPs should commence in the near future to capture knowledge of staff that is likely to retire in the next 5 to 8 years.	1–5	N/A
Monetary	Operational Capabilities and Procedures	SCADA	Update the SCADA / Information Technology Master Plan to improve control capabilities of existing processes and meet future demands of new treatment technologies. An important part of the SCADA Master plan should be a well-defined controls philosophy based on a Failure Mode Effects Analysis of each unit process. Currently only monitoring failures. Facility has Siemen's smart MCC(s) but not using to diagnose problems.	1–5	$50,000
Nonmonetary	Operational Capabilities and Procedures	Operations Software	Continue progress on implementing Ops Works to consolidate operator log entries and process data. The intent of Ops Works is to consolidate SCADA tags (such as flow results) with sample results to produce the equivalent of the existing Process Trend Spreadsheets and to eventually compile the DMR before transmitting to the State.	1–5	N/A
Nonmonetary	Operational Capabilities and Procedures	On-line Monitoring	Implement additional on-line metering possibilities i.e. sludge blanket, ammonia, TSS.	5–10	$50,000–$150,000

Type	Assessment Category	Opportunity	Opportunity	Years of Implementation (Immediate, 1–5 years, 5–10 years, 10–20 years)	Construction Cost (Does not include Engineering)
Monetary	Operational Capabilities and Procedures	On-line Monitoring	As part of the SCADA / IT Master Plan consider including real time power monitoring.	5–10	
Monetary	Operational Capabilities and Procedures	SCADA/Remote Operations	Include remote capabilities via SCADA to ensure process function and limit trips to the plant.	5–10	$50,000–$150,000
Monetary	Operational Capabilities and Procedures	SCADA/Remote Operations	Provide a reliable and sufficient internet connection for the WRF. (I.e. Fiber optic cable). This will be required to implement remote system monitoring and/or control.	5–10	N/A
Nonmonetary	Maintenance Procedures	Maintenance Management Software	Develop a CMMS Users Manual to manage the use and maintenance of the software. Base formal user training on the CMMS User's Manual.	1–5	N/A
Nonmonetary	Maintenance Procedures	Equipment Asset Management Software Updates (EAM)	Consider developing a EAMs system to better manage renewal decisions. There are several short term alternatives to implement this initiative either by; enhancing the current CMMS system to include EAM features described earlier or implementing a separate EAMs system such as AWWA's Plant Infrastructure Manager or HDR's AM Tools that are based on an MS Access database.	1–5	$50,000
Nonmonetary	Maintenance Procedures	Enterprise Asset Management Software (EAM)	As part of long term implementation plan, develop a EAMs system *department-wide* that has the capabilities of both the CMMS and EAMs based on input from the Information Management Technology Master Plan. Cost depends on Owner involvement.	5–10	$100,000
Monetary	Maintenance Procedures	Computerized Maintenance Management Software (CMMS)	Consider the eventual replacement of the existing CMMS with a commercial version. Based on a cursory review of the current CMMS architecture the migration of the asset registry and historical data should be straightforward. Implementation is estimated to be $50,000 subject to final negotiations and changes to the scope of work. The licensing for a model includes an annual cost of $15-30K assuming 20 individual users.	5–10	$50,000
Monetary	Safety Practices	Flood Protection	Add building flood indication to the Tertiary Pump Building.	5–10	Included above.
Nonmonetary	Safety Practices	Safety Standard Operating Procedures (SOPS)	Provide review and update of hazardous areas SOPs i.e. confined space and arc-flash. Arc-flash study costs can vary greatly depending on available information and scope.	2015	
Monetary	Vulnerability	Bar Screens Bypasses	Provide a tip up mechanism for manual bar screens for removing screens completely during emergency situations where screenings cannot be returned to service.	1–5	$75,000
Monetary	Vulnerability	Bar Screens Surcharge	Provide hardwire floats for level alarming.	1–5	$8,000
Nonmonetary	Vulnerability	Bar Screens Surcharge	Ensure programming is providing proper screen reversing during jamming events.	1–5	In progress.
Monetary	Process Flexibility/ Vulnerability	Aeration Basins Capacity	Modify AB Curtain Wall (Anoxic Basin) selector baffle at aeration basin inlet to allow for increased hydraulic capacity. Retrofit could occur during annual shutdown for maintenance and cleaning.	1–5	$240,000
	Process Flexibility	Aeration Controls	Blower header control and DO control strategies: Investigate malfunctions. Coordinate this opportunity with Process and Energy Evaluations. Investigate replacing blower with newer more efficient blowers with better turndown ration or adding smaller jockey blower. Investigate aeration zone header inlet valve modulation. Determine if malfunction is mechanical or a matter of loop tuning.		See energy audit.
Monetary	Process Flexibility	Sludge Dewatering Capacity[1]	Centrate flow capacity needs to be increased and the ability to bleed the side-stream through the day. It appears that foam in the centrate is limiting capacity in the outlet piping. In turn, the centrifuges are limited to approximately 140-160 gpm. This is both an energy issue and operations time investment issue. Potential	1–5	$27,000

Type	Assessment Category	Opportunity	Opportunity	Years of Implementation (Immediate, 1–5 years, 5–10 years, 10–20 years)	Construction Cost (Does not include Engineering)
			solutions include 1) defoaming chemicals 2) oversize piping 3) construct sump with dual sump pumps to receive centrate gravity discharge with discharge to centrate holding tank. Costs include oversizing piping.		
Monetary	Process Flexibility	Sludge Dewatering Monitoring[1]	Install a flow meter on centrate side-stream to more accurately quantify side-stream load.	5–10	$41,000
Monetary	Process Flexibility	Sludge Dewatering Monitoring[1]	Update cameras solids handling area.	1–5	$16,000
Monetary	Process Flexibility	Sludge Dewatering Monitoring and Control[1]	Current centrifuge system is manned at all times. Consider updating SCADA and chemical feed system to limit operational attention requirements.	1–5	$35,000
Monetary	Process Flexibility	Septage Receiving Facilities	WRF staff is in process of repairing and returning the existing facility back to service. A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility cost is contained in Appendix 5.1.A. The long-term plan is to conduct informational meeting(s) with the local septage haulers and ultimately make a determination if the cost of service and need for septage disposal match up. In the meantime the following improvements are recommended: • Repair immediate safety concerns including access hatch covers and fall protection. • Include level sensor via SCADA with volume calculation to determine the amount of septage received.	N/A	N/A
Monetary	Vulnerability	Trickling Filter Pumping Condition	Address trickling filter pump station high vulnerability i.e. poor pipe condition, short life of pumps.	1–5	Costs included in selected alternative.
Monetary	Process Flexibility	Samplers	Follow through with replacement schedule of plant composite samplers (some replacements are already in next year's budget). Provide flow proportional signal to composite sampler. Consider incorporating alarm monitoring features provided with the new composite samplers into SCADA.	1–5	$21,000
Monetary	Process Flexibility	Solids Dewatering Building Elec.	Replace and protect solids dewatering building MCC and controls.	5–10	$250,000

Included in Sludge Dewatering Improvements Project Cost.

Staff Flexibility Improvement

To more effectively address the maintenance needs of the facility, consideration should be given to contracting out the large maintenance tasks to private contractors. Projects like the trickling filter pump replacement require the use of all maintenance personnel which leaves no staff available to handle the preventive maintenance needs of the plant equipment. Additional consideration should be given to establishing a maintenance team for preventative maintenance (PM) and another team for specific projects. A minimum of two maintenance employees would be needed for PM tasks with the remaining maintenance employees assigned to project specific tasks, such as equipment replacement.

Unused Facilities

There are no unused facilities at the Rapid City WRF. However, the oil storage building was identified as potential double duty for chemical feed containment and storage.

1.1.2.2 Architectural Condition

The architectural review included a general review of building exteriors, doors, windows, interior finishes, coatings, and a cursory review of safety issues. Masonry building exteriors are typically susceptible to moisture and freeze-thaw degradation and in need of cleaning, minor maintenance and treatment with a breathable liquid water repellent in order to prevent further degradation. Railings throughout the plant do not typically conform to current standards. A thorough assessment of fall protection throughout the plant should be conducted and railings repaired, replaced or upgraded as necessary. Safety chains at guardrail openings do not meet recommended standards. Ferrous railings are corroding and causing spalling of concrete. Roofing systems throughout the plant are in the process of being replaced as determined by the Rapid City-Pennington County GIS Inspection Reports prepared by Black Hills Roofing in August of 2012. Because of this ongoing work, a detailed inspection of roofing was not performed as a part of this assessment. Detailed observation summaries are included in Appendix 1.1.B.

7905 – WATER PLANT BUILDING

The Water Plant Building is included in a plan to house water valves and meters for potable water service to the plant which will likely be constructed in 2016. The building has some minor cracking of interior masonry and cracking spalling of exterior brick. Doors and windows are in generally good condition with no significant defects noted. Interior coatings are in good condition. The building appears to be adequately suited to its current use and adaptable to house equipment for City water service in the future.

7907 – GAS BLOWER BUILDING

The Gas Blower Building is a recent addition to the facility, having been added as part of the 2010 Digester Complex Modifications. The exterior masonry is in good condition but does appear to be retaining moisture and may be subject to freeze-thaw degradation if left untreated. Cleaning and application of a breathable liquid water repellent is recommended. Exposed

concrete surfaces were not finished and have numerous bug holes and voids, leaving the surface susceptible to moisture intrusion and freeze-thaw degradation. Application of a water-resistant cementitious parge coat to exposed concrete surfaces is recommended. Doors and windows are in generally good condition with no significant defects noted. Roof drainage is currently provided by a single through-wall scupper and conductor head. Building Codes require that buildings that have parapet walls to be provided with a secondary means of draining the roof, unless the structure has been designed to accommodate the accumulation of water, in the event that the primary means of drainage should become blocked. Addition of an overflow scupper is recommended.

7909 – DIGESTER COMPLEX BUILDING

The Digester Complex Building was rehabilitated as part of the 2010 Digester Complex Modifications. The roof system was replaced and is good condition, although staining of the membrane indicates the ponding of water. This is a minor issue, as the type of PVC roof membrane installed on this roof is not typically susceptible to problems due to ponding. Interior walls and boiler stacks indicate areas of roof leaks but plant staff has indicated that the leaks have been addressed and are no longer active. Doors are in fair condition, with some damage to weather-stripping. Ferrous metal louvers installed in the door panels are corroding. The type of door hardware installed includes manual flush bolts to secure the inactive leaf of the pair of doors. This is in violation of current Code requirements. Due to the hazardous nature of this facility, the doors should be equipped with panic devices on each leaf, to facilitate egress in the event of an emergency. Piping within the Digester Complex Building is located at floor level and presents a tripping hazard in the means of egress. Consideration should be given to providing piping crossovers to facilitate safe egress from the space.

The digester covers have been insulated with a sprayed-foam insulation system. Plant staff has indicated that accessing the equipment on top of the covers is difficult in wet or snowy conditions. Temporary rubber walkway mats and ropes have been installed as an attempt to mitigate these concerns but have not proven to be adequate. Permanent walkways should be designed and installed to provide safe access.

7913-01 – PRETREATMENT BUILDING

The Pretreatment Building was most recently renovated in 2012 and is in good condition overall. There are ongoing issues with improperly applied paint on interior walls and ductwork that plant staff is working to remedy. There are fiberglass (FRP) covers over floor openings near the stairs to the pump pits that are not flush with the adjacent floor surface and present a tripping hazard. These plates should be replaced or shimmed as necessary to bring them flush with the floor surface.

7917 – OIL STORAGE BUILDING

The Oil Storage Building has been repurposed from its original function and now serves as a storage facility for oil and lubricant for maintenance. The most significant issues observed at this building were related to deficiencies in the roof, which is scheduled for replacement. It is

anticipated that the roof replacement will resolve the cause of the issues. After roof replacement, consideration may be given to repainting of corroded ferrous metal surfaces. The hollow metal entrance door is corroded and the hardware is deteriorated; replacement should be considered.

7921 – WASTEWATER MAINTENANCE SHOP

The Wastewater Maintenance Shop was originally constructed as a Vacuum Filter Building as part of the original plant construction. The building has been repurposed from its original function and now serves as a maintenance shop. For the most part, the building interior is adequate for the current usage. Some brick spalling and cracking was observed on the exterior veneer. Pedestrian doors and hardware are deteriorated; a detailed review of these doors should be performed to identify the extent of repairs or replacement needed.

8013-01 – PRIMARY SLUDGE PUMP BUILDING

The Primary Sludge Pump Building was originally constructed as a stair enclosure for the access stair to the Primary Pump Vault. The Compressor Room was added as part of the 2002 Facility Improvements. Some brick spalling and cracking was observed on the exterior veneer. The hollow metal door and hardware at the stair enclosure is badly deteriorated and should be replaced. Coatings on below-grade concrete in the pump vault are failing in isolated areas and ferrous embeds in the vault ceiling are corroding. These issues may be an indication of moisture intrusion through the concrete.

8025-01 – SECONDARY BUILDING

The Secondary Building was constructed as the Operations Building as part of the original plant construction but due to ongoing problems with the corrosive environment at its location, the at-grade office area of the building has been abandoned for the most part. The building does still house process equipment in the lower level and electrical equipment in the upper level but is not normally occupied and is used largely for file storage. If the building is to be repurposed for use in the future, extensive renovations will be necessary.

8029-01 – SOLIDS HANDLING BUILDING

The Solids Handling Building was constructed as a single story building as part of the 1985 Plant Improvements. As part of the 2003 Facility Expansion, the building was expanded to include a second story. The ground level exterior walls are Brick and CMU composite wall construction. The precast-t roof structure was maintained with a concrete floor poured on top of it. The second level is constructed of single-Wythe CMU. The original brick veneer is generally in good condition, other than some isolated areas of corrosion of ferrous metal components. The split-face CMU has a significant amount of staining and efflorescence, indicating the presence of excess moisture. Door hardware is worn and damaged, and in some cases, missing. The floor surface at the sludge load-out bay is severely worn from the steel wheels of the roll-off containers. Resurfacing of the floor should be considered; refer to the Structural assessment for a detailed discussion of options.

8029-01 – ROTATING BIOLOGICAL CONTACTOR (RBC) BLOWER BUILDING

The RBC Blower Building houses blowers and electrical equipment serving the RBCs. No significant defects were observed, other than water staining on the interior walls and floor, indicating a possible roof leak. The building includes an exterior-mounted roof access ladder. Consideration should be given to providing permanent roof railings near the point of access to the ladder and where equipment is located less than 12'-6" from the edge of roof and the roof needs to be accessed for filter element replacement.

8115 – ADMINISTRATION BUILDING

The Administration Building was constructed in 2003 and is generally in good condition. The interior is functional and in good repair, with the exception of areas that have been subject to water intrusion. Staff indicated that there is not adequate office space and have partitioned off spaces in the lower level to provide offices for current staff. Adequacy of office space for future staffing levels is in question. The laboratory is in good condition and staff reported that it is functionally suitable for current needs. Locker facilities do not provide adequate storage space and staff indicated that the lockers are too small to suit their needs. Supplementary lockers have been placed in the vehicle storage garage, taking away needed storage space in that area.

The moisture issues in this building appear to be due to a combination of causes; roof and skylight damage, intrusion through single-Wythe masonry and infiltration at and below grade. At the time of assessment, the roof system and skylights were in the process of being replaced. Staff indicated that a water repellent was to be installed on the exterior CMU and there was evidence of ongoing attempts to improve drainage around the perimeter of the building. If these remedies do not solve the water issues, a detailed evaluation of the building and surrounding grading may be necessary in order to determine the causes of the moisture intrusion and what measures will be required to remedy the problems. New larger lockers should be installed in the locker rooms to better serve the employees space needs.

8119 – METAL FABRICATION SHOP

The Metal Fabrication Shop was constructed as a Chlorine Storage and Feed building as part of the 1985 Plant Improvements. Chlorine is no longer used at the plant and the building has been repurposed. The building still houses some electrical equipment but the chlorine storage area is currently used as a metal fabrication shop. The former laboratory is used as an electronics repair shop. The interior is functional for the current uses but does show staining and minor damage from previous roof leaks.

8123-01 – AB BLOWER / PUMP BUILDING

The AB Blower / Pump Building contains pumping and blower equipment which supply air to the Aeration Basins. Typical of the other single-Wythe masonry buildings, the exterior masonry is showing evidence of moisture intrusion in the form of staining and efflorescence. Plant staff indicated that there has been a history of issues with settlement around the building, including the monorail supports. The lower level has significant moisture intrusion issues. Plant staff also

expressed concern with the bridge crane and monorail configuration and the ability to replace or add blowers.

8207-01 – UV DISINFECTION BUILDING

The UV Disinfection Building was constructed as part of the 2003 Facility Expansion. At the time of assessment, the building was in the final stages of improvements from the most recent project. No significant defects were noted, other than the water staining and mortar degradation noted for this and other structures constructed of the split-face CMU.

8207-01 – TERTIARY PUMP PIT

The Tertiary Pump Pit was constructed as part of the 1985 Plant Improvements. The masonry structure is an enclosure for stairs leading to the lower level pump vault. There appears to be issues with settlement around the building, as concrete paving has been replaced and new steps provided at the door. The steps do not meet Code requirement for a landing at egress doors. Coatings are failing, both inside the structure and the slab coating on top of the vault.

SUMMARY OF MAJOR CONSTRAINTS

The plant buildings are typically well maintained and in good condition. Roofing repairs and replacements are ongoing and should address a significant number of concerns with the weather-tightness of the buildings. Exterior masonry surfaces are in need of cleaning, tuck-pointing and application of a breathable liquid water repellent in order to arrest masonry degradation and prevent further freeze-thaw damage. Fall protection is of typical configuration for the time periods when the facility was constructed but in many instances are no longer up to recommended safety standards. Doors and hardware throughout the plant should be inspected on an annual basis, in accordance with the requirements of NFPA 101, Life Safety Code. The recommended replacements or renovations and associated time frames are listed in Table 1.1.4.

Table 1.1.4. Architectural Components Replacement or Renovation Schedule

Time Frame	Replacement or Major Renovation
0-5 Years	• Improve access to digester covers • Cleaning, tuck-pointing and application of liquid water repellent to building exteriors • Perform survey of fall protection throughout the plant and identify needed improvements • Inspect doors and hardware and identify for repairs or replacement • Remodel Administration Building locker rooms • Implement fall protection improvements • Implement door and hardware replacements and upgrades
5-15 Years	• Identify extent of Administration Building expansion

1.1.2.3 Structural Condition

The facility structures are generally in good condition despite their ages, the expansive soils native to the region, and some of the construction methods used.

Common structural issues are described in the following paragraphs, and the detailed condition of each structure is discussed in the subsections below. The documentation of the visual observations and interviews are included in Appendix 1.1.C.

Settlement of paving, sidewalk, and some structures is a common problem at the facility and is to be expected given the nature of the expansive soils in the region. Although settlement has occurred, it has not exhibited large movements or caused structural damage. Future construction at the facility should take into account the expansive soils to prevent future problems.

As discussed in the architectural evaluation, another common problem at the facility is single Wythe masonry wall construction. This type of construction is not well suited to the climate of Rapid City, which includes driving rains and high winds. Water can be driven into the concrete block, which is a porous material, and cause efflorescence, which is a problem at the plant. From a structural standpoint, if left untreated, efflorescence can eventually lead to weakening of the concrete due to the minerals leaching out of the block. Many of the older structures at the facility are holding up better than the newer structures that include exposed concrete masonry. In the future, the design should match the existing block with brick structures which have weathered the best.

Finally, exposed steel, typically railings, that becomes corroded and damaged is also a common problem at the facility. Embedding guardrail, especially steel, is a common detail that leads to corrosion and damage to the concrete, especially in high humidity environments like the WRF. While the steel can be repainted and replaced as needed, the concrete that the steel is often embedded in cannot be as easily repaired. Removing problematic steel railing and replacing it with aluminum guardrail would prolong the life of many of the structures.

7913-01 – PRETREATMENT BUILDING

Minor freeze-thaw and delamination damage was visible on the exterior of the Pretreatment Building. Regular maintenance will suffice for rehabilitation.

7913-02 – SEPTAGE RECEIVING

The septage receiving structure is in need of minor repairs to fix the corrosion and freeze-thaw damage to the above-grade concrete curb and containment. The bar screen does not require repairs.

8013-01 – PRIMARY SLUDGE PUMP BUILDING

There was minor concrete reinforcing corrosion in the ceiling of the lower level of the Primary Sludge Pump Building. There was evidence of standing water, which has left stains on the floor

of the lower level. Only minor corrosion rehabilitation of this structure is required to arrest and prevent future corrosion. Water infiltration is likely from the ground level. In addition to corrosion repair, this water source could be investigated but may be difficult to eliminate.

8013-02 – PRIMARY CLARIFIERS

The guardrail at the primary clarifiers has corroded specifically at the bases to the point that it needs to be replaced. An aluminum guardrail could be mounted to the existing walkways and walls. During the walkthrough with the staff a question was raised whether the entire guardrail currently on the clarifiers is required to access and maintain the clarifiers. This question should be further investigated before replacement to determine cost and extent. The steel walkways at the east end of the clarifiers should also be replaced with a galvanized steel or aluminum structure of a capacity equal to the expected equipment loading. The embedded guardrail has also begun to damage the concrete walkways and walls, and should be removed and filled with a cementitious patching material. There appeared to be damage at underside of the walkways. The extent of the underside reinforcing corrosion should be monitored. Based on the visual investigation, the walkways can be repaired with proper coatings to protect the reinforcing steel. However, draining of the tanks will likely be required to access and make these repairs.

8025-01 – SECONDARY BUILDING

The interior finished spaces of the structure are in good condition. The exterior brick and concrete has minor freeze-thaw damage around the length of the building that could be repaired through regular maintenance or a minor brick rehabilitation project.

The Trickling Filter Pump Station is located on the north end of this structure in the lower level. The concrete in this lower level is showing signs of significant loss of concrete cover on all surfaces at or above the waterline. Significant reinforcing corrosion has not yet started. However, once the reinforcing is exposed, corrosion of steel occurs very rapidly when compared to the rate of concrete corrosion. Corrosion of the steel also further damages the concrete by expanding. Replacing the lost concrete cover will ensure the original load carrying capacity of the floor is not compromised in the future. Also, repair of corroded reinforcing steel is more extensive, expensive, and generally does not fully repair the strength of the original structure once the s • Trickling Filter Pump Station Refurbish Project - the trickling filters and trickling filter pump station are not part of the long-term recommended improvements for the Rapid City WRF. The trickling filter process is expected to be eliminated at Permit #2 which is estimated to by year 2025. As part of provisional improvements to maintain the process for another 10+ years before the north plant is phased out of the process scheme, trickling filter pumping recommended improvements does not include repairs to the wetwell.

8025-02 – WEST TRICKLING FILTER

Minor concrete repairs are required on the inside and outside of the concrete tanks of the West Trickling Filter. There is some minor damage to the aluminum dome panels. Slight corrosion at the connections of the dome to the tank was evident due to condensation collecting to this point. At this time, repair of the connections is not required but they should be monitored in the future.

8025-03 – EAST TRICKLING FILTER

Minor concrete repairs are required on the inside and outside of the concrete tanks of the East Trickling Filter. There is some minor damage to the aluminum dome panels. Slight corrosion at the connections of the dome to the tank was evident due to condensation collecting to this point. At this time, repair of the connections is not required but they should be monitored in the future.

8025-04 – GENERATOR – SECONDARY

No structural improvements or rehabilitation recommended at this structure.

8025-05 – SECONDARY CLARIFIERS

The guardrail at the secondary clarifiers has corroded specifically at the bases to the point that it needs to be replaced. An aluminum guardrail could be mounted to the existing walkways and walls. During the walkthrough with the staff a question was raised whether the entire guardrail currently on the clarifiers is required to access and maintain the clarifiers. This question should be further investigated before replacement to determine cost and extent. The embedded guardrail has also begun to damage the concrete walkways and walls, and should be removed and filled with a cementitious patching material. Lastly, the underside of the walkways should be fully investigated to evaluate the extent of the underside reinforcing corrosion. The walkways can be repaired with standard corroded reinforcing repairs. It would likely be required to drain the tanks to access and make these repairs.

8102-01 – ROTATING BIOLOGICAL CONTACTOR (RBC) BLOWER BUILDING

No improvements or rehabilitation recommended at the RBC Blower building.

8102-02 –ROTATING BIOLOGICAL CONTACTORS (RBCS)

The Rotating Biological Contactors requires repair of the guardrail near the Secondary Clarifiers similar to the repair at the Primary and Secondary Clarifiers. In some minor cases the aluminum grating did not fit well in the concrete recesses. It is not currently a safety issue but several locations of grating were very close to falling through the embedment angle. The best short-term solution would be to add grating clips to hold the grating in place over the embeds and prevent possibility of grating falling through.

8102-03 – GENERATOR – ROTATING BIOLOGICAL CONTACTORS (RBCS)

No structural improvements or rehabilitation recommended at this structure.

8215-01 – TERTIARY PUMP PIT

No improvements or rehabilitation recommended at the Tertiary Pump Pit. There were slight stains in the basement due to pipe leakage. There was no visible water infiltration through the walls.

8215-02 – TERTIARY CLARIFIERS

No improvements or rehabilitation recommended at the Tertiary Clarifiers.

8123-01 – AB BLOWER / PUMP BUILDING

The water infiltration into the basement of the AB Blower / Pump Building needs to be addressed. The water source should be eliminated by either de-watering wells or waterproofing the wall. To patch the holes in the wall, a patch material that can be placed against running water would be desirable. One such product would be Xypex™ Patch and Plug. This product is commonly used but there are inconsistent results due to the difficulty in tracking the hidden cracks or weak concrete.

The monorail supports outside the structure were taken off the foundations and lifted up approximately three inches. The settlement of adjacent structures, sidewalk, and pavement should be monitored. The pavement and sidewalk can easily be replaced with more concern in detailing given to proper drainage away from the structure, frost protection, and expansive soil protection. Minor efflorescence was evident on the exterior of the building. Masonry sealing products will mitigate the effects of the efflorescence. As this structure is not directly adjacent to open tankage, most of the building does not see high moisture. However, since this construction is single Wythe masonry, it is more susceptible than cavity wall to long term moisture degradation.

The staff indicated they would like the hoisting system on the upper floor to be re-engineered to provide one lift off the pad and curve to move equipment out of the building. Currently one pair of rails is used to lift equipment off the pad to be set on a cart. The cart then has to be rolled several feet to another monorail and lifted out of the building again. The lifting systems in this building could be evaluated and moved to accommodate a single lifting system. Care should be taken to adequately address how the system would lift the equipment, what capacity the existing structure has, and if doors could be moved to provide a straight path out of the building from the equipment.

8123-02 – ACTIVATED SLUDGE – DISTRIBUTION BOX

No improvements recommended at the Activated Sludge – Distribution Box. There was slight corrosion at the clips holding down the aluminum grating. Recommend replacement of clips during normal maintenance cycle.

8123-03 – ACTIVATED SLUDGE – AERATION BASINS

No rehabilitation is recommended at the Aeration Basins. Staff onsite indicated a desire to replace the fabric baffles with cast in place concrete baffles. This was discussed in the process evaluation. Care should be taken to install the baffles while addressing the post tensioning strands in the tank walls.

8123-04 – ACTIVATED SLUDGE – CLARIFLOCCULATOR

No improvements or rehabilitation recommended at the Clariflocculator.

8123-05 – GENERATOR – SOUTH PLANT ACTIVATED SLUDGE

The first step would be to evaluate if the settlement of the structure has been stopped by the Owner's efforts to level the foundation. If settlement has stopped, accommodations or modifications can be made in the generator to foundation connections to properly align the generator and to provide for adequate flexibility in the connections to the site electrical. If the generator foundation is still moving however, mud jacking may be the better solution. Due to the water infiltration into the adjacent pump station, it is very likely that perched groundwater or some other source of water is in the vicinity and causing the settlement of the structure. In this case the water source could be eliminated by de-watering wells. A last alternative would be to relocate the generator and its foundation to an area where settlement is less of a potential or reconstruct the base on deep foundations similar to the on-site buildings.

Recommend working with a mud jacking contractor to determine what material would be appropriate for this application. There are many types of material available such as cementitious, soil based, and proprietary foam for different applications. Working with a contractor early and proper product selection would increase the likelihood of stopping the settlement of this structure.

8207-01 – UV DISINFECTION BUILDING

A project was recently completed to renovate the interior of this structure. No rehabilitation or improvements are recommended on the interior. See architectural section for further recommendations.

8207-02 – RE-AERATION BASIN

No improvements or rehabilitation recommended at the Re-Aeration Basin.

8207-03 – GENERATOR – UV/ADMIN

The first step would be to evaluate if the settlement of the structure has been stopped by the Owner's efforts to level the foundation. If it has stopped, accommodations or modifications can be made in the generator to foundation connections to properly align the generator and to provide for adequate flexibility in the connections to the site electrical. If the generator foundation is still moving however, jacking may be more successful. A last alternative would be to relocate the generator and its foundation to an area where settlement is less of a potential and put the generator foundation on deep foundations.

Recommend working with mud jacking contractor to determine what material would be appropriate for this application. There are many types of material available such as cementitious, soil based, and proprietary foam for different applications. Working with a contractor early and proper product selection would increase the likelihood of stopping the settlement of this structure.

8207-04 – OUTFALL STRUCTURE

No improvements or rehabilitation recommended at the Outfall Structure.

7907 – GAS BLOWER BUILDING

No improvements or rehabilitation recommended at the Gas Blower Building.

7909-01 – PUMP / BOILER BUILDING

No rehabilitation is recommended at this structure. Regular preventative maintenance is recommended to ensure the aggressive environment of the digester building does not damage the structure.

7909-02 – NORTH PRIMARY DIGESTER

No rehabilitation recommended at the North Primary Digester. The plant staff indicated that the roof of the covers needs to be accessed and the current rubber mats over the covers get slick in the winter. Per architectural review, a guardrail or bridge is required to safely access the top of the digester covers.

7909-03 – SOUTH PRIMARY DIGESTER

No rehabilitation recommended at the South Primary Digester. The plant staff indicated that the roof of the covers needs to be accessed and the current rubber mats over the covers get slick in the winter. Per architectural review, a guardrail or bridge is required to safely access the top of the digester covers.

7909-04 –SECONDARY DIGESTER

No rehabilitation is recommended at the Secondary Digester. The plant staff indicated that the roof of the covers needs to be accessed and the current rubber mats over the covers get slick in the winter. Per architectural review, a guardrail or bridge is required to safely access the top of the digester covers.

8029-01 – SOLIDS HANDLING BUILDING

Both approach slabs at the Solids Handling Building should be replaced due to the settlement damage. The floor of the load-out area could be overtopped with a cementitious coating to repair the damage already done and provide a more durable surface than exists currently.

The floor of the load-out area has been damaged by dragging the load-out bins across the floor. The entire floor could be ground down and re-topped with a more durable floor. One potential would be a metal aggregate infused concrete. This type of concrete is used on waste transfer station floors typically where dragging refuse or pushing loader buckets is used. Review installing steel wear plates to protect the floor once it has been repaired.

8029-05 – GENERATOR SOLIDS HANDLING

A stair and platform is required to properly access the generator controls. To accommodate a stair a foundation will be required as well. No other improvements or rehabilitation are recommended at this structure.

8115 – ADMINISTRATION BUILDING

Extensive water damage to concrete masonry units is apparent in many locations of the building. Recommendations and rehabilitation for this damage is contained in the Architectural Section of this report.

The water infiltration into the basement should be investigated from the outside. It is likely there is a water path at the base where the masonry wall, precast floor and cast in place basement come together. After removal of the dirt and landscaping around the exterior, re-waterproofing of the joint will prevent further infiltration. The grading can then be redone to ensure drainage away from the structure.

The exterior concrete cast in place stairs should be left in place as they are structurally sound. They will likely continue to settle slightly causing additional minor damage. If settlement affects the step height and causes a safety concern they should be torn out and replaced without significant impact to the surrounding walls or pavement.

7905 – WATER PLANT BUILDING

No improvements or rehabilitation recommended at this structure. This structure would accommodate a water main connection with minimal to no structural improvements.

7917 – OIL STORAGE BUILDING

No improvements or rehabilitation recommended at the Oil Storage Building.

7921 – WASTEWATER MAINTENANCE SHOP

No improvements or rehabilitation recommended at the Wastewater Maintenance Shop. The masonry walls inside the structure show signs of minor settlement and cracking. It does not appear that the settlement is still occurring since the cracks have not widened since the paint cracked.

8119 – METAL FABRICATION SHOP

No improvements or rehabilitation recommended at the Metal Fabrication Shop. The sidewalk outside the building shows signs of settlement and distress due to settlement. Sidewalk could be replaced with more attention paid to detailing for settlement and drainage. The structure does not appear to have settled.

SUMMARY OF MAJOR CONSTRAINTS

The recommended replacements or renovations and associated time frames are listed in Table 1.1.5.

Table 1.1.5. Structural Components Replacement or Renovation Schedule

Time Frame	Replacement or Major Renovation
0-5 Years	• Monitoring wells at AB Blower / Pump Building to determine source of water. Repair of water infiltration. • Replacement of railing and metal walkways at the Primary Clarifiers. Repair of concrete walkway damage due to corroded railings. • Replacement of railing at the Secondary Clarifiers. Repair of concrete walkway damage due to corroded railings. Addition of guardrail or walkways to the top of all three digesters to improve safety during slick conditions. • Masonry and Concrete repair at Solids Handling Building. • Mud jack UV / Administration Generator
5-15 Years	
15+ Years	• With the recommended improvements, the remaining structures could be maintained for 25+ years with normal maintenance.

1.1.2.4 Mechanical Condition

The mechanical review included review of the heating/cooling and ventilation systems. The plumbing systems were given a cursory review at the time of the evaluation. Detailed observation summaries are included in Appendix 1.1.D.

7913-01 – PRETREATMENT BUILDING

The Pretreatment Building is served by several hot water unit heaters and a roof mounted make-up air unit with energy recovery heat exchanger. The make-up air unit is a 100 percent outside air unit and has a glycol hot water coil fed by a glycol loop with recirculating pump and tied to the main hot water system. The make-up air unit ventilates the room at 12 air changes per hour (ACH). Equipment in the pretreatment room that handles exhaust air from the pretreatment rooms is explosion proof rated. The electrical room is cooled by a wall-mounted ductless fan coil with split condensing unit on the roof. A positive pressurization unit (PPU) and unit heater also serve the electrical room. Controls consist of thermostats. A floor drain on the lower level was clogged and should be cleared. The HVAC for this building was replaced in 2011 and is in good condition.

8013-01 – PRIMARY SLUDGE PUMP BUILDING

The Primary Sludge Pump Building consists of the air compressor room and the pumping pit.

Air Compressor Room

The air compressor room has two louvers but no permanent ventilation and subsequently gets very hot. A portable fan has been placed at one of the louvers to help in heat removal from the space. The room should be provided with a properly sized permanent ventilation system operated on a space thermostat to remove the compressor heat. There is also a hot water unit

heater in the room but the supply piping is disconnected. The piping should be repaired and new unit heater installed if heat is desired in this room.

Pumping Pit

The pumping pit is heated by two hot water unit heaters with explosion proof fan motors. The heaters appeared in good shape (newer), however some of the hot water piping showed signs of corrosion. The pump pit is ventilated by an exhaust fan with an intake louver.

8025-01 – SECONDARY BUILDING

The HVAC systems in the Secondary Building are not functional and should be replaced pending the long-term plan of the building. The PPU in the electrical room is new and in good condition. A temporary heater is being utilized in the restroom to prevent pipes from freezing. If the restroom is planned to remain in service, a permanent heater should be installed in the room. Two newer PPUs which are not in service are stored in this building and could be put to use elsewhere in the plant (such as the Solids Handling Building and the AB Blower/Pump Building).

Trickling Filter Pump Room

The Secondary Building Trickling Filter Pump Room is ventilated with two wall mounted propeller exhaust fans. The fans and controls are aged and should be replaced. The fans should be sized to provide general ventilation of the space as well as cooling ventilation for the pump motors. Proper make-up air louvers should also be provided in the room. The unit heaters serving the space are aged and corroded and should be replaced.

8102-01 – ROTATING BIOLOGICAL CONTACTORS (RBC) BLOWER BUILDING

The RBC Blower building is ventilated by two exhaust fans with make-up air louvers. An electric unit heater provides heat for the space. The exhaust fans and unit heater are operated off thermostats in the space. The fans are in average condition but beyond their expected service life.

8215-01 – TERTIARY PUMP PIT

The Tertiary Pump Pit is equipped with an exhaust fan and intake hood for ventilation. The fan and hood are installed on the lid of the below-grade pit. The electric heater has failed and a temporary heater has been installed in the pump pit. The permanent heater should be replaced. The exhaust fan should also be replaced as it is beyond its expected service life and could fail at any time. The space is humid, leading to corrosion issues and could benefit from either increased ventilation or dehumidification.

8123-01 – AB BLOWER/PUMP BUILDING

The building consists of the Blower Room, Pump Room, and Electrical Room which are served by separate HVAC systems. The HVAC systems for the whole building were installed in 2003.

AB Blower Room

The AB Blower Room is on the upper level of the structure and houses three blowers. The blowers draw air through a side wall louver and through the room before being sent to the aeration basins. This excess intake air overcools the room in the winter months and the unit heater cannot keep up. Plumbing piping is required to be drained before winter to prevent bursting of pipes. Additionally, the blowers reject a significant amount of heat to the room in the summer and the ventilation fan cannot keep up with the required heat removal. The HVAC for this space should be re-engineered and replaced. Modifying the blower intakes by routing them up through the roof should be considered. This would reduce the amount of outside air required to be drawn through the building. The exhaust fan size should be increased to meet the heat removal requirements and the louver damper actuator should be replaced as it is inoperable and stuck in the open position.

AB Pump Room

The AB Pump Room is on the lower level of the structure. An electric unit heater serves the space. A two supply/exhaust fan system ventilates the space. The ventilation system was not functioning at the time of the visit and should be replaced.

Electrical Room

The Electrical Room is on the upper level and walled off from the AB Blower Room. The room is ventilated by a roof mounted exhaust fan interlocked with a combination louver/damper intake. The fan enables and louver opens based on a thermostat in the space. A wall mounted electric unit heater provides heat for the space. The unit heater is rusted and in poor condition and should be replaced. Installation of a mechanical cooling system and PPU should be considered for the space to reduce the potential for corrosion of electrical equipment. An existing stored PPU could potentially be reused in this space.

8207-01 – UV DISINFECTION BUILDING

The UV Disinfection building has recently undergone a renovation and the HVAC systems are in good condition. The existing air handler was in good condition and re-used.

7907 – GAS BLOWER BUILDING

The Gas Blower Building has been recently constructed and HVAC systems are in good condition.

7909-01 – DIGESTER PUMP/BOILER BUILDING

The Digester Pump/Boiler Building is located between the three digesters. It houses two dual-fuel (propane and digester gas) hot water boilers. The boilers were installed in 2010 and are in serviceable condition. There have been issues with the boilers operating on digester gas however the controls and fuel train needs to be upgraded in the near future to improve operation on digester gas. Liquid was leaking from around the boiler exhaust flues and has caused some initial corrosion on the boilers.

An exhaust fan provides ventilation for the building. The building contains four louvers – two on the side walls and two on the doors. The louvers are permanently open. The louvers on the doors are corroded and should be replaced. Interior roof drain piping is severely corroded and should be replaced. One section of roof drain piping was leaking during the evaluation.

The Digester Pump/Boiler Building was recently declassified as the electrical and gas handling equipment was removed from the building. The building is in a grandfathered status as is allowed to meet current NFPA 820. The common wall construction with the digesters requires Class 1 Division 1 explosion proof construction. Review of the latest codes and input from the local inspector should be sought should any major modifications be considered for the building.

Two propane tanks and propane piping are outside of the building. The tanks and piping are showing signs of corrosion and should be replaced, or at a minimum be re-coated with a corrosion resistant coating.

8029-01 – SOLIDS HANDLING BUILDING

Load-Out Area

The load-out area of the Solids Handling Building is ventilated with an in-line exhaust fan and intake louver. The exhaust fan and louver were installed in 2003. The load-out is heated with several electric unit heaters with conditions ranging from good to unserviceable. A propane fired unit heater has recently been installed near the intake louver. An upgrade of the load-out HVAC system is recommended to include a propane-fired make-up air unit and exhaust fan to satisfy the push-pull requirement of NFPA 820.

Polymer Area

The Polymer Area is ventilated with a push-pull system consisting of a supply and exhaust fan on HOA switches. These fans were also installed in 2003. An electric unit heater serves the space along with another recently installed propane unit heater. A gas fired instantaneous unit heater is installed in the Polymer Area and is in good condition. The electrical equipment for the building is open to the Polymer Area. Replacement of this equipment is included in the sludge the recommended sludge handling improvements project.

Upper Level

The Upper Level of the Solids Handling Building houses the centrifuges. The centrifuge room is ventilated with a roof mounted exhaust fan and make-up air is pulled through a sidewall louver. A roof mounted exhaust fan and sidewall louver also serves the blower room on the upper level. An area being used as an office is also equipped with an exhaust fan as is the restroom on the upper level. All spaces on the upper level are heated with electric unit heaters. All fans, heaters, and louvers for the upper level were installed in the 2003 addition and should be slated for replacement in 5 years.

8115 – ADMINISTRATION BUILDING

The Administration Building is served by a water source heat pump system which uses the effluent stream as a condenser (through a heat exchanger located in the Metal Fabrication Shop). A re-design of the HVAC system was recently completed, so detailed review of the existing systems was not conducted.

7905 – WATER PLANT BUILDING

The Water Plant Building is heated by a gas fired unit heater which is beyond its expected service life and should be replaced. The ventilation fan is also beyond its service life and should be replaced.

7917 – OIL STORAGE BUILDING

The Oil Storage Building is served by a unit heater, exhaust fan and louver. The heater should be slated for replacement.

7921 – WASTEWATER MAINTENANCE SHOP

The Wastewater Maintenance Shop is heated by several hot water unit heaters served from the Maintenance Shop boiler. Several of the heaters are beyond their expected service lives and should be replaced. The boiler in the Maintenance Shop also serves the Pretreatment Building and the Primary Sludge Pump Building. The boiler was installed in 1990 and is beyond its expected service life and can be expected to fail at any time. It is recommended the boiler be replaced in the immediate future and that the replacement boiler system be provided with at least 2 boilers to provide redundancy. The existing hot water pump and piping in the boiler room should be replaced with a redundant pump system and the combustion air system reworked at that time also. A 20-gallon electric storage water heater is located in the boiler room and should be replaced also.

Currently there is no mechanical ventilation provided in the maintenance shop. Ventilation louvers and exhaust fans should be added to provide adequate ventilation to the building.

8119 – METAL FABRICATION SHOP

The Metal Fabrication Shop is a former chlorine storage building and most of the HVAC systems have not been re-worked to properly accommodate the change in use. The ventilation/exhaust systems are significantly oversized and should be replaced and ductwork re-worked. The space is heated with electric unit heaters which are beyond their expected service lives and should also be replaced. A local exhaust system (such as a retractable arm) should be provided at the welding tables.

The heat exchanger housed in this building is planned to be replaced as part of the Administration HVAC upgrade.

SUMMARY OF MAJOR CONSTRAINTS

The overall HVAC control philosophy at each of the buildings lacks functionality in most cases. Based on the type of HVAC equipment installed, a central location where all of the equipment could be monitored, but not necessarily controlled, would aid in maintenance of the systems. The recommended replacements or renovations and associated time frames are listed in Table 1.1.6.

Table 1.1.6. Mechanical Components Replacement or Renovation Schedule

Time Frame	Replacement or Major Renovation

0-5 Years	• Replace Maintenance Shop boiler and pump with new N+1 boiler system
	• Provide ventilation system for compressor room in Primary Sludge Pump Building
	• Repair/Replace roof drain piping in Digester Building
	• Install permanent heater in Secondary Building restroom
	• Full renovation of Solids Handling Building Ventilation
	• Replace Water Plant Building unit heater, exhaust fan and controls
	• Upgrade AB Blower Room Ventilation system/blower intakes
	• Add PPU and mechanical cooling to AB Blower/Pump Building Electrical Room
	• Replace Primary Sludge Pump Building Ventilation System
	• Replace corroded door louvers on Digester Building
	• Replace old Maintenance Shop unit heaters
	• Replace Maintenance Shop water heater
	• Renovation of Metal Shop HVAC system
	• Renovation of Secondary Building HVAC pending decision on use
	• Renovation of HVAC for the following will be minimized and completed as required to maintain facilities for next 10 years
	  o Trickling Filter Pump Room HVAC upgrade
	  o Replace Tertiary Pump Pit ventilation system, add dehumidifier
	  o Replace unit heater in Tertiary Pump Pit
	  o Replace RBC Blower Building Exhaust fans and unit heater

5-15 Years	• Replace AB Pump Room ventilation system • Replace UV Building air handling unit
15+ Years	• Campus Wide Odor Control System • Replace Digester boilers • Replace Gas Blower Bldg. HVAC

1.1.2.5 Electrical Condition

The following paragraphs are summaries of the conditions and recommendations discussed in this study. The Comprehensive Condition Evaluation was broken down in to four major groups:

1. Electrical Equipment. Including utility electrical service equipment, standby generator systems, switchgear, motor control centers, step down transformers and panel boards.
2. Cable and Conductors.
3. Lighting.
4. Miscellaneous. Including conduit, outlet and junction boxes, disconnect switches and receptacles.

POWER DISTRIBUTION

Black Hills Power serves the Rapid City WRF with five (5) separate utility services via oil-filled, pad-mounted transformers. The Utility owns and maintains all electrical equipment and systems on the primary side of the five (5) transformers, including the transformers themselves. The City owns and maintains all electrical equipment and distribution system equipment downstream of the secondary side of each transformer.

Based on the documentation provided, it does not appear that there is an overall functional one line diagram of the Rapid City WRF. Several partial sets of functional diagrams from past projects show interconnections of buildings and major equipment to provide a basic understanding of the distribution system with some effort. It is recommended that a comprehensive one line diagram should be developed to show all equipment, down to the 120 volt panel boards including all ratings (amps, volts, short circuit, etc.). The one line diagram should then be framed and hung in an appropriate location. It is also recommended that a tag/naming convention be developed and have all equipment provided with a unique tag/name and posted on the equipment. These two recommendations will make all future modifications or repair to the distribution system easier as it provides a “road map” for electricians or other people who come to the plant for emergency repairs.

An Electrical Preventative Maintenance (EPM) program is important to maintain distribution system cables, switchgear, MCCs, panel boards and transformers for a long service life. Such an EPM program could also proactively warn the City of pending equipment failures early, and allow scheduled equipment replacements via planned outages rather than emergency shutdowns. It appears that minimal EPM has been done on the equipment, although the City’s routine maintenance program has been periodically replacing some equipment as it becomes obsolete or too failure prone to maintain. Basic items, such as the routine exercising of breakers and lubricating breakers and switches are critical so that they operate when there is process equipment or cable failures. Making sure lugs are tight and there is no damage or corrosion that could cause the equipment to fail will keep the plant processes running without extended outages when there is a failure. Routine and periodic thermal imaging and insulation resistance testing can also track temperatures and insulation resistance values over time to

monitor hot spots and insulation system weaknesses proactively, rather than waiting for a failure to take you out of service. This approach allows operations to schedule and perform equipment replacements prior to failure and on your own time rather than wait for an emergency situation. This approach also gives piece of mind that the equipment will not be as likely to fail.

The major plant electrical equipment consists of metal enclosures with copper or aluminum bus work or coils which could have a very long life (50+ years) if regularly inspected for loose connections (heat) and corrosion (rust and hydrogen sulfide) and subsequently maintained to top working specifications and condition on a routine basis.

It is the components within the enclosures that contain moving parts or mechanically-fastened connections that are more susceptible to failure, including circuit breakers, breaker electronic trip units, controls, and draw-out breaker mechanisms that, with if appropriately maintained, should generally have another 10 – 20 years or more of life remaining, depending on the external market availability for repair and replacement components.

Although the majority of the major plant electrical equipment has several years of life remaining and in fact, several MCC lineups and related equipment have recently been replaced, there is still some key equipment that has much less useful life remaining. The facility major electrical equipment items are identified as follows:

Motor Control Center and Electrical Service Entrance Equipment

- Pretreatment Building MCC-2 (2012) – fed from Maintenance Shop MCC-3
- Secondary (Operations) Building MCC-1 (2011) – Siemens Smart MCC – Utility Service #1
- Digester Building MCC-4 (1990) – GE Spectra Series – fed from Maintenance Shop MCC-3
- AB-Blower / Pump Building MCC-BP (2003) – Eaton/Cutler Hammer – Utility Service #4
- Solids Handling Building MCC-SH (2003) – Eaton/Cutler Hammer – Utility Service #3
- UV Disinfection Building MCC-UV (2003) – Eaton/Cutler Hammer – Utility Service #5
- Maintenance Shop MCC-3 (1990) – GE 8000 Line – fed from Secondary (Operations) Building MCC-1
- RBC Blower Building MCC-1 (1986) – Westinghouse Five Star – Utility Service #2
- Metal Fabrication Shop (former Chlorine Storage Building) MCC-2 (1986) – Westinghouse Five Star – fed from RBC Blower Building MCC-1.

Standby Power Generation Equipment

- Secondary (Operations) Building 500kW Diesel Kohler Genset and ATS (Genset pre-1995, ATS New in 2011)
- RBC Blower Building 400kW ONAN Diesel Genset and Cummins ATS (pre 1990)
- Solids Handling Building 500kW Caterpillar Diesel Genset and Eaton ATS (2003)
- AB Blower / Pump Building 750kW Caterpillar Diesel Genset and Eaton ATS (2003)
- UV Disinfection Building / Admin 500kW Caterpillar Diesel Genset and ATS (2003)

CABLES AND CONDUCTORS

Exposure to heat and moisture greatly affect the longevity and reliability of cables and conductors. Heat is generated externally from the environment and internally by the loading of the conductors. Moisture is also generated externally from the environment and moisture may be more problematic if installation methods are not followed to reduce the likelihood of continually-submerged or wet cables. Moisture in conduits can freeze and form ice in colder temperatures and the expansion/contraction cycle and can damage insulation. The effects of heat and moisture can also be exacerbated by the presence of caustic and corrosive gases like hydrogen sulfide that are present at wastewater treatment facilities.

Installing cables that have tin-plated, copper conductors (over bare copper) reduces the corrosive effects of hydrogen sulfide gas and period insulation resistance testing of cables for insulation integrity can track the integrity of cables over time and in most cases can predict impending cable failures ahead of time, rather than reacting to failures after they occur unexpectedly.

LIGHTING

There are recent changes in code and laws that affect current lighting design. They include the Energy and Independence and Security Act of 2007, Energy Policy Act of 2005 (EPAct 2005) and the applicable Energy Code (as adopted by the State of SD).

EPA 2005 requirements that affect the Plant are the discontinuation of the manufacture of ballasts for mercury vapor lamps (lamps still available, but nearing discontinuation) and T12 fluorescent lamps (lamps still available, but nearing discontinuation). Some of these types of lamps were observed throughout the facility. This requirement was put in the EPAct as new lamp/ballast combinations exist that are significantly more energy efficient. Therefore, it is recommended that the luminaires with these lamps remaining be scheduled for replacement in conjunction with other improvements projects or as part of the on-going facility maintenance efforts. It should be noted that several areas of the facility have already been upgraded with fixtures that meet the new requirements as part of the facility routine maintenance program. A building-by-building schedule approach could be used to develop a comprehensive lighting replacement plan, where lamps and ballasts are salvaged and used as replacements for buildings where replacement is scheduled for future years.

Energy and Independence and Security Act of 2007 requirements basically affect the Plant incandescent lamps. Incandescent lamps will be discontinued soon and will need to be replaced with screw in compact fluorescent lamps or LED lamps. The plant appears to still use incandescent lamps in several locations that should be considered for replacement, but only as the incandescent lamps become unavailable or as part of larger overall building or facility improvements projects. These fixtures are turned on and off manually by the staff when needed during night time activities, so instant on lamp type would be necessary.

The Energy Code basically outlines watts per square foot limits and automatic lighting control requirements to reduce the amount of energy consumed by the structure. Major renovations to

facilities or fixture replacement projects, will be required to follow both requirements of the Energy Code. During the assessment walk through, it was noticed that several fixtures were not operational (ballast or lamp not functioning), but the light level appeared to be adequate, so a fixture replacement project could reduce the number of fixtures, but would also increase costs for required new conduit and wire to potential new fixture locations.

The Building Code requires emergency lighting and exit signage in rooms that require two exits. The exits sign are required to be illuminated internally or externally. The code requires the exit and emergency lights to be powered by a backup source for 90 minutes. It appears that the standby generators are the backup source and every fixture at the Plant is essentially an emergency light fixture. The Code also requires the generator to provide power to the emergency lights within 10 seconds. While “life safety” and “optional standby loads” can be powered by the same standby generator, there are specific installation and wiring requirements that must be followed to physically separate out the two systems from one another. A review of the life safety plan is also recommended.

While several of the current codes, laws and standards would directly affect new lighting designs, we do not feel it prudent at this time to do wholesale replacements of existing lighting, as long as replacements lamps and ballasts can still be procured as part of routine maintenance to keep the existing lighting systems functioning. The maintenance staff has done a good job maintaining and replacing lights and lamps as part of the routine maintenance program at the WRF. Since the majority of the plant lighting systems are switched on and off manually (and are not on all that much), it does not make financial sense to just start replacing entire lighting systems, if the installed lighting systems are still functional and capable of being maintained. We would suggest the better approach would be to wait and replace the lighting systems with higher efficiency LEDs or fluorescents as part of future overall, individual building upgrade projects.

MISCELLANEOUS

For conduit, outlet boxes, junction boxes and safety switches the major concern is corrosion (rust). For this Plant interior humidity/water, hydrogen sulfide and exterior weathering is the major source of corrosion. Over the next several years the failures in supports structures and conduit straps will increase, currently, there were a few failures identified.

GENERAL CODES AND STANDARDS

Several industry-recognized codes and standards are referenced and utilized in the design of wastewater treatment facilities. These codes and standards address requirements related to maintaining the health and safety of facilities for staff working at the facility. The total applicable list for electrical design is extensive and is briefly summarized by including the major general category references as follows:

- National Electric Code (NEC)
- National Fire Protection Association (NFPA), including NFPA 820
- National Electric Safety Code (NESC)

- Ten States Standards for Wastewater Treatment Facilities
- International Fire Code (IFC)
- International Building Code (IBC)

These codes dictate items such as equipment ratings and design requirements, clearances and access space in front of electrical equipment, hazardous area classifications and explosion-proof equipment ratings, means and methods of electrical installation, short circuit analysis and labeling, arc-flash hazard risk assessment criteria, fire protection systems, emergency systems and many other related electrical system and personnel safety requirements.

From our review of applicable codes and standards and our brief site assessment, we believe the following areas should be evaluated further pursuant to the applicable codes and standards:

- Complete an Overall Power System Study for the WRF to determine the short circuit current availability at each piece of electrical gear and label accordingly (NEC).
- Complete an Overall Arc Flash Hazard Risk Assessment Study for the WRF to determine the Arc Flash Hazard Potential at each piece of electrical gear so that adequate personnel protective equipment (PPE) is utilized by staff working on energized equipment and label each piece of equipment accordingly (NFPA 70E).

Currently, there are areas that are identified that may not be in full compliance with applicable codes and standards and may require further review and/or action as follows:

- Clearance issue in front of MCC4 located in the small Digester Electrical Building (RIO panel infringes into the required MCC4 clear space).
- Tertiary Pump Pit can be de-rated from hazardous area rated construction.

SUMMARY OF MAJOR CONSTRAINTS

The following summary identifies key constraints on a per building/area basis:

Pretreatment Building

The Pretreatment Building has recently undergone a renovation and the electrical systems are in good condition. One item to be further evaluated is the cost/benefit of adding a small natural gas standby generator set to just power the most critical loads at the Pretreatment Building. Such a generator may add additional operational flexibility and peace of mind to ensure that incoming sewage can be pre-treated, regardless of the condition of the larger existing Kohler generator, the condition of the Utility electrical supply and/or the diesel fuel supply to the existing Kohler generator. The City has had previous experience with extended storm outages and the logistics of maintaining diesel fuel to the generators beyond a couple of days. A small natural gas generator may add additional redundancy and operational flexibility to be able to ride through such catastrophic events as an extended storm outage with major damage to infrastructure.

Primary Sludge Pumping Building

The Primary Sludge Pumping Building has recently undergone a renovation to relocate some of the controls equipment to the Pretreatment Building as the internal temperature of this building gets very hot during operation. The electrical and controls infrastructure in this area of the plant is some of the older equipment in operation at the facility. It appears that the WRF is systematically replacing and upgrading several items in this area as part of routine maintenance. A PVC conduit was noted as being pulled apart underneath the walkway around one of the primary clarifier drives.

Secondary Building

The Secondary Building has recently undergone a renovation and the electrical systems are in good condition. The existing Kohler standby generator has been reliable, but it is the second oldest generation system at the facility and should be planned for replacement.

RBC Blower Building

The RBC Blower Building has some of the oldest MCC and VFD equipment installed at the facility and the standby generator, while historically reliable is the oldest standby generator at the facility and now obsolete. It is understood the RBCs may only be in operation for a short period of time going forward (10 years or less), so replacements of the electrical equipment in this facility are suggested on an as-required basis only, as part of routine maintenance activities. The enclosure front-doors for the VFDs are missing some hardware to hold the doors captive which should be repaired for safety reasons. It is further suggested to continue to use the existing standby generator until which point in time the RBCs can be eliminated and a new generator can be adequately sized to power the treatment loads that replace the RBCs.

Tertiary Pump Pit

The Tertiary Pump Pit is a below grade structure that is a damp and harsh environment for the electrical and controls equipment. The Tertiary Pump Pit is provided power from the RBC Blower Building via the Metal Fabrication Building (old Chlorine Storage Building). The electrical equipment presently installed in this facility is rated for explosion-proof service. The area can be de-rated to unclassified due to its location at the far end of the treatment stream. Pending the area classification review with local authorities, the electrical and controls equipment should be able to be replaced with a more suitable and cost effective type that will hold up better in the space. Improvements would depend on if this area can be repurposed.

AB Blower/Pump Building

The AB Blower/Pump Building MCC equipment was installed in 2003 and appears to be in normal working order for its age. The electrical room of the facility was noted to be cooled by forced-air ventilation only and was fairly dirty with dust, dirt and insects. This type of dirt and contamination can be particularly damaging to electronic components such as VFDs. It is recommended that air conditioning be added to keep the space cleaner and elongate the life of the electrical equipment. Several parallel sets of electrical service entrance conduits run

exposed in the lower level of the building until they reach the MCC on the opposite wall. The NEC requires that service entrance conduits not be exposed inside the facility since they are essentially un-protected by overcurrent devices. This would be fairly low priority as the extent of the exposure is not excessive.

UV Disinfection Building

The UV Disinfection Building recently underwent a renovation which replaced the UV equipment and reused the existing 2003 MCC B. The electrical systems are in good condition.

Gas Blower Building

The Gas Blower Building was recently constructed and the electrical systems are in good condition.

Digester Pump/Boiler Building

The Digester Pump/Boiler Building was recently declassified. A review of NFPA 820 and this declassification should be performed prior to major modifications to confirm the proper area classification for this area. This area also contains the liquid Ferric which is very corrosive and damaging to electrical equipment. The Ferric should be relocated to its own separated and dedicated space. MCC-4 was installed in the small metal building outside the digester and the MCC is now approximately 15 years old. There are some clearance issues in front of MCC-4 in this building and the MCC is showing signs of corrosion on the enclosure, hardware and electrical connections. Due to the corrosion noted and age of the MCC (15 years old), replacement is recommended soon. Options such as enlarging the metal building or relocating a replacement MCC to a portion of the Oil Storage Building should be considered.

Solids Handling Building

The Solids Handling Building contains an MCC on the lower level of the facility that is open to the polymer portion of the facility and is subject to a wet, caustic and corrosive environment. The MCC while not all that old (2003) is showing signs of corrosion and some leakage of sludge in/on the enclosure. The environment in the area surrounding the Solids Handling Facility appears to be very harsh for the standby generator installed just outside the building and the generator has much corrosion on it.

The electrical and instrumentation should be improved as follows:

- Electrical and instrumentation should be replaced as part of the recommended sludge handling improvements.
- The centrifuge control panels and the sludge holding pond mixer control panel located in the centrifuge room in the upper level should also be relocated to their own dedicated and isolated space.
- The mixer control panel should be replaced and VFDs should be added for each mixer to provide turndown capability to match low flow conditions.

- The MCC needs to be sized to accommodate the decant pump without having to utilize power from one of the mixers.

Administration Building

The Administration Building electrical equipment appears to be in good working order and no replacements are required any time soon.

Water Plant Building

The electrical equipment in the Water Plant Building, while not new, appears to be working satisfactorily and is in decent shape for its age. No replacements other than lighting are required.

Oil Storage Building

The electrical systems in the Oil Storage Building appear to be in good working order and are adequate for present operations. Upgrades and/or revisions may be required depending on what happens with the relocation/replacement of MCC-4 and the ferric from the Digester Pump/Boiler Building.

Wastewater Maintenance Shop

The Wastewater Maintenance Shop is a critical piece to the electrical distribution system at the facility as the power for the Pretreatment Facility and the Digester Building are fed from MCC-3. MCC-3 is approximately 25 years old and has some corrosion on the electrical connections internal to the MCC. The MCC is recommended for replacement soon. There is also an external wooden “cable pulling shed” that all of the power cables to/from MCC-3 run through. The shed is also approximately 25 years old and it is recommended that it be replaced with a more permanent pre-fabricated fiberglass or pre-cast enclosure that is better suited as a cable-pulling enclosure. The pre-fabricated enclosure could also house the replacement MCC-3 as this approach would get the MCC out of the maintenance shop and into a more controlled and dedicated environment. There is also a large painted steel exterior pull box on the building that should be replaced.

Metal Fabrication Shop

The Metal Fabrication Shop includes a Westinghouse MCC that used to feed the chlorination equipment loads, but now only feeds the remaining building loads. This building receives power from the RBC Blower Building and 400kW Standby Generation System. While the MCC is obsolete, it appears to be in good enough working order for the current reduced loads and should be left in service until that time when parts cannot be located for maintenance purposes or the RBCs are replaced with alternate technology. It is suggested to replace the MCC when the RBCs are removed from service and the associated standby generation system is also replaced.

Prediction of the remaining useful life for electrical equipment is an estimate and relies heavily on on-going maintenance and continued availability of repair parts. Based on this evaluation

and discussions with Operation and Maintenance staff, the equipment replacement schedule shown in Table 1.1.7 should be considered.

Table 1.1.7. Electrical Components Replacement or Renovation Schedule

Time Frame	Replacement or Major Renovation

0-5 Years	• Replace MCC-3 and any additional power panels (Maintenance Shop) along with the wooden cable pulling hut by the Maintenance Shop, possible combining into one new pre-fabricated fiberglass or concrete enclosure. While impending and immediate failure is unlikely, the age of the equipment and the noted corrosion presents a risk to leave in service.
	• Replace MCC-4 (located in the building in front of Digester Pump/Boiler Building), enlarge the building to provide adequate clearance in front of MCC-4 or possibly relocate it to the Oil Storage Building. While impending and immediate failure is unlikely, the age of the equipment and noted corrosion presents a risk to leave in service.
	• MCC-SH (located in the Sludge Handling Building) and the following should be replaced in an isolated space as part of the recommended sludge handling improvements:
	  • Replace the Solids Handling Building Standby Generation System and ATS.
	  • The centrifuge control panels and the sludge holding pond mixer control panel located in the centrifuge room in the upper level should also be relocated to their own dedicated and isolated space.
	  • The mixer control panel should be replaced and VFDs should be added for each mixer to provide turndown capability to match low flow conditions.
	  • The MCC needs to be sized to accommodate the decant pump without having to utilize power from one of the mixers.
	• Add air conditioning to the AB Blower/Pump Building Electrical Room to elongate the life of the ATS, VFD, and MCC and control panel equipment.
	• Clean and inspect the three Caterpillar Standby Generation Systems (AB Blower/Pump Building and UV/Administration Building and upgrade the controls and wiring with systems enhanced for extreme use and corrosive areas (marine package), especially the generator system and near the Sludge Handling Facility and its associated ATS.
	• Replace the 400kW ONAN Standby Generator System that presently feeds the RBC Blower Building, Metal Fabrication Shop and Tertiary Pump Pit. Provide 500 kW unit so that it can be repurposed to another location at the plant when the RBCs are taken out of service.

5-15 Years	• Replace the Blower/Pump Building MCC-AB, dependent on how well the existing MCC holds up when air conditioning is installed to the MCC Room space. It is highly likely that this may be able to be pushed out past 15 years. • Replace the 500kW Kohler Standby Generation System near the Secondary Building. This generator is critical as it powers the entire North side of the WRF.

Time Frame	Replacement or Major Renovation
15+ Years	• Replace Utility Company primary service cables and transformers, depending on testing and future corrosion caused by exposure. • Replace the Secondary Building (for remaining equipment), Pretreatment Building and UV Building MCCs. • Replace the Caterpillar Standby generation systems installed at the AB Blower/Pump Building and the UV Building.

1.1.2.6 Instrumentation and Controls Equipment Condition

GENERAL

The plant control and SCADA system recently underwent a major renovation via an improvements project. The project included the replacement of the existing in-plant WI-FI radio-modems with a single-mode fiber optic cable loop around the plant. The new fiber optic cable loop will provided a high-speed, high-bandwidth communication network for all of the local plant Allen-Bradley PLC controllers with a new polling SCADA Master PLC that was installed at the Administration Building. A SCADA HMI software package upgrade to VTScada software was also included.

The fiber optic and SCADA HMI software improvements implemented lay the high-speed, large-bandwidth groundwork for all future SCADA and peripheral WRF system improvements and monitoring. The virtually unlimited capacity of the fiber optic system can support all future control and security system enhancements including, but not limited to the following potential system improvements at the WRF:

- High Speed Internet Service to the WRF via Fiber Optic to allow remote access and the potential for off-site cloud backup storage
- WRF Access Gate System Improvements including intercom and video surveillance over fiber optic
- Septage Receiving System Improvement including card swipe for security and recording, intercom and video surveillance over fiber optic.
- Fire, Access Control, Security and HVAC communication over fiber optic and the potential integration of all of these standalone systems into one common platform for ease of use.

SUMMARY OF MAJOR CONSTRAINTS

7913-01 - PRETREATMENT BUILDING

The Pretreatment Building instrumentation and control systems are recently new and in good working order. The Allen Bradley SLC 5 PLC will need to be replaced within the next 2 to 3 years as Allen Bradley is no longer supporting these units.

7913-02 – SEPTAGE RECEIVING

Septage receiving tank level sensing should be added. The level would be converted to a volume calculation via the main PLC to track received volume.

8013-01 - PRIMARY SLUDGE PUMP BUILDING

This at-grade building presently operates with a very hot internal temperature. City staff recently relocated the controls from this building to the Pretreatment Building to deal with the heat concerns.

8013-02 - PRIMARY CLARIFIERS

The sludge blanket level detectors need to be replaced.

8025-01 - SECONDARY BUILDING

The Secondary Building instrumentation and control systems are recently new and in good working order. The Allen Bradley SLC 5 PLC will need to be replaced in the next 2 to 3 years.

8102-01 - RBC BLOWER BUILDING

The future of this building is assumed to be limited to less than 10 years. Instrumentation and control upgrades are not recommended due to the short anticipated remaining life cycle of this facility.

8215-01 - TERTIARY PUMP PIT

This facility is below-grade and humid, damp and corrosive. Presently all installed equipment is rated as explosion-proof which is not required.

8123-01 - AB BLOWER/PUMP BUILDING

The AB Blower/Pump Building includes an Allen Bradley SLC 5/05 PLC that is quickly approaching an unsupported state by Allen Bradley. The PLC should be replaced with an Allen-Bradley CompactLogix PLC in the next 2 to 3 years. Additionally, there are also Allen-Bradley SLC 5 PLCs in the Blower Control Panel and the Splitter Box Control Panel that will need to be replaced in 2 to 3 years.

8123-02 – ACTIVATED SLUDGE – DISTRIBUTION BOX

The splitter box gate actuators need to be replaced as they are worn and require frequent calibration. In addition, flow metering is included in the scope of future south plant activated sludge improvements.

8207-01 - UV DISINFECTION BUILDING

The UV Disinfection building has recently been renovated and the electrical systems are in good condition.

7907 - GAS BLOWER BUILDING

The Gas Blower Building has been recently constructed and electrical systems are in good condition.

7909-01 - DIGESTER PUMP/BOILER BUILDING

The Digester Pump/Boiler Building is located between the three digesters. The hazardous area classification of this space should be confirmed prior to any major repairs as the area is under NFPA grandfather rule status. No instrumentation and control improvements are required at this time.

8029-01 - SOLIDS HANDLING BUILDING

The Solids Handling Building includes a control panel section as part of MCC-SH. The control panel includes an Allen-Bradley SLC-503 PLC. It is likely that Allen Bradley will no longer support the SLC PLC platform for more than 2 to 3 years. Replacement of the PLC should be planned in the near future (5 to 10 years). The upper-level of the facility includes centrifuge manufacturer control panels that include Allen-Bradley SLC 5 PLCs and a separate Sludge Holding Pond Mixer Control Panel that is failing. The two Centrifuge Control Panel SLC 5 PLCs should be replaced in 2 to 3 years.

All of the controls equipment is installed in a common space with the centrifuge equipment. Further consideration should spent on determining whether all of the controls should be relocated to their own controlled space (remodel of existing blower space on upper level as an option), separate from the centrifuges to elongate the life of the equipment. The Sludge Holding Pond Mixer control panel should be replaced soon and the possibility of adding VFDs to all the mixers to be able to turn them down during low flow periods to save energy should be evaluated.

Centrate Tank

The ultrasonic level sensor in the centrate tank needs to be replaced. It is recommended to add centrate flow metering from sludge storage ponds

8115 - ADMINISTRATION BUILDING

The Administration Building Master SCADA control panel and HMI software has recently been updated and no additional improvements are recommended. The Secondary/Operations Building Control Panel includes an Allen Bradley SLC5 PLC that should be replaced in 2 to 3 years. Access control, intercom and CCTV capability should be added to the Administration Building.

7905 - WATER PLANT BUILDING

The Water Plant Building is adequate for instrumentation and control and no instrumentation and control upgrades are required.

7917 - OIL STORAGE BUILDING

The Oil Storage Building is adequate for instrumentation and control and no instrumentation and control upgrades are required.

7921 - WASTEWATER MAINTENANCE SHOP

The Wastewater Maintenance Shop has limited instrumentation and control and no instrumentation and control upgrades are required.

8119 - METAL FABRICATION SHOP

The Metal Fabrication Shop is a former chlorine storage building and has limited instrumentation and control/SCADA needs. No instrumentation and control upgrades are required. The existing Allen Bradley SLC 5 PLC will need to be replaced in 5 to15 years.

Based on the condition assessment of the control and instrumentation at the Rapid City WRF, the replacement schedule shown in Table 1.1.8 should be considered.

Table 1.1.8. Instrumentation and Controls Equipment Replacement or Renovation Schedule

Time Frame	Replacement or Major Renovation
0-5 Years	• Access Control, Intercom and CCTV (Admin/Driveway). • Add Septage Receiving Station volume metering. • Add Centrate Flow metering from Sludge Storage Ponds. • Replace Sludge Blanket Level Detectors in Primary Clarifier. • Replace Failing Ultrasonic Level Sensor in Centrate Tank. • Upgrade Splitter Box Flow metering inefficiencies. • AB SLC5 PLC Processors (Typical for remaining units).
5-15 Years	
15+ Years	• PLC Processors

1.1.2.7 Replacement and Renovation Schedule

Table 1.1.9 presents a schedule for replacement and renovation at the Rapid City WRF based on the assessment of the current physical condition of major facilities and equipment. This schedule needs to be coordinated with overall long range planning efforts to ensure that resources are being allocated meaningfully. For example, it may not be prudent to invest in equipment replacement if that equipment is going to be obsolete in the future plans for the facility.

Table 1.1.9. Rapid City WRF Replacement and Renovation Schedule

Time Frame	Process	Architectural	Structural	Mechanical	Electrical	Instrumentation
0–5 Years	Trickling Filter Lift Pumping and Piping Remove and replace waste gas flare gas line with slope to building as required. Influent Screening: An emergency unscreened bypass is required. Automatic restart after power outage needs to be added. Provide tip up mechanism for manual bar screens or removing screens completely for emergency situation where screenings cannot be returned to service. Provide hardwire floats for level alarming due to critical function. Ensure programming is providing proper screen reversing during jamming events. Digester Boilers: Replace controls with dual controls. Recoat units. Primary clarifier effluent trough bypass gate: Broken free of its mountings and is in poor condition and needs to be removed and replaced. AB Curtain Wall (Anoxic Basin): Remove and replace with concrete curtain wall which withstand high flows. AB Blower: Investigate replacing blower with newer more efficient blowers with better turndown ratio or adding smaller jockey blower(s). If blowers are not slated for replacement, complete overhaul is required in next 5 years. Include costs to extend blower inlets to exterior complete with inlet hoods for exterior service. AB Distribution Gate Actuator: Replace actuators as units are worn and need to be recalibrated frequently. Review options for flow metering to South Plant or to each aeration basin. AB Diffuser Grid: Inspect and replace diffusers as required. Given age replace all diffusers in next 5 years. AB Air Supply: Investigate aeration zone header inlet valve modulation. Determine if malfunction is mechanical or a matter of loop tuning. Replace valve actuators. RAS/Drain Pump: Add new self-priming pump on RAS suction header with discharge tied to discharge header. This would drain to other tank and could be sized to add additional RAS pumping capacity for future. Grounds Wells: Plug wells. Roads: Resurface plant access drives. Laboratory Samplers: Follow through with replacement schedule of plant composite. Provide flow proportional signal to composite sampler. Consider incorporating alarm monitoring features provided with the new composite samplers into SCADA. Provided cost for 3 new units to provide for improved sampling at influent, effluent and primary effluent. Assumed remaining will rotate as required. Primary Scum Pump and Piping to Digester: Remove and replace with Gorman Rupp 40p Air Diaphragm Pump with automated suction valving, and new suction and discharge piping -To be run off	Improve access to digester covers Cleaning, tuck-pointing and application of liquid water repellent to building exteriors Perform survey of fall protection throughout the plant and identify needed improvements Remodel Administration Building locker rooms Implement fall protection improvements Implement door and hardware replacements and upgrades	Rehabilitation of wet well of Trickling Filter Pump Station (Lower level of Secondary Building) Monitoring wells at AB Blower / Pump Building to determine source of water. Repair of water infiltration. Replacement of railing and metal walkways at the Primary Clarifiers. Repair of concrete walkway damage due to corroded railings. Replacement of railing at the Secondary Clarifiers. Repair of concrete walkway damage due to corroded railings. Addition of guardrail or walkways to the top of all three digesters to improve safety during slick conditions. Masonry and Concrete repair at Solids Handling Building.	Replace Maintenance Shop boiler and pump with new N+1 boiler system Provide ventilation system for compressor room in Primary Sludge Pump Building Repair/Replace roof drain piping in Digester Building Install permanent heater in Secondary Building restroom Replace unit heater in Tertiary Pump Pit Full renovation of Solids Handling Building Ventilation Replace Water Plant Building unit heater, exhaust fan and controls Trickling Filter Pump Room HVAC upgrade Replace RBC Blower Building Exhaust fans and unit heater Upgrade AB Blower Room Ventilation system/blower intakes Add PPU and mechanical cooling to AB Blower/Pump Building Electrical Room Replace Tertiary Pump Pit ventilation system, add dehumidifier Replace Primary Sludge Pump Building Ventilation	Replace MCC-3 and any additional power panels (Maintenance Shop) along with the wooden cable pulling hut by the Maintenance Shop, possible combining into one new pre-fabricated fiberglass or concrete enclosure. While impending and immediate failure is unlikely, the age of the equipment and the noted corrosion presents a risk to leave in service. Replace MCC-4 (located in the building in front of Digester Pump/Boiler Building), enlarge the building to provide adequate clearance in front of MCC-4 or possibly relocate it to the Oil Storage Building While impending and immediate failure is unlikely, the age of the equipment and the noted corrosion presents a risk to leave in service. MCC-SH (located in the Sludge Handling Building) should be replaced in an isolated space as part of the recommended sludge handling improvements. The centrifuge control panels and the sludge holding pond mixer control panel located in the centrifuge room in the upper level should also be relocated to their own dedicated and isolated space. The mixer control panel should be replaced and VFDs should be added for each mixer to provide turndown capability to match low flow conditions. The MCC needs to be sized to accommodate the decant pump without having to utilize power from one of the mixers. Add air conditioning to the AB Blower/Pump Building Electrical Room to elongate the life of the ATS, VFD, and MCC and control panel equipment. Clean and inspect the three Caterpillar Standby Generation Systems (Sludge Handling, AB Blower/Pump Building and UV/Administration Building and upgrade the controls and wiring with systems enhanced for extreme use and corrosive areas (marine package), especially the generator system and near the Sludge Handling Facility and its associated ATS. Replace the 400kW ONAN Standby Generator System that presently feeds the RBC Blower Building, Metal Fabrication Shop and Tertiary Pump Pit. Provide 500 kW unit so that it can be repurposed to another location at the plant when the RBCs are taken out of service.	Access Control, Intercom and CCTV (Admin/Driveway) Add Septage Receiving Station volume metering Access Control, Intercom, CCTV and Billing Recording -- New Septage Receiving Station Add Centrate Flow metering from Sludge Storage Ponds Replace Sludge Blanket Level Detectors in Primary Clarifier Replace Failing Ultrasonic Level Sensor in Centrate Tank. Automate controls for Centrate Flow Upgrade Splitter Box Flow metering inefficiencies AB SLC5 PLC Processors

Time Frame	Process	Architectural	Structural	Mechanical	Electrical	Instrumentation
	of existing compressed air. Also includes replacing buried piping as is plugged from primary clarifier. Primary Clarifier Skimmer: Replace skimmers and extend new grease lines. Primary Skimmer Gearbox: Remove and replace. Primary Sludge Collector Gearbox: Remove and replace. Secondary Clarifier 1, 3, 4 Gearbox: Remove and replace. Clariflocculator Seal: Replace Seal. Secondary Humus Pump: Removed and replace. Digester Boiler Gas Lines: Replace gas feed piping with stainless steel. Digested Sludge Chemical Feed: Ferric and Sodium Hydroxide chemicals feed need new isolated location complete with containment. Chemical should be relocated and sealed in the meantime. Centrifuges: Address reliability with alternate technology which can be serviced in-place. Review piping rerouting and review defoaming options. Consider installing a sump with dual sump pumps to receive centrate gravity discharge and pump to centrate holding tank. Install flow meter on centrate side-stream to more accurately quantify side-stream load. Pond Aerator/Mixer: Options are Install header style pumped mixing similar to Rotamix, Jet-Tech or Jet mix, or provide cover that can walk on. Solids Handling Blower: Provide loose spare complete. Continue to maintain existing. Pond Decant Pump: Provide metering. Process Water Pump Check Valve: Replace check valves with tide flex style valve. Hypo chlorinator Metering Pump: Provide flooded suction. Tertiary Clarifier Gearbox: Three (3) drives need to be replaced per clarifier - three shaft drives, shafts in the tanks - sprockets have been converted and are in good condition. RBC Air Lines: Remove and replace 25% of stainless steel headers on an as-need basis. Tertiary Humus Pump: Continue to operate and maintain pumps as required. Pumps are not included in the long term plan. Grounds Gates: Replace main gate with automated security style gate. Continue to maintain remaining gates.		Mud jack UV / Administration Generator	System Replace corroded door louvers on Digester Building Replace old Maintenance Shop unit heaters Replace Maintenance Shop water heater Renovation of Metal Shop HVAC system Wall off Solids Handling electrical equipment and install PPU and mechanical cooling Renovation of Secondary Building HVAC pending decision on use		

Time Frame	Process	Architectural	Structural	Mechanical	Electrical	Instrumentation
5–10 Years	Admin Lift Station: Continue to maintain remove and replace as required. Planning costs include pump and panel replacement only. AB Distribution Box Gate: Metering should be considered as currently flow is split based on head over the weir gate and gate position. SCF Scum Pump: Planning costs should include complete replacement of 1 pump. RAS Pump: Planning costs should include pump replacement cost of 3 pumps. WAS Pumps Air Compressor: Planning costs should include complete replacement of 1 unit. WAS Pumps Air Dryer: Planning costs should include complete replacement of two units. UV Effluent Weir Gates: Planning costs should include replacing actuators. Grit Pump: Planning costs should include replacing check valves with Golden Anderson style 250 or potentially tide flex. Trickling Filter Lift Pump 1: Monitor pump and replace impeller as required. Polymer Pump: Planning costs include complete replacement. Centrifuge Feed Pump: Continue to maintain. Costs include complete replacement of 2 pumps. Centrifuge Feed Pump Gearbox: Continue to maintain remove and replace as required. Polymer Blending Units: Continue to maintain. Costs include complete replacement of 2 pumps. Thickened Sludge Transfer Pump: Provide loose spare complete. Cost included for loose spare due to critical nature. Process Water Pumps: Costs include pump replacement and option for strainer on the pump suction header. RBC Blowers: Continue to replace as required as RBCs have limited life. Costs include complete replacement of 4 pumps. RBC Units: Units have reached the expected service life. Units should continue to be serviced with normal maintenance as RBCs have limited life. Grit Removal Units: Coat Interior. Remove and replace mechanisms. Sludge Recirculation Pump: Removed and replace.	Identify extent of Administration Building expansion		Replace AB Pump Room ventilation system Replace UV Building air handling unit	Replace MCC-2 in the Metal Fabrication Shop. Replace the electrical equipment in the Tertiary Pump Pit. Replace MCC-SH in the Solids Handling Facility. Replace the Solids Handling Building Standby Generation System and ATS. Replace the Blower/Pump Building MCC-AB, dependent on how well the existing MCC holds up when air conditioning is installed to the MCC Room space. It is highly likely that this may be able to be pushed out past 15 years. Replace the Solids Handling Building Standby Generation System and ATS. Replace the 500kW Kohler Standby Generation System near the Secondary Building. This generator is critical as it powers the entire North side of the WRF.	

Time Frame	Process	Architectural	Structural	Mechanical	Electrical	Instrumentation
10–15 Years	WAS Pump: Continue to maintain. Costs include complete replacement of 2 pumps. Septic Cells: Monitor level/volume to determine amount returned via SCADA. Costs include level monitoring with SCADA volume calculation only. Primary Clarifier Cross Collector Gearbox: Planning costs should include complete replacement of 4 gearboxes. Primary Sludge Pump Compressor: Planning costs should include complete replacement. Primary Sludge Pump: Replace check valves. Vacuum/ Pressure Relief Valve: Refurbish or replacement cost for 4 total. Digester Boiler Equipment Digested Sludge Pump: Continue to maintain. Costs include complete replacement. Solids Handling Compressor: Continue to maintain. Costs include complete replacement. Centrifuge Conveyor: Continue to maintain. Costs include complete replacement. Centrifuge Feed Pump Grinder: New. Continue to maintain. Solids Handling Disposal Valves: Continue to maintain. Assumed 25 valves replaced. Solids Handling Blower: Continue to maintain. Process Water Pump Gate Valves: Continue to maintain. Costs include complete replacement of 3 valves. Process Water Pressure Gauge: Continue to maintain.					
15+ Years	Disinfection Basin Blowers: Reaches service life at 15-20 years. UV System: Reaches service life at 15-20 years. Grit Cyclone: Reaches service life at 15-20 years. Bar Screens: Reaches service life at 15-20 years. Grit Classifier: Reaches service life at 15-20 years. Screening Washer Compactor: Reaches service life at 15-20 years. Primary Clarifier Cross Collector: Reaches service life at 15-20 years. Secondary Clarifier 2 Gearbox: Reaches service life at 15-20 years. Digester Gas Component Replacement Required: • Flame Arresters • HP and standard Manual Drip Traps		With the recommended improvements, the remaining structures could be maintained for 25+ years with normal maintenance.	Campus Wide Odor Control System Replace Digester boilers Replace Gas Blower Bldg. HVAC	Replace Utility Company primary service cables and transformers, depending on testing and future corrosion caused by exposure. Replace the Secondary Building, Pretreatment Building and UV Building MCCs. Replace the Caterpillar Standby generation systems installed at the AB Blower/Pump Building and the UV Building.	PLC Processors

Time Frame	Process	Architectural	Structural	Mechanical	Electrical	Instrumentation
	• Vacuum/ Pressure Relief Valves • Blower Flame Trap Assemblies • Boiler Flame Arresters • Sediment Traps • Thermal Valve • Metering • Cover Gas Lines • Waste Gas Flare • Boiler Gas Lines and Valves Waste Gas Flare: Reaches service life at 15-20 years. Centrifuge Conveyor: Reaches service life at 15-20 years. Centrifuge Feed Pump Grinder: Reaches service life at 15-20 years. Odor Control: Provide for odor control for future planning. Included in HVAC.					

Note: An asterisk (*) indicates an ongoing repair, monitoring, or maintenance item.

Chapter 1.2 Energy Audit

The intent of this section of the facility plan is to summarize the energy audit that was completed for the City of Rapid City Water Reclamation Facility (WRF). In 2011, the South Dakota Department of Environment and Natural Resources (SDDENR) retained HDR to conduct comprehensive energy audits on 16 selected wastewater treatment plants (WWTPs), one of which was the Rapid City WRF. The goal was to identify potential Energy Conservation Measures (ECMs) that could be further evaluated and implemented at the WRF. The energy audit consisted of the following:

- Collection of plant data
- Kick-off meeting
- Field investigation and additional collection of plant data
- Review of utility bills and rate schedules
- Identification and evaluation of ECMs
- Final report summarizing the findings and recommendations

The final report completed in 2012 as part of the SDDENR energy audit included the following eight ECMs:

- ECM 1 – Replace one aeration basin blower with a smaller turbo blower
- ECM 2 – Replace one aeration basin blower with a smaller centrifugal blower
- ECM 3 – Install two variable frequency drives (VFDs) on existing aeration basin blowers
- ECM 4 – Install VFDs on lift pumps and retrofit trickling filter distributor arms to be pneumatically controlled rotary distributor arms
- ECM 5 – Convert from propane to natural gas as a pretreatment building and shop building heat source
- ECM 6 – Supply air to the rotating biological contactors (RBCs) by aeration basin blowers
- ECM 7 – Rotate through sludge lagoon mixers; operate 2 at a time rather than all 3
- ECM 8 – Replace Electric Supplemental Boiler with Natural Gas Boiler in Administration Building

ECMs 4, 5, 7, and 8 were shown to have favorable payback periods of less than 7 years and were recommended for further evaluation and implementation.

The energy audit report was updated in October 2015 to incorporate recent energy usage by the plant as well as recent energy rates, and to evaluate additional ECMs related to the solids handling facilities. The updated report is included in Appendix 1.2.A. Data from 2014 were used to update the October 2015 Energy Audit Report. However, the tables, figures, and other information for 2010 were left in the report to allow for comparison of energy usage and energy costs between the two years. 2010 data was utilized to generate the 2012 Energy Audit Report.

Seven additional ECMs were evaluated as part of the updated report and include the following:

- ECM 9 – Increase size of centrate discharge line from solids handling facilities
- ECM 10 – Replace the centrifuges with screw presses and rotary drum thickener
- ECM 11 – Maximize the use of digester gas by using it for building heat
- ECM 12 – Increase current biogas production by feeding fat, oil, and grease (FOG)
- ECM 13 – Install cogeneration system to utilize excess biogas from projected future loadings
- ECM 14 – Increase future projected biogas production by feeding fat, oil, and grease (FOG)
- ECM 15 - Supply air to the sludge holding basin by aeration basin blowers

1.2.1 Energy Intensity Review

The Rapid City WRF treated an average raw influent flow of approximately 9.5 million gallons per day (MGD) in 2010. Electrical energy cost for 2010 was approximately $408,000. The energy intensity of the plant was 1,640 kilowatt-hours per million gallons (kWh/MG) in 2010. In 2014, the WRF treated a similar average raw influent flow of approximately 9.45 MGD. Electrical energy cost for 2014 was approximately $478,300, and the energy intensity for the plant was 1,646 kWh/MG. The energy intensity values for 2010 and 2014 are very similar and are very good for a fixed film plant and reflect the continued excellent operation of the plant. Average electricity costs for 2010 were 7.1 cents per kilowatt-hour (kWh) in comparison to 8.4 cents per kWh for 2014, reflecting an increase in the energy costs from 2010 to 2014 of approximately 20 percent. Demand charges constitute a relatively low percentage of the overall electrical bill and were at an average of 13 percent for 2010 and 18 percent for 2014. An energy snapshot of the plant for both 2010 and 2014 is presented in Table 1.2.1.

Table 1.2.1. Energy Snapshot

Parameter	2010	2014	Unit of Measure
Volume Treated	3,484	3,449	MG/yr
Average Flow	9.54	9.45	MGD
Electrical Energy	5,720,840	5,678,420	kWh/yr
Energy Intensity	1,642	1,646	kWh/MG
Electrical Energy Cost	$408,069	$478,312	$/yr
Electrical Rate	$0.071	$0.084	$/kWh
Electrical Rate	7.13	8.40	¢/kWh
Billing Demand	865-991	747-934	kW
Average Demand	925	866	kW
Propane Gas Cost	$42,192	$56,062	$/yr
Winter Demand Charge	**13%**	**18%**	Of Total Electrical Energy Cost
Summer Demand Charge	**14%**	**16%**	Of Total Electrical Energy Cost

1.2.2 Energy Conservation Measures (ECMs)

HDR identified and evaluated 14 ECMs for the Rapid City WRF. Five of these ECMs are recommended for further evaluation and possible implementation. ECMs 4, 5, 7, and 8, which were recommended in the 2012 report, were evaluated further and now only ECMs 4 and 5 are still recommended along with ECMs 9, 10 and 11 from the updated 2015 report, with a total potential savings of 963,800 kWh/year or $190,422 per year. The total cost of these recommended ECMs was $1,483,000 with an overall simple payback of 7.8 years.

ECMs were evaluated based on the data gathered before, during, and after the site visits. Accuracy of estimates provided are to conceptual planning levels and should be refined through design. A discussion of each ECM is provided in the following sections.

1.2.2.1 ECM 1: Reduce Air Flow to Aeration Basin with Turbo Blower

EXISTING CONDITION

There are three multi-stage centrifugal blowers, each rated at 300 horsepower (HP). Each blower has a capacity of 5,200 standard cubic feet per minute (scfm). There are two aeration basins, and both basins can be served by a single blower. The blowers are oversized for current loading and do not operate at their best efficiency point. Typically, only one blower is operating, and excess air is delivered to the aeration basins at times when the demand for oxygen is lower than the blower capacity.

PROPOSED CHANGES

Replace one centrifugal blower with a single-stage, variable-speed turbo blower.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	310,411 kWh
Demand Savings	36 kW
Annual Cost Savings	$26,074
Cost of Change	$502,000
Simple Payback	19 years
Recommend	**No**

DISCUSSION

This ECM was not recommended in the initial SDDENR energy audit and would still not be recommended as part of this updated evaluation, because the pay back for operation of the one

smaller centrifugal blower is more than 10 years assuming savings would be continuous at 24 hours per day, 365 days per year. A 500 scfm reduction in air flow was assumed. Decreasing air flow would also impact effluent dissolved oxygen (DO), which has been low, requiring post aeration. Reducing airflow in the aeration basins would further reduce effluent DO requiring additional energy input from the post aeration blower at less favorable conditions for oxygen transfer. The overall electrical energy rate would need to increase to $0.16 per kWh before a payback period of 10 years or less would be realized.

1.2.2.2 ECM 2: Reduce Air Flow to Aeration Basin with Centrifugal Blower

EXISTING CONDITION

There are three multi-stage centrifugal blowers, each rated at 300 HP. Each blower has a capacity of 5,200 scfm. There are two aeration basins, and both basins can be served by a single blower. The blowers are oversized for current loading and do not operate at their best efficiency point. Typically, only one blower is operating, and excess air is delivered to the aeration basins at times when the demand for oxygen is lower than the blower capacity.

PROPOSED CHANGES

Replace or add one smaller, multi-stage centrifugal blower.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	236,300 kWh
Demand Savings	27 kW
Annual Cost Savings	$19,800
Cost of Change	$356,000
Simple Payback	18 years
Recommend	**No**

DISCUSSION

This ECM was not recommended in the initial SDDENR energy audit and would still not be recommended as part of this updated evaluation because the pay back period for operation of even one smaller centrifugal blower is more than 10 years assuming savings would be continuous at 24 hours per day, 365 days per year. Neither a turbo nor a centrifugal blower would meet the 5-year payback threshold. The overall electrical energy rate would need to increase to $0.15 per kWh before a payback period of 10 years or less would be realized.

From an operational or process control standpoint, the addition of a smaller centrifugal blower or replacement of one of the existing blowers with a smaller centrifugal blower under the current arrangement is also not recommended. Throttling the blowers increases wear and may reduce the service life of the blowers. However, the cost to overhaul each blower, based on information from the manufacturer, is $15,000 to $20,000 each. To overhaul all three blowers would cost $45,000 to $60,000, which is less than the estimated total project cost of $356,000 for a smaller centrifugal blower. Additionally, with the future plan of directing the majority of the flow through the activated sludge plant, the blowers will be replaced with smaller blowers as part of the proposed upgrades to the activated sludge system. The blowers would be replaced as part of Permit 2 – Phase I to be completed by the year 2025.

1.2.2.3 ECM 3: Install Variable Frequency Drives on Aeration Basin Blowers

EXISTING CONDITION

The three multi-stage centrifugal blowers operate at a constant speed. Each blower has a capacity of 5,200 scfm, and the inlet is throttled to reduce airflow. The blowers were originally equipped with variable-speed couplings, but the couplings were removed due to mechanical problems.

PROPOSED CHANGES

Install VFDs on two of the blowers to improve blower efficiency. A variable-speed drive would allow some additional turndown, but the drive also would cause a reduction in efficiency.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	84,900 kWh
Demand Savings	10 kW
Annual Cost Savings	$7,100
Cost of Change	$253,000
Simple Payback	36 years
Recommend	**No**

DISCUSSION

This ECM was not recommended in the initial SDDENR energy audit and would is still not be recommended as part of this updated evaluation. The operational range of a VFD would be limited. If blower speeds are reduced too much, insufficient airflow would be provided (surge condition). This ECM assumed an airflow reduction of 200 scfm with an increased blower efficiency of 2 percent and a loss of efficiency due to the VFD of 2 percent. The overall

electrical energy rate would need to increase to $0.30 per kWh before a payback period of 10 years or less would be realized.

From an operational or process control standpoint, VFD's are not recommended on the existing blowers. As discussed in ECM 2, with the future plan of directing the majority of the flow through the activated sludge plant, the blowers will be replaced with smaller blowers as part of the proposed upgrades to the activated sludge system. The blowers would be replaced as part of Permit 2 – Phase I to be completed by the year 2025.

1.2.2.4 ECM 4: Trickling Filter Recirculation Rate

EXISTING CONDITION

The existing layout of the Trickling Filter Pump Station limits operational control over recycle rates. Constant-speed pumps have little flexibility. The recent project of replacing the rotary distributor arms with pneumatically controlled distributor arms in combination with future installation of variable-speed pump drives would improve operational flexibility and performance. Further discussion is provided in the process modeling section.

PROPOSED CHANGES

Install VFDs on the Trickling Filter Pump Station pumps to compliment the recent replacement of the trickling filter rotary distributor arms with pneumatically controlled distributor arms. Cost savings would be realized by gaining the ability to reduce recycle (re-pumping) rates. Replacement of the distributor arms with pneumatically controlled, hydraulically driven arms provides for flushing cycles to avoid sloughing and to provide positive control of the rotary distributor speed during normal and low flows.

EFFECT ON OPERATION

Reducing the dosing rate can lead to media plugging. Flushing cycle frequency will need to be adjusted to prevent media plugging. Media performance should also be monitored during the operational change process because recycle may be required to account for short circuiting through the relatively shallow media depth.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	803,800 kWh/yr
Demand Savings	84 kW
Annual Cost Savings	$67,500
Cost of Change	$239,000
Simple Payback	3.5 years
Recommend	**Yes**

DISCUSSION

Since the trickling filter rotary distributors have already been replaced with pneumatically operated distributor arms, only the cost for VFDs on the Trickling Filter Pump Station pumps was included to calculate the payback period. The combination of VFD's on the trickling filter pumps and the pneumatically operated distributor arms would improve operation of the trickling filters. In addition, the pumps and lift station configuration need to be addressed for future operations. Improvements to the Trickling Filter Pump Station pumps and trickling filter recirculation system in general are currently being evaluated to address both long- and short-term goals. Operational flexibility and energy efficiency should be included in any proposed improvements, including consideration of replacing all starters with VFDs.

1.2.2.5 ECM 5: Heat Pretreatment Building with Natural Gas

EXISTING CONDITION

The Pretreatment Building air handler was recently replaced. The old system was nonfunctioning, and the new system will increase heating energy requirements. The Pretreatment Building is now being ventilated with 12 air changes per hour to comply with the building classification. Propane is currently used to fire the heat source boiler.

PROPOSED CHANGES

Switch to natural gas as a heat source.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	NA
Demand Savings	NA
Annual Cost Savings	$40,800
Cost of Change	$25,000 (Owner verify)
Simple Payback	0.6 year
Recommend	**Yes**

DISCUSSION

An indoor temperature of 73 degrees was assumed. Heating costs increase significantly as the indoor temperature increases. Capital costs include $19,000 for a natural gas service and $6,000 for modifications to the existing boiler. The existing boiler in the wastewater maintenance shop building may be near the end of its useful life. Boiler replacement was not included in this ECM because it is an expense common to all fuel sources. Montana-Dakota

Utilities (MDU) was contacted regarding the potential for servicing the WRF. MDU has an adequately sized main nearby. The existing boiler is aging and may need to be repaired or replaced in the near future.

1.2.2.6 ECM 6: Supply Air to RBCs by Aeration Basin Blowers

EXISTING CONDITION

The RBCs and aeration basins each have their own dedicated blower systems. The RBC basins have a 6.5-foot side water depth (SWD) compared to the aeration basins, which have a 16.0-foot SWD.

PROPOSED CHANGES

Install air piping from the aeration basin to the RBC basin. Install a throttling valve to control air flow and pressure. This variation in depth would result in different pressure requirements, and energy would need to be removed from the air using a throttling valve.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	-189,300 kWh/yr
Demand Savings	-22 kW
Annual Cost Savings	-$15,900
Cost of Change	$52,000
Simple Payback	NA
Recommend	**No**

DISCUSSION

For this ECM it was assumed that a total of 2500 cfm is required from the aeration blowers to drive the RBCs. Conservatively, 1500 is wasted due to the blower low limit so it is “free”. The remaining is 2500-1500 = 1000 scfm that will need to be produced and operated at 8.5 psi. The disadvantage of this ECM is that 9.5 feet or over 4 pounds per square inch (psi) of head is wasted in the throttling valve. The advantage is that the aeration blowers currently are oversized, and during low and nighttime loadings, air is being wasted even at the lowest turndown. Replacing an RBC blower at a cost of $20,000 to $30,000 is more energy efficient than using the aeration basin air.

1.2.2.7 ECM 7: Rotate Operation of Sludge Lagoon Mixers

EXISTING CONDITION

There are currently three sludge pond mixers, each rated at 25 HP. All mixers run continuously to maintain a consistent feed to the centrifuges, with sludge at approximately 2 percent solids.

PROPOSED CHANGES

Connect mixers to a timer-controlled system such that either one or two mixers run at a time and rotate so each area of the sludge pond is mixed.

EFFECT ON OPERATION

Based on discussions with operations staff, all three mixers need to be operating to maintain sludge consistency.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	163,400 kWh/yr
Demand Savings	19 kW
Annual Cost Savings	$13,700
Cost of Change	$42,000
Simple Payback	3 years
Recommend	**No**

DISCUSSION

This ECM was recommended for further evaluation in the initial SDDENR energy audit, but is not recommended in this updated energy audit with the existing sludge mixing system. Based on discussions with operations staff, all three mixers need to be operating to maintain sludge consistency.

1.2.2.8 ECM 8: Replace Electric Supplemental Boiler with Natural Gas Boiler in Admin Building

EXISTING CONDITION

Heat for the administration building was intended to be provided by a plant effluent source heat pump. However, the heat pump does not perform as anticipated, resulting in the Administration Building being heated by a 40-kW electric backup boiler. Heat cannot be turned down at night due to the long recovery time in the morning. A new natural gas fired boiler would use a less expensive fuel source and would be sized to allow reduced thermostat settings while the building is vacant. If digester gas monitoring indicates that there is enough biogas available, heating with digester gas should also be pursued.

PROPOSED CHANGES

Replace electric supplemental boiler with natural gas boiler.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	28,800 kWh/yr (replaced with natural gas)
Demand Savings	40 kW
Annual Cost Savings (after accounting for gas cost)	$1,700
Cost of Change	$9,400
Simple Payback	5.5 years
Recommend	**No**

DISCUSSION

This ECM was recommended for further evaluation in the initial SDDENR energy audit, but is not recommended in this updated energy audit, because the reliability of the main heating, ventilation, and air conditioning (HVAC) system for the Administration Building is anticipated to improve when planned upgrades to the HVAC system are implemented. Use of the electric supplemental boiler will then be infrequent.

1.2.2.9 ECM 9: Increase Size of Centrate Discharge Line from Solids Handling

EXISTING CONDITION

The centrate discharge lines from the centrifuges are 6 inches in diameter and limit the amount of biosolids that can be pumped through the centrifuges to approximately 160 gallons per minute (gpm). The centrifuges should be capable of receiving biosolids at rate of 250 gpm when thickening and 200 gpm when dewatering. However, at rates higher than 160 gpm, foaming will occur in the centrate discharge lines.

PROPOSED CHANGES

Increase the size of the centrate discharge lines from 6 inches to 12 inches in diameter to allow a higher rate of centrate to be discharged.

EFFECT ON OPERATION

The centrifuges turn at the same speed and require the same approximate energy to process biosolids regardless of the rate at which biosolids are pumped to the centrifuges. With the centrate lines increased in size, the centrifuges would be capable of processing biosolids at a higher rate while using the same amount of energy.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	42,000 kWh/yr
Demand Savings	NA
Annual Cost Savings	$3,900
Cost of Change	$46,000
Simple Payback	12 years
Recommend	**Yes**

DISCUSSION

The payback period for implemantation of this is ECM is more than 10 years. However, it is still recommended because it would also reduce the total annual labor hours required to operate the centrifuges by 25 percent or more.

1.2.2.10 ECM 10: Replace the Centrifuges with Screw Presses

EXISTING CONDITION

The WRF currently uses two centrifuges to either dewater biosolids for direct disposal to the Rapid City Regional Landfill or to thicken biosolids for disposal at the Rapid City Material Recovery Facility for composting. Each centrifuge has a 100 HP bowl drive motor and 25 HP back drive motor. The centrifuges are operated 10 to 14 hours per day, 4 to 5 days per week and require continuous monitoring during operation. The centrifuges require frequent overhauls, which have cost approximately $80,000 per unit. In 2014, the WRF produced approximately 1,627 dry tons of primary biosolids that were sent to the anaerobic digesters. Following digestion, approximately 785 dry tons of solids were pumped to the sludge holding cell. In addition, 518 dry tons of waste activated sludge were pumped to the sludge holding cells, giving a total of 1,303 dry tons of biosolids for thickening and dewatering.

PROPOSED CHANGES

Changes to the solids handling facilities assume that the existing centrifuges will need to be replaced within the next 3 to 5 years. WRF staff is planning to transition to sludge dewatering only and discontinue sludge thickening. Therefore, the energy evaluation for this ECM was completed by comparing the capital costs and energy costs for dewatering only between the alternatives of replacing the centrifuges in-kind with two new centrifuges and replacing the

centrifuges with three screw presses. The three screw presses would have 7.5 HP main drives each. Two screw presses operating in parallel would have a similar dewatering capacity to one centrifuge. The third screw press would be for standby.

EFFECT ON OPERATION

The cost to retrofit the solids handling facilities and replace the centrifuges with three screw presses would be more expensive than replacing the existing centrifuges with new centrifuges. The estimated cost difference is approximately $963,000. However, there would be a savings in energy use by replacing the centrifuges with screw presses.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	118,000 kWh/yr
Demand Savings	93 kW
Annual Cost Savings	$9,922
Capital Cost Difference Between Alternatives	$963,000
Simple Payback	97 years
Recommend	**Yes**

DISCUSSION

Several alternatives for sludge dewatering were developed and reviewed in Chaper 4.2 of the Facility Plan. For energy usage, only two of the alternatives were compared for this ECM. Capital cost estimates for the two alternatives assumes the existing centrifuges will need to be replaced in the next 3 to 5 years. The first alternative, which is Alternative 1A in Chapter 4.2, assumes that the centrifuges would be replaced in-kind with two new centrifuges. The second alternative, which is Alternative 2B in Chapter 4.2, assumes that the centrifuges would be replaced with three screw presses. For the retrofit alternatives, costs were estimated based on conceptual layouts of screw presses manufactured by FKC and centrifuges, manufactured by Andritz, in the existing Centrifuge Room. These layouts are not for design and include only dewatering devices, screw conveyors, monorails, and access platforms. Alternative 2B assumes the screw presses would be operated 24 hours per day. Therefore, dry cake sludge storage and conveyance to transfer dewatered sludge to storage during the hours that dewatering operations are unmanned is included in the capital cost for Alternative 2B. No dry sludge storage is included in Alternative 1A as it assumed the centrifuges would need to be monitored at all times during dewatering operations, which is estimated to be 12 hours per day. Electrical and instrumentation costs are estimated as a percentage of equipment costs. Other costs such as building modifications, equipment upgrades and replacement, and additional liquid sludge storage as discussed in Chapter 4.2 are also included in the capital costs for each alterntive.

The payback period for implementation of this ECM, based on energy use only, is 97 years. However, in making a decision regarding the selection of a solids handling alternative, other economic and noneconomic factors also need to be considered in more detail. A more detailed evaluation was completed as part of Chapter 4.2: Solids Handling Evaluation, of the Facility Plan. Based on that evaluation the total savings in operation and maintenance costs, factoring in biosolids hauling and disposal, permitting, power, labor, polymer usage, and equipment replacement and maintenance, is estimated to be approximately $135,000 for Alternative 2B over Alternative 1A, giving a pay back period of less than 6 years. As indicated in Chapter 4.2, it is recommended that pilot testing and further investigation is completed before a final decision is made on a dewatering alternative.

1.2.2.11 ECM 11: Maximize the Use of Digester Gas

EXISTING CONDITION

Total biogas production numbers were not available for this report because the piping to the waste gas burner does not function properly and a significant portion of the biogas is being wasted through the digester covers. However, it was estimated that the WRFcurrently wastes over 50 percent of the digester gas. Digester gas is used to heat the primary digesters. Propane gas is used to heat the Pretreatment Building and the Wastewater Maintenance Shop and is used to supplement biogas for heating the digesters.

PROPOSED CHANGES

Repair piping to the waste gas burner. Maximize the use of digester gas by using excess boiler capacity or installing a new dual fuel boiler to subsidize heat to the Pretreatment Building and Wastewater Maintenance Shop during winter months. This would effectively reduce the use of propane gas even if some needs to be used during peak (coldest) winter days.

EFFECT ON OPERATION

Energy savings and cost savings are realized by reducing the use of propane gas.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	NA
Demand Savings	NA
Annual Cost Savings	$68,300
Cost of Change	$210,000
Simple Payback	3.1 years
Recommend	**Yes**

DISCUSSION

The waste gas burner piping needs to be repaired to eliminate the wasting of excess biogas through the digester covers and to determine the amount of biogas actually produced in the digesters. The use of digester gas to heat one or more of the buildings, such as the Pretreatment Building and Wastewater Maintenance Shop would help in maximizing the use of biogas and would reduce the amount of propane required for heating purposes and the annual propane cost. Based on initial evaluation, the payback to provide the capability of using biogas to heat the Pretreatment Building and Wastewater Maintenance Shop is approximately 3 years. The costs include a new dual fuel boiler. If the existing boilers in the digester building have excess capacity to provide heat to the Pretreatment Building and Wastewater Maintenance Shop, the overall cost could be reduced and the payback period would be less. This ECM should be investigated in more detail because the capital cost per building for extending hot water piping could be impacted by other conflicts.

1.2.2.12 ECM 12: Increase Biogas Production by Feeding Fat, Oil, and Grease (FOG)

EXISTING CONDITION

The current estimated average biogas production from the anaerobic digesters at the WRF is 59,700 cubic feet per day (cf/day). Of the current biogas produced, an average of 30,300 cf/day is needed to heat the digesters. The remaining biogas is wasted.

PROPOSED CHANGES

Increase the amount of biogas produced by feeding FOG to the digesters and use the excess biogas for cogeneration. Based on previous studies, assume an increase in biogas production of 30 percent by feeding FOG. Average biogas production was estimated at 77,600 cf/day for evaluation of this ECM.

EFFECT ON OPERATION

Power could be generated to reduce electrical costs by feeding FOG and generating more biogas. Based on literature for Microturbines, it is assumed that power could be generated at 0.05 kWh per cubic foot of biogas.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	950,000 kWh/yr
Demand Savings	120 kW
Annual Cost Savings	$80,700
Cost of Change	$5,574,000
Simple Payback	69 years
Recommend	**No**

DISCUSSION

An average of 30 percent increase in biogas production was used for this analysis. However, the increase in biogas production from the digesters will vary depending on the quantity and quality of FOG received. Increase in biogas production could vary from 25 to 100 percent. Nonetheless, the costs of the cogeneration system and FOG receiving facilities make this ECM cost prohibitive.

1.2.2.13 ECM 13: Install Cogeneration System to Utilize Excess Biogas Produced from 20 Year Projected Loadings

EXISTING CONDITION

The current estimated average biogas production from the anaerobic digesters at the WRF is 59,700 cf/day. Of the current biogas produced, an average of 30,300 cf/day is needed to heat the digesters. The remaining biogas is wasted. Based on projected future flows and loadings, the 20-year projected biogas production from the anaerobic digesters would be 122,700 cf/day. For the future 20-year period, an estimated 47,100 cf/day of biogas would be needed to heat the digesters, leaving an excess of 75,600 cf/day of gas that could be used for cogeneration.

PROPOSED CHANGES

Install a cogeneration system to use the excess biogas produced from future loadings for generation of electrical power to be used at the WRF.

EFFECT ON OPERATION

Power could be generated from the excess biogas to reduced electrical costs. It is assumed that power could be generated at 0.05 kWh per cubic foot of biogas.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	1,379,700 kWh/yr
Demand Savings	120 kW
Annual Cost Savings	$197,400
Cost of Change	$2,601,000
Simple Payback	13 years
Recommend	**No**

DISCUSSION

This ECM was evaluated based on an estimated future overall electrical cost of $0.15/kWh. There would be a significant savings in electrical utility costs with this ECM. However, the cost

to install a cogeneration system to use the excess biogas would make the payback period over 10 years, even at estimated future electric rates.

1.2.2.14 ECM 14: Increase the 20 Year Projected Biogas Production by Feeding Fat, Oil, and Grease (FOG)

EXISTING CONDITION

The current estimated average biogas production from the anaerobic digesters at the WRF is 59,700 cf/day. Of the current biogas produced, an average of 30,300 cf/day is needed to heat the digesters. The remaining biogas is wasted. Based on projected future flows and loadings, the 20-year projected biogas production from the anaerobic digesters would be 122,700 cf/day. For the future 20-year period, an estimated 47,100 cf/day of biogas would be needed to heat the digesters, leaving an excess of 75,600 cf/day of gas that could be used for cogeneration.

PROPOSED CHANGES

Increase the amount of future biogas produced by feeding FOG to the digesters, and use the excess biogas produced from FOG plus future loadings for cogeneration. Based on previous studies, assume an increase in biogas production of 30 percent by feeding FOG. Average biogas production was estimated at 159,500 cf/day for evaluation of this ECM.

EFFECT ON OPERATION

Power could be generated to reduced electrical costs by feeding FOG and generating more biogas. Based on literature for Microturbines, it is assumed that power could be generated at 0.05 kWh per cubic foot of biogas.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	2,051,300 kWh/yr
Demand Savings	180 kW
Annual Cost Savings	$293,700
Cost of Change	$6,873,000
Simple Payback	23 years
Recommend	**No**

DISCUSSION

This ECM was evaluated based on an estimated future overall electrical cost of $0.15/kWh. An average 30 percent increase in biogas production was used for this analysis. However, the increase in biogas production from the digesters will vary depending on the quantity and quality of FOG received. Increase in biogas production could vary from 25 to 100 percent. Nonetheless, the costs of the cogeneration system and FOG receiving facilities make this ECM cost prohibitive.

1.2.2.15 ECM 15: Supply Air to Sludge Holding Basin by Aeration Basin Blowers

EXISTING CONDITION

The sludge storage basin currently use three mechanical mixers, each rated at 25 HP. All mixers run continuously to maintain a consistent feed to the centrifuges, with sludge at approximately 2 percent solids. The sludge storage basin has a depth ranging from 9 to 14-foot side water depth (SWD) compared to the aeration basins, which have a 16.0-foot SWD.

PROPOSED CHANGES

Install air piping from the aeration basin to the sludge storage basin and add an aeration system in the sludge storage basin for mixing. Install throttling valves to control air flow and pressure. This variation in depth would result in different pressure requirements, and energy would need to be removed from the air using the throttling valves.

EFFECT ON OPERATION

None anticipated.

ENERGY COST SAVINGS

The energy cost savings would be as follows:

Energy Savings	-99,007 kWh/yr
Demand Savings	-12 kW
Annual Cost Savings	-$8,317
Cost of Change Diff.	$333,000
Simple Payback	NA
Recommend	**No**

DISCUSSION

For this ECM it was assumed that a total of 3000 cfm is required from the aeration blowers to provide sufficient mixing of the sludge storage basin. Conservatively, 1500 is wasted due to the blower low limit so it is “free”. The remaining is 3000-1500 = 1500 scfm that will need to be produced and operated at 8.5 psi. The disadvantage of this ECM is that 2 to 7 feet or 0.9 to 3 pounds per squre inch (psi) of head is wasted in the throttling valves. The advantage is that the aeration blowers currently are oversized, and during low and nightime loadings, air is being wasted even at the lowest turndown. The energy usage to use air from the existing activated sludge aeration blowers for mixing the sludge storage pond would be more than the combine energy currently used by the existing mixers plus the estimated energy used for wasted air by the blowers. Therefore this ECM is not recommended.

A summary of the ECMs is presented in Table 1.2.2.

Table 1.2.2. ECM Summary

ECM #	Description	Savings kW	Savings kWh/yr	Savings $/yr	Cost	Simple Payback (yrs)	Recommended For Evaluation	Trigger Point	Comments
1	Replace one aeration basin blower with a smaller turbo blower.	36	310,400	$26,000	$502,000	19	No	Electric rate would need to reach $0.16/kWh	Energy savings are possible but the capital payback is extended.
2	Replace one aeration basin blower with a smaller centrifugal blower.	27	235,300	$19,800	$356,000	18	No	Electric rate would need to reach $0.15/kWh	A centrifugal smaller blower has similar payback as a turbo blower. The future plan is to direct the majority of the flow through the activated sludge plant, the blowers will then be replaced with smaller blowers as part of the Permit 2 – Phase I proposed upgrades to the activated sludge system.
3	Install two VFDs on existing blowers.	10	84,900	$7,100	$253,000	36	No	Electric rate would need to reach $0.30/kWh	Benefits of installing VFDs on existing blowers are limited. As mentiond in ECM 2, the future plan is to direct the majority of the flow through the activated sludge plant, the blowers will then be replaced with smaller blowers as part of the Permit 2 – Phase I proposed upgrades to the activated sludge system.
4	Install VFDs on the lift pumps to complement the recently retrofitted trickling filter distributor arms with pneumantically controlled distributor arms.	84	803,800	$67,500	$239,000	3.5	Yes	Rotary distributor arms have already been replaced. VFDs should be included on new trickling filter pump station.	The combination of VFD's on the trickling filter pumps and the pneumatically operated distributor arms would improve operation of the trickling filters. In addition, the pumps and lift station configuration need to be addressed for future operations. Improvements to the Trickling Filter Pump Station pumps and trickling filter recirculation system in general are currently being evaluated to address both long- and short-term goals. Operational flexibility and energy efficiency should be included in any proposed improvements, including consideration of replacing all starters with VFDs.
5	Convert from propane to natural gas as a pretreatment building and shop building heat source.	NA	NA	$40,800	$25,000	0.6	Yes	As soon as NG service is extended to the WRF	Natural gas is significantly less expensive than propane and electric heat.
6	Supply air to RBCs by aeration basin blowers.	-22	-189,300	-$15,900	$52,000	NA	No	NA	A negative savings is achieved by utilizing the aeration basin blower for RBC air supply. Energy is wasted due to differences in basin depth.
7	Rotate through sludge lagoon mixers; operate 2 at a time rather than all 3.	19	163,400	$13,700	$42,000	3	No	NA	Based on discussions with operations staff, an acceptable sludge consistency cannot be maintained unless all three mixers are operating.
8	Replace Electric Supplemental Boiler with Natural Gas Boiler in Administration Building	40	28,800	$1,700	$9,400	5.5	No	NA	The reliability of the main HVAC system for the administration building is anticipated to improve when upgrades currently being planned are implemented.

ECM #	Description	Savings kW	Savings kWh/yr	Savings $/yr	Cost	Simple Payback (yrs)	Recommended For Evaluation	Trigger Point	Comments
9	Increase size of centrate discharge lines from the centrifuges in the biosolids handling building.	NA	42,000	$3,900	$46,000	12	Yes	Within the next year or as funds are available.	This payback period for implementation of this ECM is more than 10 years. However, it is still recommended for further evaluation as it would also reduce the total annual labor hours required to operate the centrifuges by 25%.
10	Replace the Centrifuges with an alternate dewatering system that uses less energy, such as screw presses.	93	118,000	$9,922,	$963,000 (Cost difference)	97	Yes	When centrifuges require overhaul (3 - 5 Years)	ECM assumes the existing centrifuges will need to be overhauled or replaced within the next 3 to 5 years. The cost is the difference between replacing the centrifuges with three screw presses verses replacement in-kind with new centrifuges. With other factors considered such as biosolids hauling, labor, maintenance costs, polymer usage, and equipment replacement costs, the payback period would be less than 6 years. Pilot testing and futher investigation is recommend before making a final selection of dewatering technologies.
11	Maximize the use of digester gas by using excess biogas to heat buildings at the WRF, such as the Pretreatment Building and the Shop Building.	NA	NA	$68,300	$210,000	3.1	Yes		The waste gas burner piping needs to be repaired to eliminate the wasting of excess biogas through the digester covers. The use of excess digester gas to heat one or more of the buildings, such as the pretreatment building and shop building would help in maximizing the use of biogas and reduce the amount of propane required for heating purposes.
12	Increase biogas production by feeding Fat, Oil, and Grease to the anaerobic digesters. Install FOG receiving facilities and Cogeneration System to Utilize additional biogas.	120	950,000	$80,700	$5,574,000	69	No	NA	Based on similar communities an average of 30% increase in biogas production for FOG was used for this analysis. However, the increase in biogas production from the digesters will vary depending on the quantity and quality of FOG received. Increase in biogas production could vary from 25% to 100%. Nonetheless the cost of the cogeneration system and FOG receiving facilities make this ECM cost prohibitive.
13	Install Cogeneration System to Utilize Excess Biogas Produced from 20 Year Projected Loadings.	120	1,379,700	$197,400[a]	$2,601,000	13	No	NA	There would be a significant savings in electrical utility costs with this ECM. However, the cost to install a cogeneration system to utilize the excess biogas would make the payback period over 10 years even at estimated future electric rates.
14	Increase 20 year projected future biogas production by feeding Fat, Oil, and Grease to the anaerobic digesters. Install FOG receiving facilities and Cogeneration System to Utilize additional biogas.	180	2,051,300	$293,700[a]	$6,873,000	23	No	NA	As with ECM #13, there would be a significant savings in electrical utility costs with this ECM. However, the cost to install FOG receiving facilities and cogeneration system to utilize the excess biogas would make the payback period over 20 years even at estimated future electric rates.
15	Supply air to Sludge Holding by aeration basin blowers.	-12	-99,007	-$8,317	$333,000 (Cost difference)	NA	No	NA	A negative savings is achieved by utilizing the aeration basin blower for sludge holding basin air supply for mixing.
	Total for Recommended ECMs	**177**	**963,800**	**$190,422**	**$1,483,000**	**7.8**			

Note:

[a] *Savings are based on an estimated future electrical cost of $0.15/kWh, which includes an electric rate of $0.08/kWh, adjustment rate of $0.05/kWh and demand charges ranging from $13.50 to $14 per KW.*

1.2.3 Recommendations

1. Implement ECM 5 as soon as natural gas service is extended to the WRF. By having the natural gas service to the WRF as identified in this ECM, additional fuel cost savings will be realized by converting the other propane using heaters to natural gas, including the primary clarifier pump pit, shop building, the new supplemental heaters for the sludge handling building and potentially other locations. These additional potential savings were not included in the ECM 5 evaluation and will serve to reduce the actual payback period even further.

2. Implement ECM 4 as part of any proposed trickling filter improvement project. This will help to reduce energy costs and will also benefit the overall operation of the WRF.

3. Increasing the size of the centrate discharge line under ECM 9 should be done within the next year as this will not only reduce energy usage, but should also reduce the labor hours required to operate the centrifuges.

4. Verify actual biogas production and usage of the boilers for ECM 11 if possible. If the amount of biogas wasted is more than the assumed 50% for the two coldest months, this ECM should be implemented as soon as possible. If the amount of biogas wasted is uncertain, we recommend monitoring production and usage over the upcoming winter months to verify KW usage and implement if equal to or higher than the assumed level. In addition, the shop has a third boiler that is capable of running off digester gas but that supply line has plugged and can only run off LP. If sufficient digester gas is available, this line could be replaced to utilize that source.

5. ECM 10 indicates a very long payback period based on energy usage and the cost difference between the two biosolids dewatering and thickening alternatives presented. However, further investigation is recommended as part of a biosolids study to review other economic and non-economic factors that would impact the decision on whether to stay with the existing technology or change to dewatering and thickening technologies that use less energy. A review of biosolids studies for similar facilities shows that factors such as labor, equipment maintenance and replacement costs, polymer usage, reliability, ease of use, and complexity of operation have resulted in the selection of other technologies over centrifuges.

6. Pay special attention to demand charges, and create a demand reduction protocol for the plant.

7. Set yearly energy goals and monitor results. Energy team should address progress at every meeting. Energy team should pursue incentives (economic or otherwise) at the WRF to promote sustainability and energy savings.

8. Conduct staff training on energy fundamentals and conservation measures.

9. Regularly inspect pumps for wear ring, impeller or other damage that could affect performance. Pumps should be tested every two to three years to ensure that they are operating efficiently.

10. Consider replacing motors requiring rewinding with new premium efficiency motors. Replacement of operable motors with premium efficiency motors is not recommended.

11. Meet with your BHP representative to identify all incentive programs and technical assistance they can provide.

Chapter 2.1 Flows and Loads

When planning or evaluating facilities to collect and treat wastewater, two primary wastewater characteristics are considered: (1) the quantity or volume of wastewater, expressed as "flows"; and (2) wastewater loads, which include BOD, ammonia, solids, and other physical parameters. Wastewater flow and load projections are used to evaluate the ability of existing facilities to adequately collect, transport, and treat future wastewater flows.

The current flows and loads were evaluated and future flows and organic loads estimated for the planning period for the WRF. This chapter presents an evaluation of current flows and loads and future flows and loads for the planning period for the City of Rapid City Water Reclamation Facility (WRF). The information in this chapter is the basis for the evaluation of unit process capacities in subsequent Chapters as wastewater projections are the fundamental criteria on which the sizing and design of treatment facilities are based.

The methodology used to analyze population trends, wastewater flow and treatment facility loadings are described herein. A series of meetings (referred to as workshops in this report) were conducted between the consultant team and City Public Works staff to review and analyze operating data, historical trends and anticipated future conditions. Input on population trends was also obtained from Community Planning and Development Services. An analysis of historic data is included in Appendix 2.1.A as part of the Workshop #2 information.

2.1.1 Objective

Potential new effluent nutrient standards are a significant consideration for future planning at the WRF. An evaluation of the current WRF facilities and consideration for future planning requires an understanding of existing and projected flows and loadings to the facility. This chapter summarizes recent flows and loads operating data from monthly monitoring reports and additional data provided by City staff. Current and projected flows and loadings were developed for the planning period through 2045 with a planning year of 2035, and is the basis for further facility evaluations in subsequent chapters.

The terms flows and loading as used in this document are defined as follows.

Wastewater Flow: A volumetric measurement of the quantity of wastewater over a selected time period. This report uses million gallons per day (mgd) for reporting flows.

Wastewater Loadings: A calculated weight of pollutants contained in wastewater for a selected time period. This report uses pounds per day (lb/day) for reporting pollutant loadings. Loadings are determined by multiplying the laboratory tested concentration of pollutants (expressed in mg/l) times the daily flow (in mgd) and converting to pounds per day.

2.1.2 Methodology

2.1.2.1 Wastewater Service Population

HISTORICAL POPULATION DATA

The historical population within the Rapid City corporate limits is known from US Census Bureau statistics dating back to 1920 for 10-year increments up to 2010. The City Community Planning and Development Services Department has a Long Range Planning Division which provided estimates of City population on an annual basis beginning in 2006. The Planning Department utilizes building permit activity, annexation statistics and other similar information to estimate changes in City population from year to year.

The Planning Department also makes projections of future city population at 5 to 10 year increments using this data. Population forecasts are currently available for the years 2025, 2035 and 2040. The future population data are used for a variety of purposes, including transportation planning, and are considered to be the best available population information.

WASTEWATER SERVICE POPULATION

Rapid City provides wastewater treatment for numerous residential and commercial properties located outside of the City's corporate limits. These properties include organized sanitary districts and homeowner associations with central wastewater collection systems which are connected to the City collection system. Flow handling and treatment is provided via a contractual arrangement with the City. In 2015 there are approximately 10,500 people whose residence is outside of the corporate limits, but who contribute flow to the WRF. The principal sanitary district connected to the City for treatment is Rapid Valley Sanitary District with about 9,150 people in 2015.

There are also some residential properties located within the City limits which are not connected to the City's central collection system. These properties are typically large widely spaced lots with no nearby collection mains, or are properties which were developed with on-site septic systems but have since been annexed into the City. Examples include Pinedale Heights, Wildwood, and portions of Carriage Hills. The estimated population of City residents who do not contribute wastewater flow to the WRF is approximately 2600 in the year 2015. Many of these properties are expected to be encouraged or required to abandon their on-site wastewater systems and connect to the City collection system in the future. As the City continues to develop via infill within the current City limits, the sewer collection system will extend and expand in a way that current regulations will require connection to City sewer based upon proximity to collection mains. The estimated rate of conversion from on-site systems to City sewer for existing City properties has been assumed to be 2.5% per year based on recent trends.

A substantial population resides in development areas at the perimeter of the corporate limits which currently use on-site septic systems for wastewater disposal. These properties are located within the Rapid City Metropolitan Planning Organization (MPO) boundary and within the "Tier 1" planning boundary as established in the City's 2006 Utility Master Plan. The Tier 1

area represents an estimate of potential City expansion by the year 2030. Existing properties located within the Tier 1 boundary could reasonably be expected to become City sewer users by 2030 as a result of expanding and extending the sewer collection system to growth areas. There are an estimated 700 people without central sewer residing within the Tier 1 boundary of as of 2015. Figure 2.1.1 shows the planning area for the wastewater system.

The wastewater service population as used in this chapter refers to the population which contributes wastewater flow to the WRF. It is a combination of City and non-City residents whose properties are connected to the wastewater collection system. City and non-City residents using on-site wastewater disposal systems are potential flow contributors, but are not a part of the wastewater service population until connected. The service population is the total City population inside the City limits less the in-City population using septic systems, plus the population outside of the City limits who contribute flow to the WRF. Figure 2.1.2 shows the current (2015) wastewater collection system service area.

GROWTH PROJECTIONS

The future wastewater service population will increase as a result of new development within the existing City limits and annexation of new development. Additional service population will include existing homes inside the City which are converted from on-site septic systems to the City collection system. Annexation of existing development near the City may also result in additional sewer users when the collection system is extended.

The Long Range Planning group forecasts for City population do not distinguish between residents with and without City sewer service. The population estimates and forecasts also do not include existing non-City population which is connected to the City sewer system.

For purposed of this study, the future wastewater service population was estimated as described following.

<u>Wastewater Service Population</u>

WWSP = CP – CP (Septic) + OC (Sewered) + OC (Annex)

Where: WWSP = Wastewater Service Population

CP = Estimated City Population (Planning Dept.)

CP (Septic) = City Population with septic system

OC (Sewered) = Outside City population connected to City system

OC (Annex) = Outside City population which is annexed and added to the City system.

The CP (Septic) population was assumed to decrease at a rate of 2.5% per year from the 2015 estimate of 2614 people. The decrease assumes conversion of existing properties from septic systems to City sewer over time.

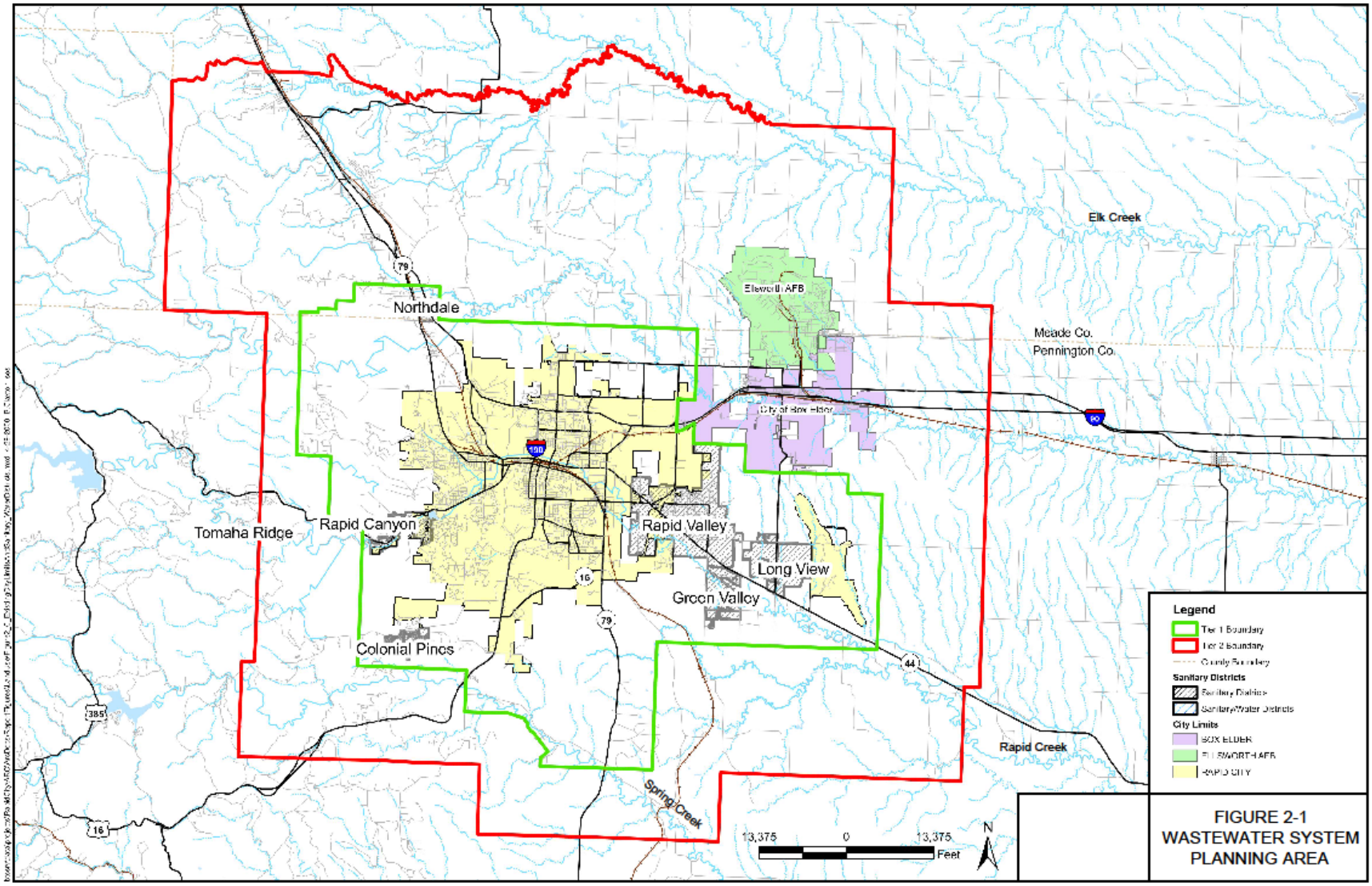


Figure 2.1.1. Wastewater System Planning Area

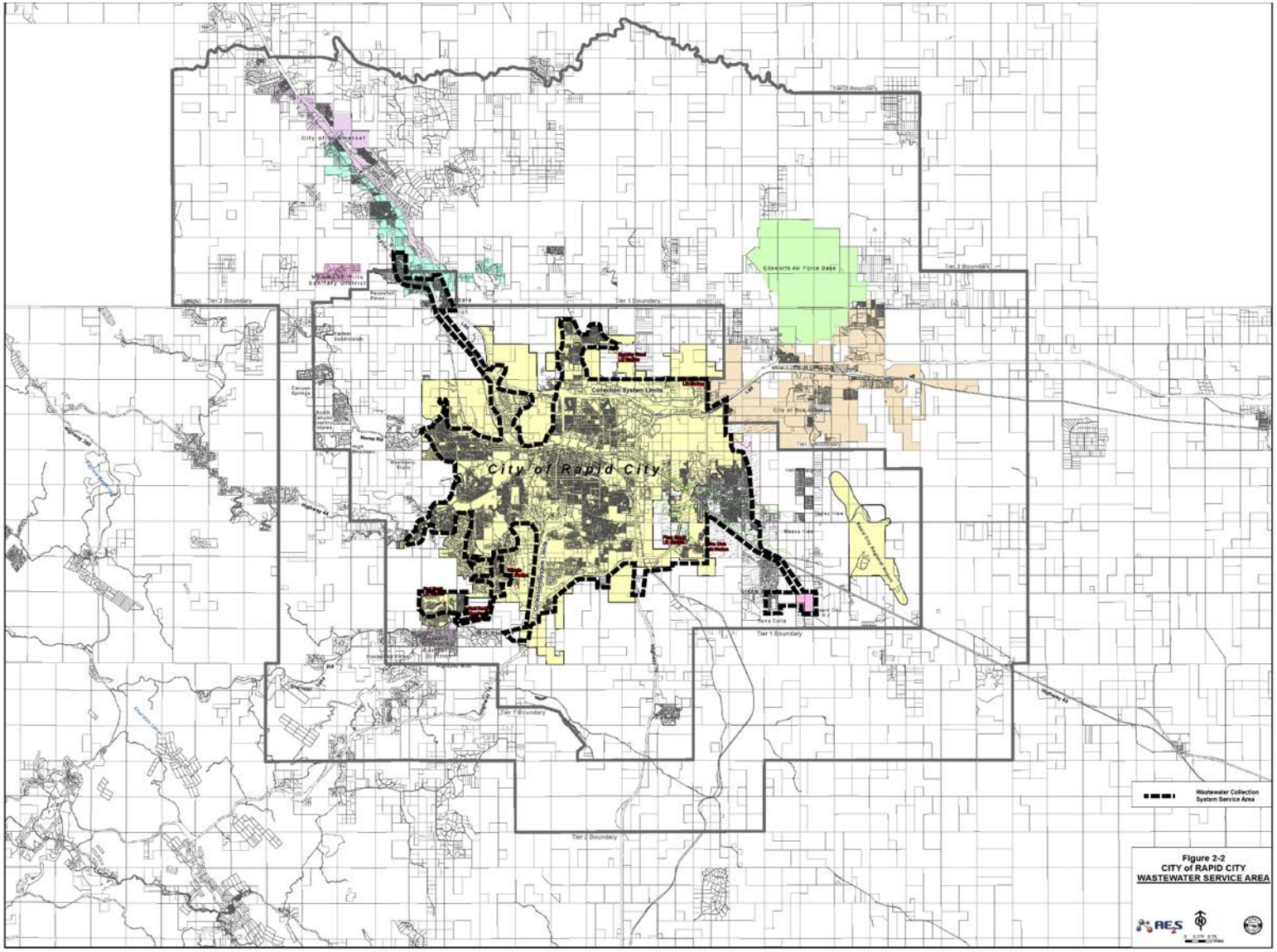


Figure 2.1.2 Wastewater Collection System Service Area (2015)

The OC (Sewered) population was assumed to increase due to growth within development areas. The principal growth is expected from Rapid Valley Sanitary District which has grown at a 2.5% rate in recent years.

The OC (Annex) population was assumed to convert to City sewer as a result of annexation at a rate of 2% per year.

Figure 2.1.3 shows the estimated wastewater service population for future years 2020, 2025, 2030, 2035, 2040 and 2045.

2.1.2.2 Wastewater Flow and Loadings

FLOW DATA

The WRF measures both influent and effluent flow rates on a continuous basis. The influent flow meter is a non-submerged Flo Dar meter located in the influent piping upstream from the original plant measuring flume and headworks. Effluent flow is measured by a Parshall flume at the outlet of the effluent disinfection system just prior to discharge to Rapid Creek. The influent Flo Dar system was installed in 2011 to replace unreliable flow measurement in the inlet flume system due to screening system clogging and flow back-up conditions. The effluent flume measurements are used for regulatory reporting, thus measured effluent flows have been selected for analysis and future flow projections.

The historical flow data presented in Appendix 2.1.A was obtained from plant records. The plant flow data includes total daily flow as well as maximum and minimum flow rates recorded for each day. Analysis of the recorded flow data has been performed to determine the following flow parameters for each year from 2010 to 2014, and for the January through May period for 2015. All flows are in units of million gallons per day (mgd).

Rapid City Water Reclamation Facility
Figure 2-3 - Service Population Data and Forecast

	Yearly Historical Data												Future Years							
	2010		2011		2012		2013		2014		2015 (Jan-May)		2025		2035		2040		2045	
Population in City Limits		67,956		68,886		69,529		70,555		71,907		71,907		80,000		91,000		105,000		115,000
Septic System in City Limits (1)(2)	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population
Pine Hills/Kingswood	45	115	45	115	45	115	45	115	45	115	45	115	45	115	45	115	45	115	45	115
Pinedale Heights/Berry Pine	66	168	66	168	66	168	66	168	66	168	66	168	66	168	66	168	66	168	66	168
Wildwood	68	173	68	173	68	173	68	173	68	173	68	173	68	173	68	173	68	173	68	173
Skyview	34	87	34	87	34	87	34	87	34	87	34	87	34	87	34	87	34	87	34	87
Corral Drive/Westview	78	199	78	199	78	199	78	199	78	199	78	199	78	199	78	199	78	199	78	199
Carriage Hills/Wonderland Drive	214	546	214	546	214	546	214	546	214	546	214	546	214	546	214	546	214	546	214	546
Springbrook Acres	150	383	150	383	150	383	150	383	150	383	150	383	150	383	150	383	150	383	150	383
Skyline Ranch/Skyline Drive	42	107	42	107	42	107	42	107	42	107	42	107	42	107	42	107	42	107	42	107
Enchanted Hills	119	303	119	303	119	303	119	303	119	303	119	303	119	303	119	303	119	303	119	303
Countryside (3)									197	502	197	502	197	502	197	502	197	502	197	502
Harmony Heights	12	31	12	31	12	31	12	31	12	31	12	31	12	31	12	31	12	31	12	31
Other, misc. (estimate)	50	128	50	128	50	128	50	128	50	128	50	128	20	51	20	51	20	51	20	51
		2,111		2,111		2,111		2,111		2,614		2,614		2,614		2,614		2,614		2,614
													-25%	653	-50%	1,307	-63%	1,634	-65%	1,699
														1,960		1,307		980		915
Outside City with City Sewer	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population
Northdale/Hideaway Hills (4)	311	793	311	793	311	793	311	793	311	793	311	793	311	793	311	793	311	793	311	793
Black Hawk (5)	200	510	200	510	200	510	200	510	200	510	200	510	210	536	210	536	210	536	210	536
Rapid Valley (6)	3,501	8,928	3,527	8,994	3,549	9,050	3,566	9,093	3,591	9,157	3,591	9,157	4,578	11,674	5,476	13,964	5,925	15,109	5,925	15,109
Terra Cotta (7)	30	77	32	82	35	89	39	99	40	102	40	102	50	128	50	128	50	128	50	128
		10,307		10,379		10,442		10,496		10,562		10,562		13,130		15,420		16,565		16,565
Existing Development Outside City within Tier 1 (8)													# Homes	Population	# Homes	Population	# Homes	Population	# Homes	Population
Green Valley Estates (274 d.u.)		0		0		0		0		0		0	55	140	110	279	137	349	164	419
Valley View Estates/Paradise Subdivision (104 d.u.)		0		0		0		0		0		0	21	53	42	106	52	133	62	159
Valley Heights Estates (105 d.u.)		0		0		0		0		0		0	21	54	42	107	53	134	63	161
Mesa View Estates (40 d.u.)		0		0		0		0		0		0	8	20	16	41	20	51	24	61
Colonial Pine Hills/Highland Hills (450 d.u.)		0		0		0		0		0		0	90	230	180	459	225	574	270	689
Westberry Trails (68 d.u.)		0		0		0		0		0		0	14	35	27	69	34	87	41	104
High Meadows/Cambridge/Ridgeland (60 d.u.)		0		0		0		0		0		0	12	31	24	61	30	77	36	92
South Canyon Country Estates (150 d.u.)		0		0		0		0		0		0	30	77	60	153	75	191	90	230
Other/Misc (100 d.u.)		0		0		0		0		0		0	20	51	40	102	50	128	60	153
		0		0		0		0		0		0		689		1,378		1,723		2,067
Wastewater Service Population		**76,152**		**77,153**		**77,860**		**78,939**		**79,855**		**79,855**		**91,205**		**105,184**		**120,674**		**131,018**

Notes:
(1) The number of septic systems in City limits is assumed to decrease by 2.5% per year to a minimum of 63% of the current number.
(2) Population on Septic Systems = Dwelling Units x 2.55
(3) Countryside Annexed in 2014
(4) Northdale is at build-out condition, no additional homes.
(5) Black Hawk growth limited to about 10 homes per Northdale pumping agreement.
(6) Rapid Valley Growth, 2.5% per year
(7) Terra Cotta build out of 50 lots assumed by 2025.
(8) Existing Development within Tier 1 assumed connections at a rate of 2% year.

Figure 2.1.3 Service Population

Flow Parameters:

Average Day: Average (50th percentile) of all recorded daily flows for the year.

Peak Month: Average (50th percentile) of recorded daily flow during the month with the highest total flow for the year.

Peak 7-Day: Average (50th percentile) of recorded daily flows for the highest consecutive 7-day period during the year.

Summer Average Day: The daily average flow for the period May through October.

Winter Average Day: The daily average flow for the period November through April.

Maximum Day: Highest one-day total flow for the year.

Maximum Flow: Peak instantaneous flow rate recorded during the year.

Minimum Day: Lowest one day total flow for the year.

Minimum Flow: Lowest instantaneous flow rate during the year.

The peak monthly and peak 7-day flows are commonly associated with wet weather over an extended time period. The maximum day flow and maximum flow are often associated with a significant precipitation event or rapid snowmelt.

POLLUTANT LOADINGS

WRF pollutant loadings are determined from laboratory analysis of representative samples of plant influent collected by automatic sampling equipment over the course of the day. The principal pollutants tested are as follows.

Influent Pollutants Tested

Parameter	Concentration
5-Day Biochemical Oxygen Demand (BOD)	mg/l
Total Suspended Solids (TSS)	mg/l
Ammonia (NH_3)	mg/l

The total daily loadings of these pollutants are determined by multiplying the tested concentration (mg/l) by the daily recorded flow (mgd) and are converted to the total weight of the pollutant in pounds per day (lb/day). The WRF enters flow and pollutant concentration data into a spreadsheet which calculates the total daily pollutant load for each parameter. The pollutant loadings presented in this chapter are from WRF sampling data.

The per capita (per person) contributions for flow and pollutant loadings have been calculated by dividing the WRF calculated flow and loadings by the estimated service population for a selected time period.

The term “peaking factor” as used in this chapter refers to the ratio of maximum or peak flow and loadings to the annual average day value. For example in 2014 the peaking factor for maximum month was determined as follows.

$$\frac{\text{Maximum Monthly Flow}}{\text{Annual Average Daily Flow}} = \frac{246.78\ \text{mgd}}{200.28\ \text{mgd}} = 1.23\ (\text{Peaking Factor})$$

2.1.2.3 Flow and Loading Projections

Flow and loading projections for future years have been calculated by multiplying the projected wastewater service population by the per capita flow or pollutant loading concentration. The per capita concentrations are based upon average values for the period from 2010 through mid-2015. Table 2.1.1 summarizes the 5 ½ year average of flows and loading.

Table 2.1.1. Influent Flows and Loads, 5.5 Year Average, January 2010 – May 2015

	Flow/Loading	Peaking** Factor	Per Capita	Concentration, mg/L
Flow, MGD*				
Average Annual	9.69	1.00	124 gpd***	-
Maximum Month	12.51	1.29	160 gpd	-
Maximum Day	19.00	1.96	243 gpd	-
BOD_5, lb/d				
Average Annual	15,084	1.00	0.193	208.84
Maximum Month	16,553	1.10	0.211	191.41
Maximum Day	23,267	1.54	0.297	209.84
TSS, lb/d				
Average Annual	16,061	1.00	.205	218.82
Maximum Month	18,392	1.15	.235	210.39
Maximum Day	32,582	2.02	.417	267.64
Ammonia, lb/d				
Average Annual	1966	1.00	.025	27.4
Maximum Month	2115	1.08	.027	24.45
Maximum Day	3002	1.53	.038	23.79

Notes:
**Based on Monthly Operating Report Data (Effluent)*
*** Ratio to average annual value*

**** gpd per capita*

The 5 ½ year average per capita flow and pollutant loading values are considered to be the best available data, realizing that anomalies may occur in any one year or time period. Although data from years prior to 2010 was available for analysis, the more recent data was judged to be more representative of conditions going forward. Trends toward reduced infiltration/inflow from tighter construction practices, low volume bathroom fixtures and similar water conservation measures are more accurately represented in recent year data.

2.1.3 Analysis

2.1.3.1 Current Flows and Loads

Plant influent flows and loads were calculated based on available data from January 2010 through May 2015. A statistical analysis and review of historical trends was used to derive annual average, maximum month and maximum day values for influent flow rate, BOD_5, TSS, and ammonia loads.

Seasonal variations were observed for the influent data. Influent flow rate varies significantly during the spring and early part of summer, likely due to inflow and infiltration during wet weather periods. Figure 2.1.4 illustrates effluent flow from 2006 through May 2015 and Figures 2.1.5 through 2.1.7 illustrate BOD, TSS and ammonia loadings from January 2010 through May 2015.

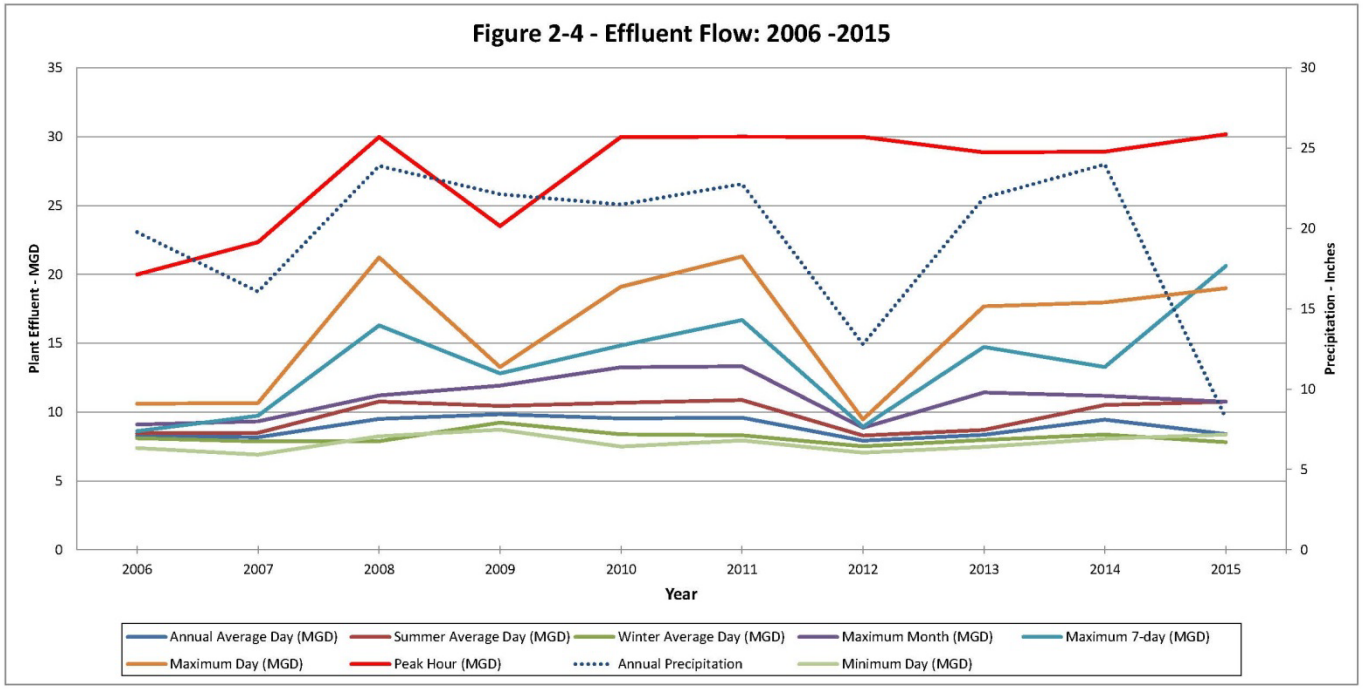
Data for the spring of 2015 was added after the initial workshop to address unusually high plant flows that occurred during the spring rains and resultant high (510 cfs) releases from Pactola Reservoir from mid-May to late July. The high flows at the WRF continued even after the rains subsided and it was determined that it was likely due to the proximity of the main interceptor sewers to Rapid Creek and resulting infiltration along with possible inflow throughout the system.

Influent BOD_5 and TSS fluctuated over a wide range as shown in Figures 2.1.5 and 2.1.6. Influent ammonia increased during the fall through early spring, possibly as a result of additional population in town while SDSM&T and other schools are in session.

2.1.3.2 Outliers

Significant outliers were found for influent BOD_5 and TSS and these data points were removed from the data set. The outliers included TSS values in excess of 30,000 lb/day and BOD in excess of 24,000 lb/day. No outliers for ammonia data was observed, thus no ammonia data was removed from the data set. The TSS and BOD outliers occurred in 2014 and have been attributed to sampling while a high strength septic load was being received into the process flow.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average Day (MGD)	8.27	8.17	9.51	9.84	9.54	9.60	7.93	8.35	9.45	8.41
Summer Average Day (MGD)	8.45	8.49	10.76	10.45	10.68	10.88	8.29	8.71	10.53	10.75
Winter Average Day (MGD)	8.11	7.87	7.88	9.24	8.39	8.31	7.51	7.99	8.36	7.81
Maximum Month (MGD)	9.09	9.32	11.21	11.92	13.26	13.32	8.87	11.43	11.18	10.75
Maximum 7-day (MGD)	8.62	9.74	16.30	12.81	14.83	16.69	8.94	14.73	13.27	20.61
Maximum Day (MGD)	10.60	10.66	21.23	13.28	19.10	21.31	9.47	17.68	17.96	19.00
Minimum Day (MGD)	6.33	5.92	7.07	7.48	6.43	6.81	6.05	6.41	6.91	7.18
Peak Hour (MGD)	20.00	22.33	29.99	23.51	29.99	30.00	29.99	28.86	28.92	30.18
Annual Precipitation	19.77	16.07	23.9	22.14	21.50	22.78	12.79	21.92	23.99	8.19



*2015 data: January - May 31, 2015

Figure 2.1.4. Influent Daily Flow

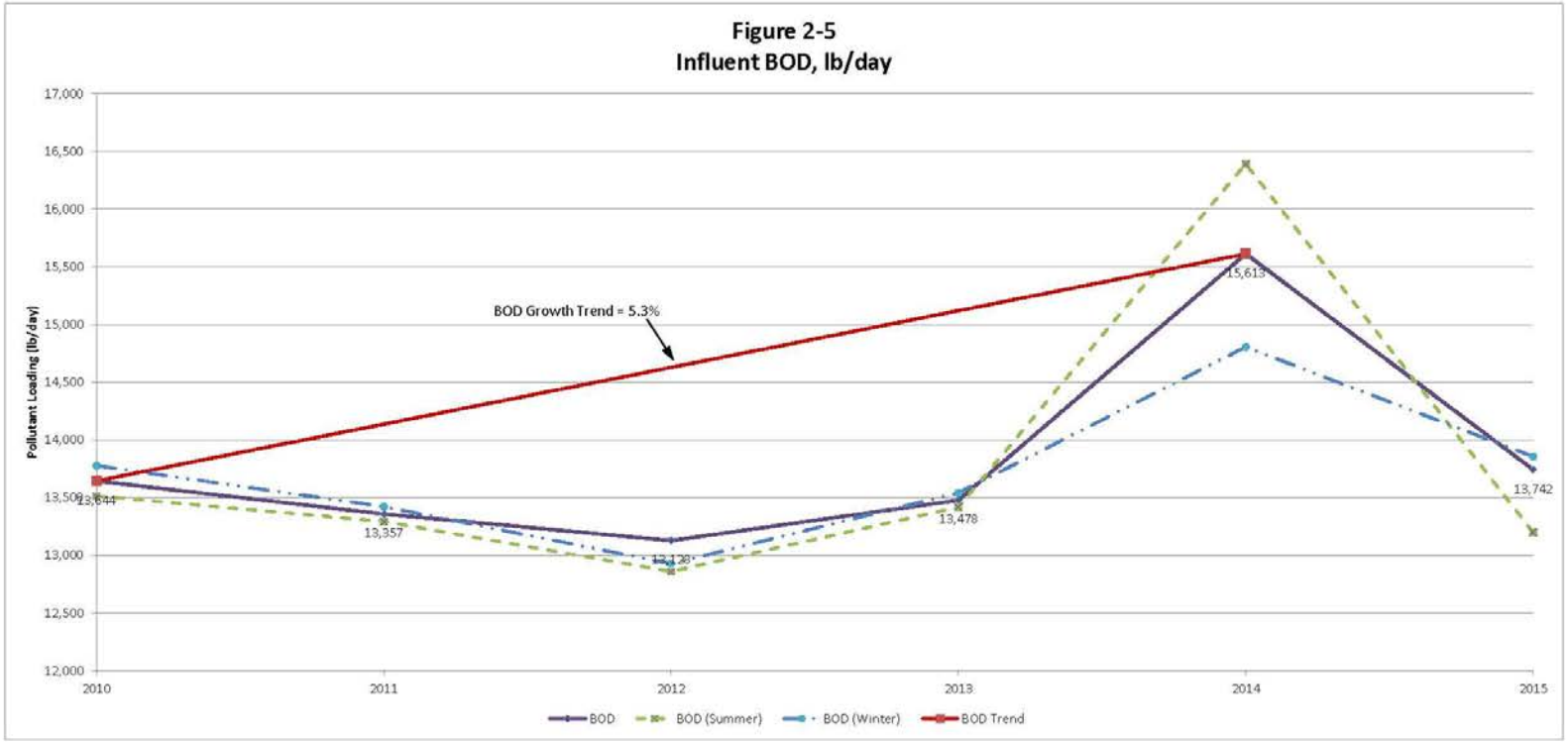


Figure 2.1.5. Influent BOD_5 Loading

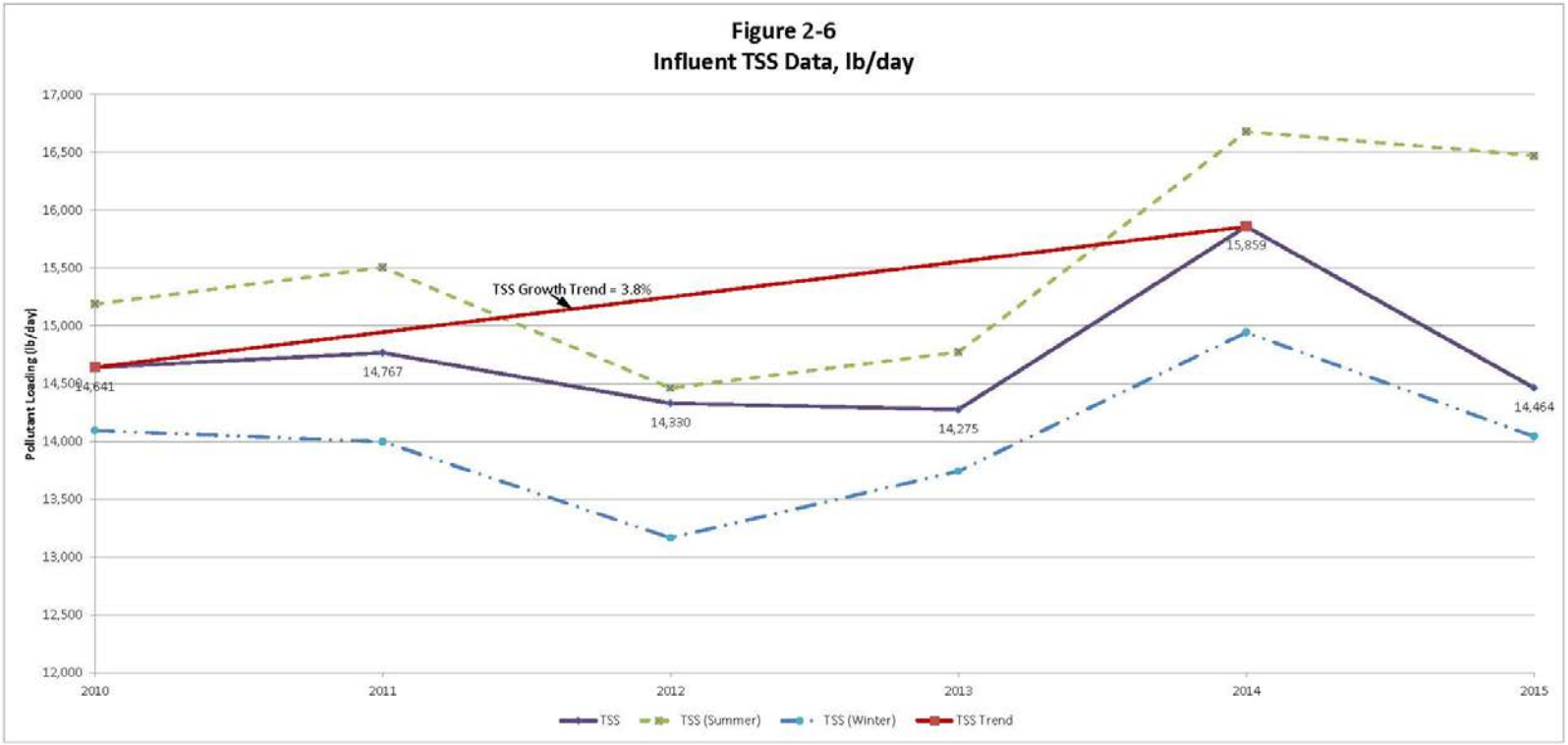


Figure 2.1.6. Influent TSS Load

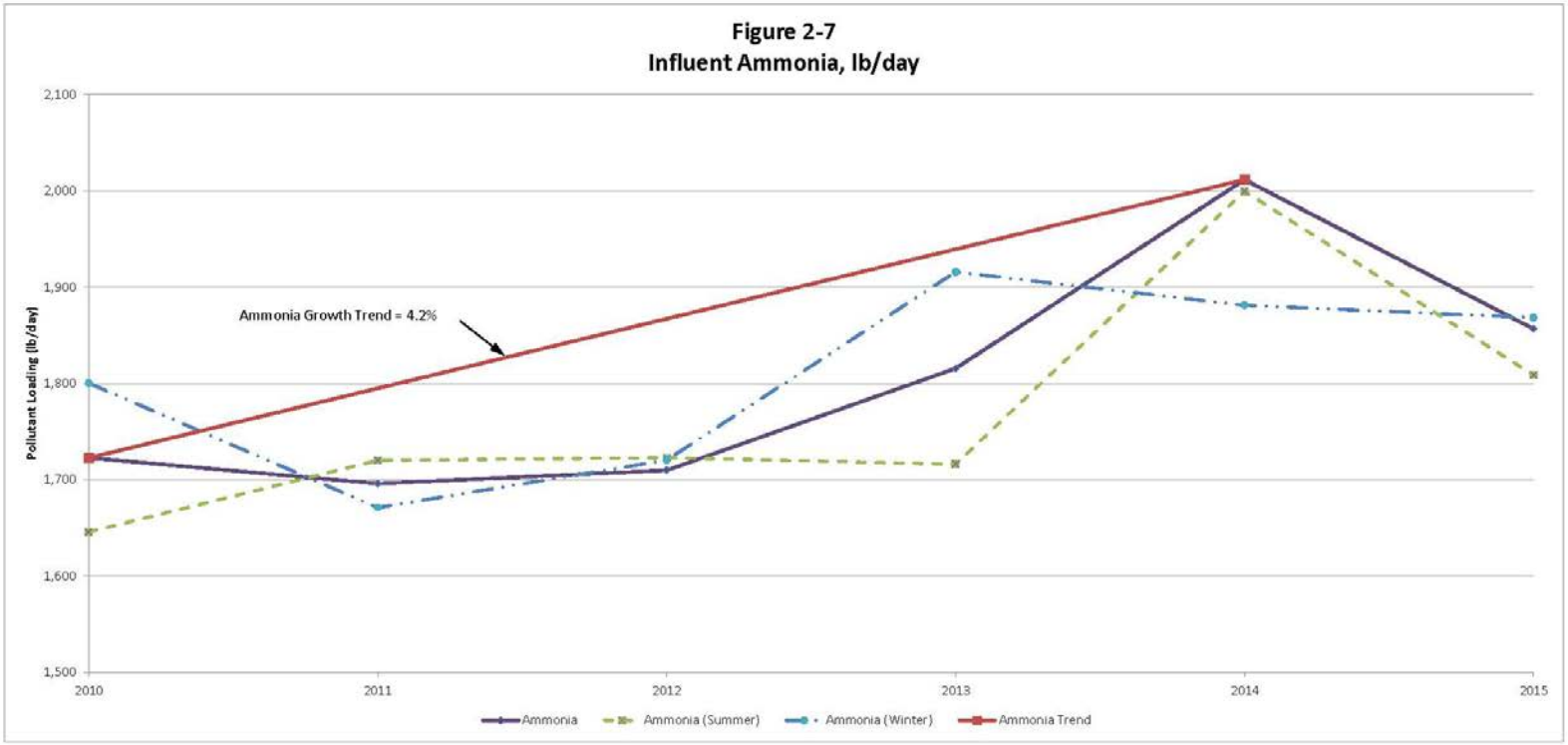


Figure 2.1.7. Influent Ammonia Load

2.1.3.3 Supplemental Nutrient Sampling

Additional supplemental nutrient sampling data was collected in June through August 2015 as discussed at Workshops #1 and #2 to improve characterization of the influent nutrient loadings, confirm assumptions and measure existing process performance. Supplemental Sampling is included in Appendix 3.2.A.

2.1.3.4 Population and Growth Projections

The wastewater service population includes all City residents connected to the municipal sewer system as well as non-City residents who have central sewer which is connected to the City system. Specific growth in sub-basins is inconsequential to the treatment facility and this level of planning was left for the up-coming Rapid City Sewer Collection System Planning efforts. A projected population growth of about 1.9% per year from 2010 to the design year of 2035 and projected thru 2045 is appropriate. 2010 census population was utilized as a starting point. Growth varies over the years per Table 2.1.2 and Figure 2.1.8 which show the projected population based on the growth rate developed from City Planning estimates.

Table 2.1.2. Wastewater Service Population Projection

Year	Wastewater Service Population
2010	76,152
2015	79,855
2020	85,560
2025	91,205
2030	98,195
2035	105,184
2040	120,674
2045	131,018

Rapid City Population (Inside City Limits)			Growth Rate
Year	Population	Source	since 2010
1920	5,777	Census	
1930	10,404	Census	
1940	13, 844	Census	
1950	25,310	Census	
1960	42,399	Census	
1970	43,836	Census	
1980	46,492	Census	
1990	54,523	Census	
2000	59,607	Census	
2006	62,715	Planning Dept.	
2010	67,956	Census	
2011	68,886	Planning Dept.	
2012	69,529	Planning Dept.	
2013	70,555	Planning Dept.	
2014	71,907	Planning Dept.	1.5%
2025	80,000	Planning Dept.	
2035	91,000	Planning Dept.	
2040	105,000	Planning Dept.	1.8%
2045	115,000		
Year	WW Service Population		
2010	76,152		
2011	77,153		
2012	77,860		
2013	78,939		
2014	79,855		1.2%
2020	85,560		
2025	91,205		
2030	98,195		1.9%
2035	105,184		
2040	120,674		
2045	131,018		

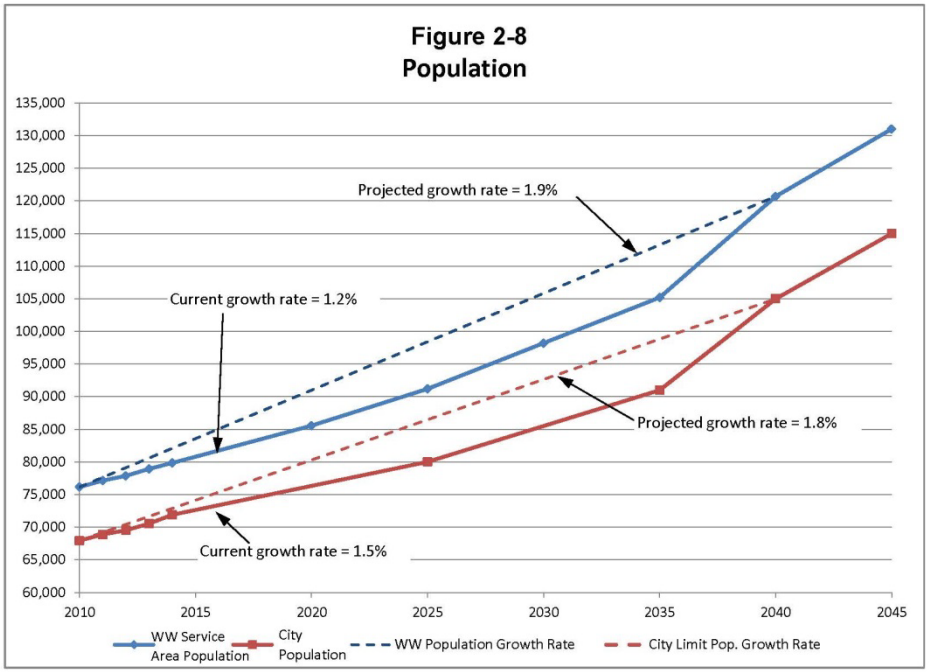


Figure 2.1.8. Population Projection

2.1.3.5 Future Flows and Loads

INFLUENT FLOW REVIEW

Five and one-half years (January 2010 – May 2015) of monthly influent flow and precipitation data from discharge monitoring reports (DMR) were reviewed to establish trends in average dry weather, average annual and maximum day flows compared to precipitation as shown in Figure 2.1.4.

From Figure 2.1.4 average influent flows from 2010 through 2015 have shown the following characteristics:

- Minimum day flow has remained relatively constant at about 6.6 mgd.
- Average day flow has varied in the range of about 8.0 mgd to 9.6 mgd with the variation attributed to variation in annual precipitation.
- Maximum day flow has varied from as low as 9.5 mgd in 2012 to 30 mgd in 2015. 2012 was an abnormally dry year and there was record rainfall during May and early June of 2015 when the maximum day was recorded.

Average annual precipitation has varied from a low of 12.79 inches in 2012 to 23.99 inches in 2014.

SEWER CAPACITY

There is a potential that the siphon or other collection system bottlenecks may be limiting flows to 30 mgd as the flow appears to flat-line at 30 mgd. Past records were researched and measurements indicated that it was not due to instrument error at the plant. Refer to Figure 2.1.4.

FUTURE FLOWS AND LOADS

The existing flows and loads, based on 2010-2015 data and population projections, were used to forecast the future average annual flows and loads to the WRF. The future maximum month and maximum day flows and loads were calculated from the average per capita values shown in Table 2.1.1 multiplied by the projected wastewater service population shown in Table 2.1.2.

Industrial and commercial reserve is limited to the nature of the existing service area and is included in projected population growth loadings.

Infiltration and inflow (I&I) appears to be a contributing component of flows during high wet weather periods and will be evaluated in further detail in the Rapid City Collection System Facility Planning process. The projected flows in this chapter did not include reduction in I&I from potential sewer improvement projects.

A summary of the projected future flows and loads is presented in Table 2.1.3.

Table 2.1.3. Projected Future Influent Flows and Pollutant Loading

Parameter	Loading Projections 2020	2025	2030	Planning Year 2035	2040	2045
Population						
WW Service Population	85,560	91,205	98,195	105,184	120,674	131,018
Influent Flow	MGD	MGD	MGD	MGD	MGD	MGD
Annual Average Day	10.43	11.12	11.97	12.83	14.71	15.98
Summer Average Day	11.32	12.07	12.99	13.92	15.97	17.34
Winter Average Day	9.59	10.22	11.00	11.79	13.52	14.68
Maximum Month	13.28	14.15	15.24	16.32	18.73	20.33
Maximum 7-day	17.87	19.05	20.51	21.97	25.21	27.37
Maximum Day	20.08	21.41	23.05	24.69	28.32	30.75
Peak Hour	33.96	36.20	38.98	41.75	47.90	52.01
Biochemical Oxygen Demand	lb/day	lb/day	lb/day	lb/day	lb/day	lb/day
Annual Average Day	16,563	17,651	18,997	20,343	23,326	25,318
Summer Average Day	16,419	17,502	18,843	20,184	23,157	25,142
Winter Average Day	16,355	17,435	18,771	20,107	23,068	25,045
Maximum Month	18,275	19,468	20,944	22,421	25,694	27,880
Maximum 7-day	19,802	21,108	22,726	24,343	27,928	30,322
Maximum Day	25,433	27,111	29,188	31,266	35,870	38,945
Total Suspended Solids	lb/day	lb/day	lb/day	lb/day	lb/day	lb/day
Annual Average Day	17,626	18,784	20,143	21,577	24,829	26,951
Summer Average Day	18,487	19,707	21,217	22,727	26,074	28,309
Winter Average Day	16,687	17,788	19,152	20,515	23,536	25,553
Maximum Month	20,328	21,655	23,077	24,940	28,581	31,012
Maximum 7-day	22,964	24,479	26,355	28,231	32,388	35,164
Maximum Day	35,655	38,008	40,921	43,833	50,288	54,599
Ammonia	lb/day	lb/day	lb/day	lb/day	lb/day	lb/day
Annual Average Day	2,150	2,292	2,464	2,643	3,028	3,291
Summer Average Day	2,107	2,246	2,418	2,591	2,972	3,227
Winter Average Day	2,156	2,299	2,483	2,651	3,041	3,302
Maximum Month	2,320	2,472	2,653	2,850	3,269	3,548
Maximum 7-day	2,505	2,670	2,875	3,079	3,533	3,835
Maximum Day	3,278	3,494	3,762	4,029	4,623	5,019

2.1.4 Summary

Current influent flows and loadings were developed based on monthly monitoring report data from 2010 through May 2015. Projected flows and loads in 5 year increments from present to the planning design year of 2035 and continued to 2045 were developed based on future population growth estimates developed via meetings with and data provided by the Community and Development Services Department. The projected population was checked and confirmed with linear extension of historic census trends from 1990 through 2014 as well.

Monthly influent flow and precipitation data for a ten year period (2006 – 2015) was reviewed to determine trends in influent flows. Peak flows are currently measured at the plant influent via a Flo Dar meter and plant effluent via a Parshall Flume. Since the Parshall Flume is utilized for permitting purposes; effluent metering was chosen to be utilized for projecting plant flows.

Additional nutrient sampling was conducted June thru August 2015 to improve characterization of the influent nutrient loadings, confirm assumptions and measure existing process performance. As described in more detail in the following sections the current (2015) wastewater service population of 79,855 is expected to increase at a rate of approximately 1.9% per year to over 131,000 by 2045. The current average daily flows to the treatment facility are expected to increase from the current 9.51 mgd to nearly 16 mgd by 2045. Pollutant loadings, including BOD, TSS, ammonia, nitrogen and phosphorus are all expected to increase from current levels in proportion to the expected wastewater flow increase in future years.

The following sections of this chapter include detailed discussion of the methodology of analysis and evaluation and development of the projected future influent flows and loadings.

Chapter 2.2 Regulatory Planning

2.2.1 Introduction

This section of the facility plan is to provide regulatory information to be used in planning for the City's wastewater treatment needs for the next 20 years and beyond. The goal is to best identify the physical modifications required to plan for potential future Surface Water Discharge (SWD) permit changes. Specific planning emphasis is to address ammonia limits which are expected to be implemented in 2025 and nutrient discharge limits which are expected to be implemented in 2030 with planning for continued treatment through year 2045.

The driving factor in this planning effort became the anticipated regulatory requirement of more strict ammonia and nutrient removal from the facility's discharge. A wider regional focus on nutrients is occurring because of the Gulf of Mexico hypoxia shown in Figure 2.2.1. Hypoxic zones are areas in the ocean of such low oxygen concentration that animal life suffocates and dies, and as a result are sometimes called "dead zones. The focus on solving these environmental endangerments is driving efforts to reduce nutrient discharges throughout the Missouri River watershed, which includes discharges from the Rapid City WRF as shown in Figure 2.2.1. In fact, due to the lack of progress on the part of the states, legislation has begun pushing the EPA to take primacy and implement these new nutrient standards on a federal level. To avoid more stringent limits directly enforced by the EPA, surrounding states including Minnesota, Wisconsin Montana and Colorado are in the process of incorporating nutrient discharge limits which indicates that any municipal wastewater treatment facility, such as the Rapid City WRF, should be prepared for new and/or more stringent nutrient limits for future discharge permits. The regulatory planning and associated dates in this section are based on the best available information from the South Dakota Department of Environment and Natural Resources (SD DENR), United's States Environmental Protection Agency (US EPA) and surface water discharge permit development in other states within this watershed.

As outlined in this chapter, the nutrient removal treatment capacity evaluations along with the recommended improvements are based on meeting a "Level 1" Total Nitrogen (TN) requirement of less than 10 mg/l and a Total Phosphorus (TP) limit of 1 mg/l. However, the City should be aware there is a significant level of ongoing effort in determining nutrient criteria across the U.S. As such, future nutrient discharge limits should still be considered to be very unpredictable. Proposed limits have been challenged in court by environmental activist groups and/or the EPA in instances where the proposed limits were considered to be inappropriate or untimely. In some states, legal action has greatly accelerated the implementation of more stringent discharge limits. Therefore, there is a chance that the limits may be more restrictive than Level 1, but Level 1 is consistent with limits imposed in similar U.S. states.

The primary driver for reduction in ammonia in Rapid Creek is the 2013 EPA update to the 1999 and 2009 aquatic life ambient water quality criteria which is approximately half of the current ammonia permitted values.

(Source – Moving Forward on Gulf Hypoxia Annual Report 2011 – Gulf of Mexico Watershed Nutrient Task Force)

Figure 2.2.1: Missouri River and Gulf of Mexico Hypoxic Zone

There are several significant issues that influence the wastewater facilities planning and discharge limitations for the City of Rapid City:

- New and future discharge permits with the greatest affect being ammonia and nutrient discharge limits.
- Increased design flow affecting permit limits and non-degradation provisions to Rapid Creek.
- Rapid Creek water quality.
- Revised federal ammonia nitrogen criteria adopted in 2013, which will be incorporated into South Dakota water quality standards at the completion of the next triennial review in 2017 and implemented into Permit #2.
- 40 CFR Part 503 regulation impacts on biosolids

Discussions with SDDENR and review of WRF influent and effluent data have identified the significant issues that are likely to be introduced in the new discharge permit, which include: a

new ammonia nitrogen discharge limit and new total nitrogen (TN) and total phosphorus (TP) limits. The ammonia limits are fairly well defined based on the new federal ammonia criteria. Many factors affect the future TN and TP limits. At this time the TN and TP numeric limits in the upcoming discharge permits cannot be confidently defined. However, a progression of more stringent limits has been developed based on discussions with SD DENR and comparisons with how other similar Midwest states are dealing with implementing these pending EPA driven limits. The ammonia, TP and TN limits have significant effects on treatment processes. The existing treatment processes will require modification/ expansion to meet these anticipated limits.

Additional monitoring will be required in the upcoming discharge permit. Requirements are likely to include more complete effluent quality data with a focus on more intensive requirements for ammonia and nutrients.

Biosolids are affected by 40 CFR Part 503 regulation if the City moves away from landfilling the dewatered biosolids for all or part of the year. Depending on the use of biosolids and public contact, the biosolids would need to meet Class A or Class B requirements. As it stands now, both landfilling and processing biosolids through the Materials Recycle Facility (MRF) Co-composting Facility meet federal guidelines and Rapid City has no intention of changing biosolids management methods.

2.2.1.1 Ammonia Water Quality Criteria

In 2013, EPA updated the freshwater ammonia aquatic life ambient water quality criteria in accord with the provisions of Section 304(a) of the Clean Water Act to revise Ambient Water Quality Criteria (AWQC) to reflect the latest scientific knowledge. The largest impact for ammonia is the presence, or not, of fresh water mussels. The anticipated mussel toxicity criteria are significantly more stringent than those currently in place for the Rapid City WRF.

The two primary drivers for reductions in nutrients in water bodies are Total Maximum Daily Loads (TMDLs) and Numeric Nutrient Criteria.

2.2.1.2 Total Maximum Daily Load

As with ammonia, changing water quality regulations for nutrients may dictate that consideration be given to modifications to improve treated wastewater effluent quality. The South Dakota Department of Natural Resources (SD DENR) is required to develop Total Maximum Daily Load Evaluation (TMDL) for all water bodies on the 303(d) list which includes Rapid Creek. A TMDL determines the total amount of a constituent that a water body may receive from all sources without exceeding water quality standards. A TMDL may require a reduction in constituent loading to meet water quality standards.

2.2.1.3 Numeric Nutrient Criteria

Numeric water quality limits are intended to control excessive nutrient (nitrogen and phosphorus) pollution in streams, rivers, and lakes. The intent of numeric nutrient discharge

limits is to provide water quality that protects the beneficial uses of these water bodies. Areas of the country already have numeric standards in place and others are developing them. It is not uncommon for nutrient criteria to be set below the limits of technology. In South Dakota, minimal work has been done to date on numeric nutrient criteria.

2.2.2 Timing for Planning

Anticipated regulatory changes that will be imposed on the WRF were evaluated and their potential impact on the proposed improvements required to meet those conditions for the next 20 years and beyond. Specific planning emphasis addressed ammonia limits which are expected to be implemented in 2025 and nutrient discharge limits which are expected to be implemented in 2030, with planning for continued treatment through year 2045.

The primary driver for reduction in ammonia in Rapid Creek is the 2013 EPA update to the 1999 and 2009 aquatic life ambient water quality criteria, most notably impacted by the presence or absence of fresh water mussels. The proposed limits are approximately half of the current 2016 ammonia permitted values. There has been little documentation regarding fresh water mussels in the waters of South Dakota and no documentation regarding these species in Rapid Creek at this time. DENR is working with the Game, Fish and Parks regarding a mussel study and Rapid Creek is one of the sites to be investigated, however, a schedule for that study has not been developed. Given the presence of mussels in similar streams across the United States, mussels have been assumed to be present in Rapid Creek for planning purposes.

The nutrient removal treatment capacity evaluations along with the recommended improvements are based on meeting a “Level 1” Total Nitrogen (TN) requirement of less than 10 mg/l and a Total Phosphorus (TP) limit of 1 mg/l. Planning to meet Level 1 is consistent with discussions with SD DENR and limits imposed in similar U.S. states. The City should be aware there is a significant level of ongoing effort in determining nutrient criteria across the U.S. As such, future nutrient discharge limits should still be considered to be very unpredictable. Proposed limits have been challenged in court by environmental activist groups and/or the EPA in instances where the proposed limits were considered to be inappropriate or untimely. In some states, legal action has greatly accelerated the implementation of more stringent discharge limits. Therefore, there is a chance that the limits may be more restrictive than Level 1.

The following Table 2.2.1 presents a summary of anticipated future Rapid City WRF discharge permit renewal dates and the anticipated limitations to be included in each permit. In addition, the corresponding recommended activity for the City is listed. The permit sequence is defined as follows:

- Current permit (2016): The permit that is expected to be issued in 2016.
- Permit #1 (2020) – Compliance Schedule for New Ammonia Standards
- Permit #2 (2025) – New Ammonia Standards
- Permit #3 (2030) – New Nutrient Standards

Table 2.2.1. Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit 2016	New Ammonia Standards based on updated Rapid Creek water quality	Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability. Establish schedule for construction – assume major projects are 5 years from study completion unless other justification (i.e. Trickling Filter Pump Station type trigger).
Permit #1 2020	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project to be constructed by 2025. Ammonia standards will become part of the SD Water Quality Standards After 2017 and new treatment process is required to meet proposed Ammonia limits.
Permit #2 2025	New Ammonia Standards	Assuming required improvements for ammonia removals complete. Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2030.
Permit #3 2030	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty. Track potential for more stringent nutrient standards.
Permit #4 2035	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

2.2.3 Preliminary Draft Surface Water Quality Permit

A preliminary draft of the WRF Surface Water Discharge (SWD) Permit No: SD0023574 was received in the spring of 2015 for review by the City. The most significant proposed change from the 2001 permit to the 2016 permit is more stringent ammonia limits. It is anticipated this permit will be issued to the City in 2016. This permit will be refered to as the Current (2016) Permit throughout this plan. This permit change was not identified nor anticipated during the last Facility Plan Update in 2000 and impacts the results and recommendations of that plan.

The basis for this preliminary draft permit is the Total Maximum Daily Loads (TMDLs) for waters at levels necessary to achieve and maintain water quality standards. The SD DENR has made a recommendation on the permit and Rapid City along with HDR have reviewed and commented on the permit. The DENR next reviews these comments and makes a determination on whether to incorporate the Owners comments. Next, DENR publishes the surface water quality permit limits in a local newspaper for a 30-day public comment period. If

the permit is contested, the DENR decides whether or not to incorporate the comments. If the comments are further disputed, a contested hearing is conducted and Secretary considers evidence and issues a final decision with the permit changes to reflect the decision.

Ammonia is the key parameter which affects treatment capacity in this draft permit. The draft permit and statement of basis (SOB) is attached in Appendix 2.2.A for reference.

The following sections contain a summary of the key treatment limits for the following permit parameters:

- Ammonia
- BOD
- Escherichia coli (E. coli)
- Total Suspended Solids (TSS) and,
- Dissolved Oxygen

2.2.3.1 Ammonia

The permit will have effluent limits for ammonia which vary monthly and are calculated based on actual receiving stream and plant flow as variables. The ammonia limits include both monthly average and daily maximum ammonia calculations for determining concentration based limits. Table 2.2.2 summarizes the draft ammonia limit equations and the resultant concentration modeled under critical flow conditions.

Critical flow conditions assume river flow is the monthly 7Q25 value and plant effluent is the monthly 80th percentile of effluent flow. The 7Q25 flow is the minimum 7-day average low flow that can be expected to occur once every 25 years in Rapid Creek. For the monthly critical conditions simulations, the 7Q25 low flow for Rapid Creek and 80th percentile effluent flows were used.

Critical conditions utilized by SD DENR to formulate the equations include using the monthly 80th percentile values for temperature, conductivity, TSS, ammonia, nitrate, total p-phosphate, alkalinity, and pH. To ensure that the ammonia standards are maintained during critical conditions, the 80th percentiles of the pH and temperature data at the water quality monitoring station upstream of the discharge point were calculated. The monthly 20th percentile values for DO were used. Fast CBOD5 was estimated as 1 mg/L in the absence of data. For the effluent, conductivity, total P-phosphate, and alkalinity were estimated from TMDL for ammonia and dissolved oxygen in Rapid Creek (SD DENR 2000).

For downstream conditions, the South Dakota Surface Water Quality Standards (SDSWQS) are determined at the mixing zone boundary to determine if the standards are met at the end of the mixing zone as the upstream and effluent conditions are modeled. The SDSWQS for ammonia are calculated based on actual water quality data. For further reference, the Permit Statement of Basis (SOB) outlines the formulas and data utilized to calculate the coefficients for the formulas in Table 2.2.2.

Note that the 2016 Current Permit became more stringent with regard to ammonia. The amount ammonia lowered from the 2001 permit to the 2016 permit at critical flows is indicated in the table as a negative value. Based on analysis of historic Rapid Creek flows, the impact to the WRF's ability to meet the permit is greatest in October.

Table 2.2.2. Ammonia Limit Formulas & Limits at Critical Flows – 2016 Permit

	30-day Average mg/L	30-day Average Limits at Critical Flows mg/L	Amount 30-day Average Lowered from 2001 Permit mg/L	Daily Max Limits mg/L	Daily Max Limits at Critical Flows mg/L	Amount Daily Max Lowered from 2001 Permit Limits mg/L
January	$2.91 + 2.86 \frac{Qu}{Qe}$	5.7	-3.4	$5.73 + 5.68 \frac{Qu}{Qe}$	15.9	-4.6
February	$2.73 + 2.68 \frac{Qu}{Qe}$	6.1	-3.0	$5.30 + 5.25 \frac{Qu}{Qe}$	15.9	-3.9
March	$1.38 + 1.33 \frac{Qu}{Qe}$	3.2	-1.9	$4.20 + 4.15 \frac{Qu}{Qe}$	9.0	-
April	$1.43 + 1.38 \frac{Qu}{Qe}$	2.5	-2.6	$4.36 + 4.31 \frac{Qu}{Qe}$	9.0	-1.4
May	$1.36 + 1.31 \frac{Qu}{Qe}$	1.9	-0.2	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
June	$1.01 + 0.96 \frac{Qu}{Qe}$	1.3	-0.8	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
July	$1.03 + 0.98 \frac{Qu}{Qe}$	1.4	-0.7	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
August	$1.47 + 1.42 \frac{Qu}{Qe}$	1.7	-0.4	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
September	$1.54 + 1.49 \frac{Qu}{Qe}$	1.8	-0.3	$3.29 + 3.25 \frac{Qu}{Qe}$	3.7[a]	0[a]
October	$1.29 + 1.24 \frac{Qu}{Qe}$	1.6	-1.8	$3.88 + 3.83 \frac{Qu}{Qe}$	6.0	-1.2
November	$2.32 + 2.27 \frac{Qu}{Qe}$	4.4	-	$4.36 + 4.31 \frac{Qu}{Qe}$	6.0	-
December	$2.09 + 2.04 \frac{Qu}{Qe}$	4.6	-4.5	$3.88 + 3.83 \frac{Qu}{Qe}$	15.9	-7.3

a. *Gray cells indicate that the values that do not meet anti-backsliding requirements. "Backsliding" is a term used to describe a circumstance where a facility has a permit that lists certain effluent limitations and upon renewal/reissue of the permit, the "new" effluent limitations are made less stringent then those in the previous permit. In general, "backsliding" is not allowed. The regulations that discuss "backsliding" are found at 40 CFR 122.44(l). These regulations discuss the renewal or reissue of discharge permits (for direct dischargers) and say that the effluent limitations, standards, or conditions in the renewed/reissued permit "must be at least as stringent" as the effluent limitations, standards, or conditions in the previous permit. The regulations do provide several exemptions which would allow "backsliding" (e.g., circumstances have materially and substantially changed since the time the permit was issued).*

2.2.3.2 BOD

The five-day biochemical oxygen demand (BOD5) limits are shown in Table 2.2.3. The 2001 permitted 30-day average BOD limit was 30 mg/l year-round. The 2016 Current Permit lowest limit is 24 mg/l during the summer months (May 1 thru September 30) for both the 30-day average and 7-day average. The 2016 Current Permit 30-day BOD limit was also lowered to 28 mg/l for October 1 thru November 30. Planning will include a permit level for BOD consisting of discharge concentrations in Table 2.2.3 through year 2025. At these levels, it is unlikely that BOD will drive improvements, as ammonia limits will control treatment requirements.

Table 2.2.3. Five-Day Biochemical Oxygen Demand (BOD5) Limits

Season	30-Day Average mg/l	7-Day Average mg/l
January 1 – January 31	30	30
February 1 – February 29	30	30
March 1 – March 31	30	30
April 1 – April 30	30	30
May 1 – May 31	24	24
June 1 – June 30	24	24
July 1 – July 31	24	24
August 1 – August 31	24	24
September 1 – September 30	24	24
October 1 – October 31	28	28
November 1 – November 30	28	28
December 1 – December 31	30	30

2.2.3.3 Escherichia coli (E. coli)

The 2001 permit included a monthly limit of Fecal Coliform less than 200 colonies/100ml geometric mean and a daily max of 400 colonies/100ml. This limit was effective from May 1 to September 30. The new indicator organism is Escherichia coli (E. coli).

The 2016 Current Permit stipulate E. coli organisms shall not exceed a concentration of 126 per 100 milliliters as a geometric mean. The draft permit requires three samples per week, with a monthly limit of less than 126 colonies/100ml geometric mean, and a daily max of 235 colonies/100ml. This limit is also effective from May 1 to September 30.

2.2.3.4 Total Suspended Solids (TSS)

The Total Suspended Solids (TSS) concentration shall not exceed 30 mg/L (30-day average) or 45 mg/L (7-day average). This was unchanged from the 2001 permit limit.

2.2.3.5 Dissolved Oxygen

The dissolved oxygen lower limits are shown in Table 2.2.4. Dissolved oxygen limits will be met with the current automated post aeration system followed by the final cascade aeration steps.

Table 2.2.4. Dissolved Oxygen Limits

Season	Dissolved Oxygen (mg/l)
January 1 – January 31	5
February 1 – February 29	5
March 1 – March 31	5
April 1 – April 30	5
May 1 – May 31	6.5
June 1 – June 30	6.5
July 1 – July 31	6.5
August 1 – August 31	6.5
September 1 – September 30	6.5
October 1 – October 31	6
November 1 – November 30	6
December 1 – December 31	5

2.2.4 Future Permit Limits

This section contains a summary of the key future treatment limits including the following permit parameters:

- Permit #2 -Ammonia
- Permit #3 -Total Nitrogen
- Permit #3 -Total Phosphorus

2.2.4.1 Ammonia Limits (Permit #2, 2013 EPA Ammonia Criteria)

A potential regulatory driver for future SWD permits is the Permit #2 Ammonia Criteria which lower toxicity limits. The largest impact for ammonia is the presence (or not) of fresh water mussels. The anticipated mussel toxicity criteria are significantly more stringent than those currently in place for the Rapid City WRF.

Table 2.2.5 summarizes the current SWD permit limits along with the potential ammonia limits when a mussel water quality criterion is used. Per discussions with SD DENR, the potential ammonia limits are one half of the of current ammonia limits. The revised federal ammonia nitrogen criteria will be incorporated into South Dakota water quality standards at the completion of the next triennial review in 2017 and implemented into permits.

Table 2.2.5. Current (2016) and Potential Permit #2 Ammonia Limits

		Current 2016 Permit Ammonia Limits				Permit #2 New Ammonia Limits[2]	
	30-day Average mg/l	Amount 30-day Average Lowered from 2001 Permit	Daily Max mg/l	Max Day w/o Backsliding mg/l	Amount Daily Max Lowered from 2001 Permit Limits	30-day Average mg/l	Daily Max w/o Backsliding mg/l
January	5.7	-3.4	11.3		-4.6	2.9	5.6
February	6.1	-3.0	12.0		-3.9	3.1	6.0
March	3.2	-1.9	10.0		n/a	1.6	5.0
April	2.5	-2.6	7.6		-1.4	1.2	3.8
May	1.9	-0.2	4.6[1]	6.1	n/a	1.0	3.0
June	1.3	-0.8	4.1[1]	6.1	n/a	0.6	3.1
July	1.4	-0.7	4.4[1]	6.4	n/a	0.7	3.2
August	1.7	-0.4	3.8[1]	7.5	n/a	0.8	3.7
September	1.8	-0.3	3.8[1]	5.6	n/a	0.9	2.8
October	1.6	-1.8	4.8		-1.2	0.8	2.4
November	4.4	1.0	8.3		n/a	2.2	4.2
December	4.6	-4.5	8.6		-7.3	2.3	4.3

1. *Gray cells indicate that the values that do not meet anti-backsliding requirements.*
2. *Based on discussions between HDR and SD DENR, future ammonia limits will be one half of the existing limits.*

There has been little documentation regarding fresh water mussels in the waters of South Dakota and no documentation regarding these species in Rapid Creek at this time. In addition, there has not been a schedule determined for Rapid Creek fresh water mussel analysis; however, there is currently a plan to conduct mussel surveys. DENR is working with the Game, Fish and Parks regarding a mussel study and Rapid Creek is one of the sites to be investigated.

HDR met with SD DENR and it was indicated that they have recently completed their triennial review and therefore, any ammonia discharge limit changes will not be included until the next triennial review. After the next triennial review there will be a one to two year period of rulemaking. Then, as permits are renewed, they will include the proposed ammonia limits with a compliance schedule for implementation of new facilities if necessary. This may take two permit cycles. Under the current approach, incorporation of the new ammonia limits will not take place for a minimum of 10 years.

Given that mussels are likely present, facility planning will be for treating to the new Permit #2 ammonia criteria with mussels present in 2025.

2.2.4.2 Nutrient Discharge Limits

Over the next three SWD permit cycles point source discharges, such as the Rapid City Water Reclamation Facility, will likely be required to monitor parameters to be used to achieve biological nutrient removal, and then will be provided a moratorium with more stringent standards in place for the year 2030. As noted previously, EPA or legal action could force a more aggressive approach in South Dakota.

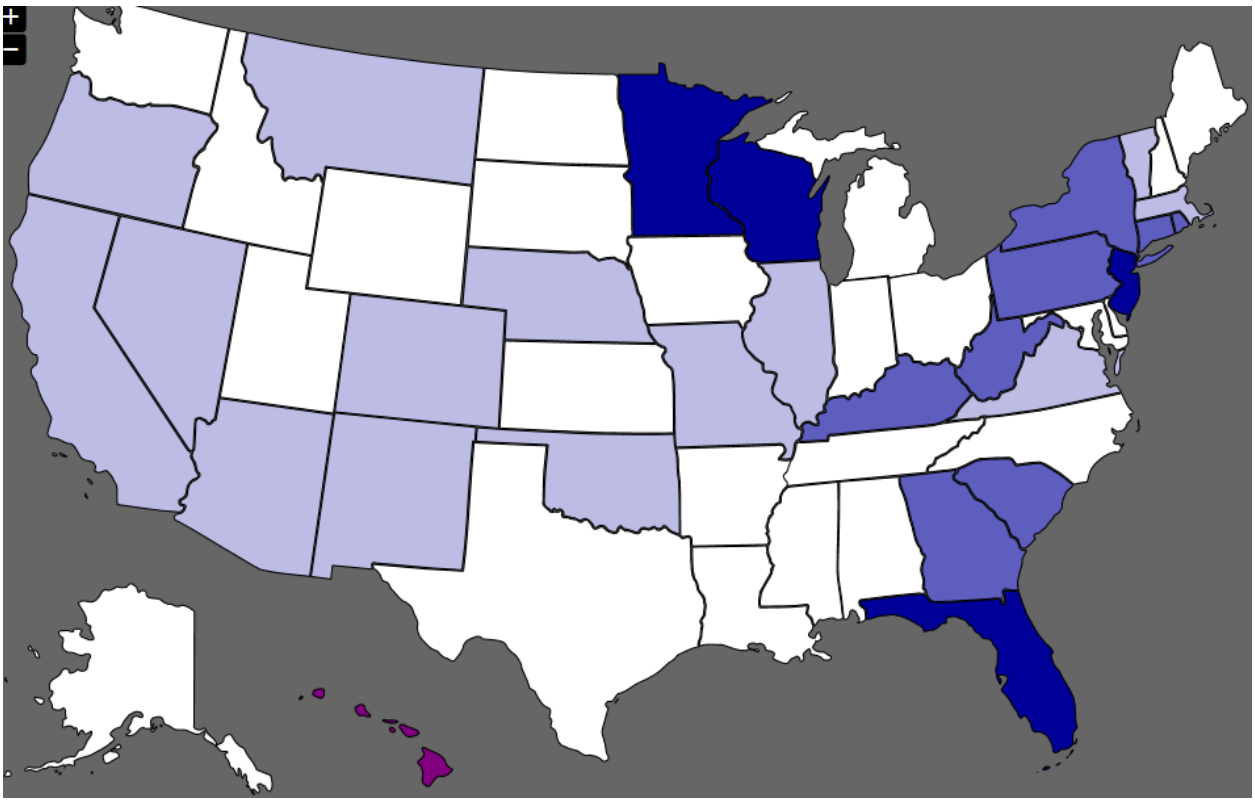
A nutrient criterion for Nitrogen and Phosphorus with respect to Rapid City's planning efforts was discussed with SD DENR. Based on conversations with SD DENR, there does not appear to be a current planned date for establishing nutrient criteria for South Dakota. Per the discussions, the planning team and SD DENR have agreed to a permit level for nutrients consisting of discharge concentrations in the ranges of 1.0 mg/l P and 10 mg/l TN to be met in year 2030.

For comparison purposes, Table 2.2.6 summarizes the total nutrient goals for several other states in the region.

Table 2.2.6. Nutrient Goals for other States in the Region

State	Total Nitrogen Goal, mg-N/L	Total Phosphorus Goal, mg-P/L
Kansas (Tier 1)	8	1.5
Iowa	10	1.0
Missouri	10	1.0
Minnesota	n/a	1.0
Wisconsin	≥ 10	1.0

Figure 2.2.2 depicts the total nation-wide nutrient implementation status based on the individual state's documented milestones thru year 2019. This indicates that a plan is in place to implement some form of nutrient limits within the next 3 years in these states. North Dakota has a task force in place, which is actively working to address implementing nutrient limitations.



Two or more water types with N and/or P criteria

One water type with N and/or P criteria

Waters with N and/or P criteria

Figure 2.2.2: State-wide Nutrient Permit Limit Status

Chapter 3.1 Plant Hydraulic Capacity

This chapter presents the evaluation of the hydraulic capacity of the City of Rapid City Water Reclamation Facility (WRF). The results have been used to identify capital improvements to increase capacity for both current and future needs consistent with the long-term plan for the WRF.

Unit process capacities have been evaluated based on *Recommended Standards for Wastewater Facilities as compiled by the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers*, which is commonly referred to as Ten States Standards. These standards referenced are based on the latest 2014 revised edition. The standards are commonly referenced in the industry and are intended for use as a guide in the design and preparation of plans and specifications for wastewater treatment facilities. These standards are used in conjunction with actual unit process recorded past performance to determine if improvements to the unit processes are necessary.

In addition, firm hydraulic capacity requirements will be verified for critical equipment. Firm capacity is defined as having adequate critical equipment and/or treatment capacity when the largest treatment unit or pump is out of service.

A copy of the calculation summary report from the hydraulic model is included in Appendix 3.1.A.

3.1.1 Objectives

The objectives for this chapter are as follows:

- Consider process performance implications, if any, associated with the preliminarily identified hydraulic capacity based on past performance records and Ten States Standards Recommendations.
- Make a preliminary assessment of the WRF hydraulic capacity using available information, including original North Plant hydraulic profile, South Plant hydraulic profile, UV disinfection hydraulic profile, and historic plant influent flow data.
- Identify hydraulic bottlenecks, conduct additional hydraulic analysis, and identify modifications that could potentially increase hydraulic capacity consistent with process performance implications.

3.1.2 Unit Process Descriptions and Evaluations

The following section summarizes the individual unit processes at the WRF that are hydraulic capacity driven. An overview of the sizing and capacity guidelines is also provided.

3.1.2.1 Pretreatment Hydraulics

INFLUENT SEWER

Wastewater is conveyed from the City of Rapid City to the WRF by a 48-inch-diameter sewer. At 45 MGD, the wastewater in the sewer beneath the WRF site fence (which is the edge of study area) reaches the top of the pipe. The sewer is surcharged at this flow, but the wastewater is still contained in the pipe and is not overflowing any manholes.

INFLUENT METERING

Raw influent wastewater from the trunk sewer is metered with a Flo-Dar velocity/area open channel flow measurement device located in a manhole in the influent sewer adjacent to the Pretreatment Building. The Flo-Dar unit is capable of operating under submerged conditions and can measure flows in excess of 45 MGD.

INFLUENT SCREENING

Screening at the Rapid City WRF is accomplished with two mechanically cleaned bar screens. Each screen is 4.5 feet wide with 5/16-inch-wide bars and ¼-inch bar spacing. The screens have a combined rated capacity of 37 MGD. However, assuming 20 percent screen blockage, the flow through the screens may be increased to 45 MGD with the upstream channel freeboard at approximately 0.75 foot. This means that the cleaning mechanisms may have to operate continuously during the peak even to keep the screen clean. Typically new plant design would be for one foot of freeboard minimum, however, 0.75 foot is acceptable for existing conditions. For a relatively low cost, curb could be added at the upstream channel.

GRIT REMOVAL

Two 16-foot-diameter vortex-type grit removal units are used at the WRF to remove grit from the wastewater prior to primary and secondary treatment. Based on the product data sheets provided by the supplier, the two grit removal units have a combined capacity of 40.0 MGD, with a resultant headloss of 1 inch. However, if the plant flow exceeds 34 MGD, the freeboard in the channels directly upstream of the grit removal units decreases to approximately 0.75 foot. Typically new plant design would be for one foot of freeboard minimum, however, 0.75 foot is acceptable for existing conditions. As with the fine screens, curb could be added at the upstream channel. Figure 3.1.1 shows a section view of one of the grit removal units.

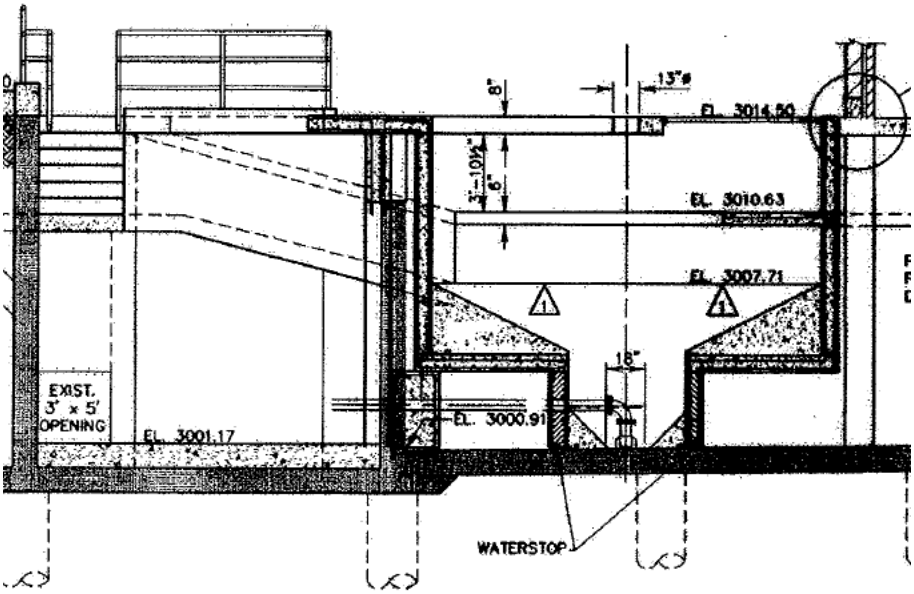


Figure 3.1.1. Grit Removal Unit Section

The effluent of the grit removal units flows by gravity through channels to the pretreatment splitter box. Downward opening weir gates in this box allow operators to manually divert some of the flow to the South Plant. The flow that is not diverted travels through two 42-inch-diameter pipes to the North Plant. Table 3.1.1 presents the key physical dimensions of the pretreatment splitter box.

Table 3.1.1. Pretreatment Splitter Box

Description	Weir Length, feet	Lowest Weir Elevation	Top of Wall Elevation
Pretreatment Splitter Box	4.0	3007.25	3012.50

3.1.2.2 South Plant Hydraulics

AERATION BASIN SPLITTER BOX

The flow diverted to the South Plant is conveyed through a 48-inch-diameter pipe to the aeration basin splitter box. The splitter box contains motorized gates that are automatically modulated to control the amount of flow to the South Plant and to split that flow evenly to the two aeration basin trains. Table 3.1.2 presents the key physical dimensions of the aeration basin splitter box.

Table 3.1.2. Aeration Basin Splitter Box

Description	Weir Length Per Gate, feet	Lowest Weir Elevation	Top of Wall Elevation
Aeration Basin Splitter Box	5.0	3010.5	3014.5

AERATION BASINS

The aeration basins consist of two trains with four cells in each train. The first cell is a selector cell and is separated from the rest of the basin by a movable curtain. The other cells are separated by concrete walls containing openings to allow the flow to travel from one cell to the next.

Currently, the flow through aeration basins is limited to 4 MGD. At flows above 4 MGD, the selector cell curtain begins to rip. Modifications are required in order to eliminate the restriction created by the curtain. Assuming that the curtain restriction is addressed, the flow to the aeration basins can be increased to 12 MGD (assuming 30 MGD through the North Plant and 42 MGD total plant flow) before the effluent weir becomes submerged. There is approximately 1.8 feet of freeboard in the aeration basins at this flow.

The aeration basin flow collects in effluent channels and then flows through a 42-inch-diameter pipe to the clariflocculator.

CLARIFLOCCULATOR

A single 110-foot-diameter clariflocculator is used to settle the activated sludge coming from the aeration basins.

The peak hour design surface overflow rate recommended by the 10 States Standards for final activated sludge clarifiers is 1,200 gallons per day per square foot (gpd/sf). This equates to a peak hour hydraulic capacity of 11.4 MGD. However, the effluent weir of the clariflocculator will submerge at a flow rate of 9 MGD through the South Plant (assuming 30 MGD through the North Plant and 39 MGD total plant flow).

Flow is conveyed from the clariflocculator through a 48-inch-diameter pipe to the UV Disinfection Building.

RETURN ACTIVATED SLUDGE PUMPS

Settled activated sludge is returned to the aeration basins via three screw centrifugal return activated sludge (RAS) pumps (two duty pumps and one standby pump). Each pump has a capacity of 2,200 gallons per minute (gpm) (3.17 MGD), for a total firm capacity of 4,400 gpm (6.33 MGD).

RAS rates typically range from an equivalent of 50 to 150 percent of the influent flow. At an assumed RAS rate of 50 percent of the influent flow, the RAS pumps have the firm capacity to accommodate an aeration basin influent flow of 12.7 MGD. At an assumed RAS rate of 150 percent of the influent flow, the RAS pumps have the firm capacity to accommodate an aeration basin influent flow of 4.2 MGD and total capacity of 6 MGD. If RAS rates approaching 150 percent of the influent are required for the selected alternative, the RAS sludge pumps will need to be upsized.

3.1.2.3 North Plant Hydraulics

PRIMARY CLARIFIERS

The WRF has four 40-foot x 142-foot rectangular primary clarifiers that receive flow from the pretreatment splitter box downstream of the grit removal units. Humus from the secondary clarifiers is blended with the primary clarifier influent flow upstream in the Pretreatment Building.

The design average surface overflow rate recommended by the 10 States Standards for primary clarifiers is 1,000 gpd/sf. This equates to a design average capacity based on hydraulic loading of 22.7 MGD. The peak hour design surface overflow rate recommended by the 10 States Standards is 2,000 gpd/sf. This equates to a peak hour capacity based on hydraulic loading of 45.4 MGD.

The 10 States Standards recommended weir loading rate is 30,000 gpd/linear foot. In the primary clarifiers, this equates to a capacity of 26 MGD. Weir loading rates are not as critical to process operation as other factors, and should not be considered to be the limiting factor in existing wastewater facilities and additional weir troughs can be added to correct this limitation.

Finally, the primary clarifiers have a depth of 7.2 feet, which is less than the 10 States Standards recommended depth of 10 feet. The relatively shallow depth may reduce the solids removal efficiency at higher flow rates which also is not critical to plant function. In fact, nutrient removal processes depend on higher organic loading rates and plants have had to add bypass systems to increase the load to the nutrient removal portion of the process.

TRICKLING FILTER RECYCLE PUMPS

After leaving the primary clarifiers, the flow travels to the Trickling Filter Pump Station. Three vertical turbine pumps convey raw wastewater and trickling filter effluent to the trickling filter distributor arms. All three pumps are of the same capacity: 11,000 gpm (15.8 MGD) at 17 feet of head. Two of the pumps are duty, and one is standby. Therefore, the firm capacity of the pump station is 31.7 MGD. If all three pumps are running, up to 47 MGD may be conveyed to the trickling filters. Figure 3.1.2 presents the pump curve for the trickling filter pumps.

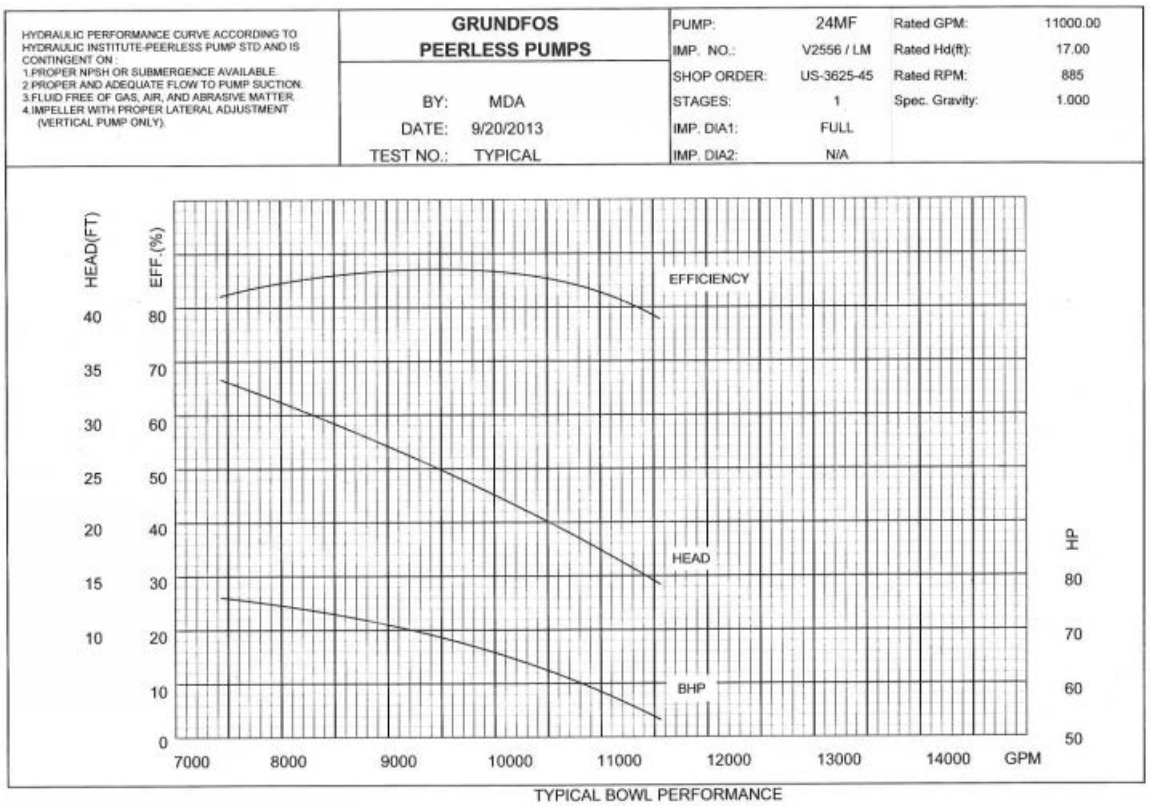


Figure 3.1.2. Trickling Filter Pump Curve

TRICKLING FILTER ROTARY DISTRIBUTORS

The trickling filter feed pumps convey flow to the trickling filter rotary distributor arms. The new distributor arms in each trickling filter have a rated capacity of 2.5 MGD (minimum flow) to 18.0 MGD (maximum flow). This equates to a combined peak capacity of 36.0 MGD. Because the trickling filter pumps have a capacity of 31.7 MGD, the rotary distributor capacity is adequate.

SECONDARY CLARIFIERS

The WRF has four 40-foot x 142-foot rectangular secondary clarifiers that serve as intermediate clarifiers downstream of the trickling filters. The peak hour design surface overflow rate recommended by the 10 States Standards for intermediate clarifiers is 1,200 gpd/sf. With all four secondary clarifiers in service, the peak hour hydraulic capacity is 27.3 MGD.

The secondary clarifier effluent weirs submerge at a flow rate of 30 MGD through the North Plant (assuming 10 MGD through the South Plant and 40 MGD total plant flow,).

The 10 States Standards recommend a weir loading rate of 30,000 gpd/linear foot. In the secondary clarifiers, this equates to a capacity of 26 MGD. Weir loading rates are not as critical to process operation as other factors and should not be considered to be a limiting factor.

In addition, the secondary clarifiers have a depth of 7.2 feet, which is less than the 10 States Standards recommended depth of 10 feet. The relatively shallow depth may reduce the solids removal efficiency at higher flow rates.

SECONDARY CLARIFIER SLUDGE PUMPS

The settled sludge collected off the bottom of the secondary clarifiers is returned to the head of the plant by non-clog centrifugal pumps. These pumps are adequately sized for North Plant flows in excess of 30 MGD. The pumping time per hour can be increased as flow through the plant increases in order to maintain the desired sludge level.

ROTATING BIOLOGICAL CONTACTORS

The flow travels to the rotating biological contactors (RBCs) from the secondary clarifiers. There are four banks of RBCs, with eight units in each bank. The RBC effluent weir submerges at a North Plant flow rate of 38 MGD (assuming 10 MGD through the South Plant and 48 MGD total plant flow). The original construction documents show solid wooden baffles between the RBCs, with a 1.5-inch space between the bottom of the baffles and the floor. These baffles created an unreasonably large amount of headloss. These baffles were eliminated in the hydraulic model to achieve a headloss across the RBCs that more accurately reflects the actual observed headloss. Top sections of these baffles may need to be removed to increase flow through the RBCs.

TERTIARY CLARIFIERS

The RBC effluent flows to four rectangular tertiary clarifiers, each 39 feet x 140 feet in plan dimensions. The peak hour design surface overflow rate recommended by the 10 States Standards for final clarifiers is 1,200 gpd/sf. This equates to a maximum hour flow capacity of 26.2 MGD for the tertiary clarifiers. The invert of the tertiary clarifier effluent weir submerges at a flow rate of 18 MGD (assuming 8 MGD through the North Plant and 10 MGD through the South Plant). The top of the effluent weirs submerge at 26 MGD (assuming 16 MGD of North Plant flow and 10 MGD of South Plant flow). The tertiary clarifier effluent flows through a 48-inch-diameter pipe to the UV Disinfection Building.

The 10 States Standards has a recommended weir loading rate of 30,000 gpd/linear foot. In the tertiary clarifiers, this equates to a capacity of 26.3 MGD. In addition, the tertiary clarifiers have a depth of 7.9 feet, which is less than the 10 States Standards recommended depth of 10 feet. The relatively shallow depth may reduce the solids removal efficiency at higher flow rates.

TERTIARY CLARIFIER SLUDGE PUMPS

The settled sludge collected off the bottom of the tertiary clarifiers is pumped to the trickling filter recirculation pit adjacent to the Trickling Filter Pump Station. These pumps are adequately sized for North Plant flows in excess of 30 MGD. The pumping time per hour can be increased as flow through the plant increases in order to maintain the desired recycle ratio.

3.1.2.4 UV Disinfection Building Hydraulics

POST AERATION

Flows from the North Plant and South Plant combine in a post aeration channel adjacent to the UV Disinfection Building. The combined flow travels over a series of diffusers in the channel. The diffusers aerate the flow to meet the City's discharge permit dissolved oxygen limit. The aeration channel can accommodate flows in excess of 65 MGD.

UV DISINFECTION

Two parallel channels containing UV disinfection units are located downstream of the post aeration channel. The design of the UV system incorporates modulating weirs to maintain a consistent wastewater surface elevation in the UV channel at minimum and maximum plant flows. The hydraulic profile across the UV system is presented in Figure 3.1.3. Minimal headloss results from the UV system at the system's rated channel capacity of 64 MGD. Treatment capacity is rated at 40 mgd.

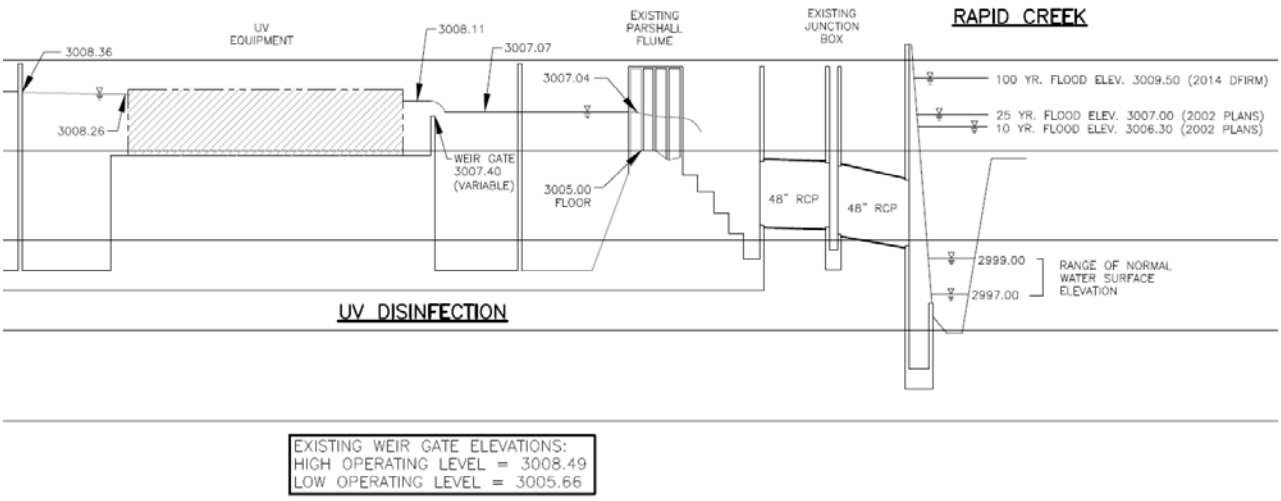


Figure 3.1.3. UV Disinfection Hydraulic Profile

EFFLUENT FLOW MEASUREMENT

The plant flow is measured by a 5-foot-wide Parshall Flume located in a channel downstream of the UV disinfection units. Parshall Flumes of this size have a rated capacity of 55.4 MGD.

PLANT OUTFALL

The flume discharges to a cascade aerator which discharges to Rapid Creek via a 48-inch-diameter, 120-foot-long outfall pipe. At the discharge of the pipe, the flow travels over a cascade aerator. The cascade aerator provides additional aeration at lower creek levels. At creek levels approaching an elevation of 3000.00, the cascade aerator begins to submerge, and its ability to provide additional aeration decreases.

RIVER ELEVATION

Rapid Creek's water surface elevation adjacent to the WRF outfall is normally between elevation 2997.00 and 2999.00. When the creek is flowing in this range, it has no hydraulic impact on the WRF upstream. At higher river elevations and flows, water begins to back into the plant. Table 3.1.3 summarizes the river elevations and plant flows that result in upstream processes becoming submerged.

Table 3.1.3. Impact of Rapid Creek Elevation on WRF Hydraulics

Rapid Creek Water Surface Elevation, feet	Description of Rapid Creek Water Surface Elevation (from 2002 plans)	Flow at which the Effluent Parshall Flume Becomes Submerged,[a] MGD	Flow at which the UV System Becomes Submerged,[b] MGD
2997.00	Low end of normal range	>100	64
2999.00	Upper end of normal range	>100	64
3006.30	10-year flood	Submerged from 1 MGD to 22 MGD, Not submerged above 22 MGD	64
3007.00	25-year flood	Submerged at all flows	47
3009.50	100-year flood	Submerged at all flows	Submerged at all flows

Notes:

[a] *The flows presented are the flows that are required to achieve a water surface elevation of 3008.11 directly downstream of the penstock weir, which is the operating elevation for the UV units.*

[b] *The flow is based on the lowest possible UV penstock weir elevation of 3005.66.*

The existing top of channel at the lowest spot is 3009.66, therefore, the UV units are submerged but wastewater stays in the channel at the 100-year event. The 500-year estimated flood elevation is 3012.4 at the outfall. At this elevation flooding would occur in the UV Building. Refer to Appendix 3.1.B for elevations from FEMA Mapping.

Due to a recent executive order (EO 13690) the definition of the floodplain will be changing. As various agencies adopt the order, the impact on treatment facilities will be in flux as there are grey areas that need to be addressed. One of the key elements of the executive order is that it changes the elevation standards for structures by redefining the floodplain to be higher than base flood to include a higher freeboard criteria, 500-year floodplain, or future conditions with climate change. This would likely require the WRF to be protected to the 500-year elevation.

Preliminary solutions include the following:

- Construct a berm to isolate the WRF from the river at 3012.4 and provide either permanent or temporary pumping to the creek.
- Construct a berm to isolate the WRF from the river at 3012.4, provide influent equalization and divert all flow to a storm event equalization pond. Peak flow events in Rapid Creek occur quickly and an initial estimate for equalization of 3.5 to 4 million gallons is recommended.

3.1.3 Hydraulic Modelling

A comprehensive plant hydraulic model was developed by HDR to help determine the WRF hydraulic capacity and identify hydraulic bottlenecks and limitations. The model combines low-pressure gravity piping components with weir headloss calculations and launder and channel headloss calculations in one tool that can be easily modified to reflect various operating conditions.

This model structure has been used in numerous wastewater facility and sewer/pump station evaluations and designs across the country, and has met HDR's internal quality control requirements. The model was not specifically calibrated to water surface elevations at the Rapid City WRF; however, the headloss friction factors, fitting losses, and weir losses used in the model are conservative.

The physical features of the WRF, including pipe diameters, pipe lengths, top of wall elevations, channel inverts, wetwell levels, and valves, were obtained from the as-built drawings. No field verification or survey of these features was conducted.

3.1.4 Model Results

The plant hydraulic model was used to review the hydraulic losses and freeboard conditions for the Rapid City WRF. First, the original design influent flow of 40 MGD (assuming 30 MGD through the North Plant and 10 MGD through the South Plant) was used, and then flows were increased to maximum to determine points of failure.

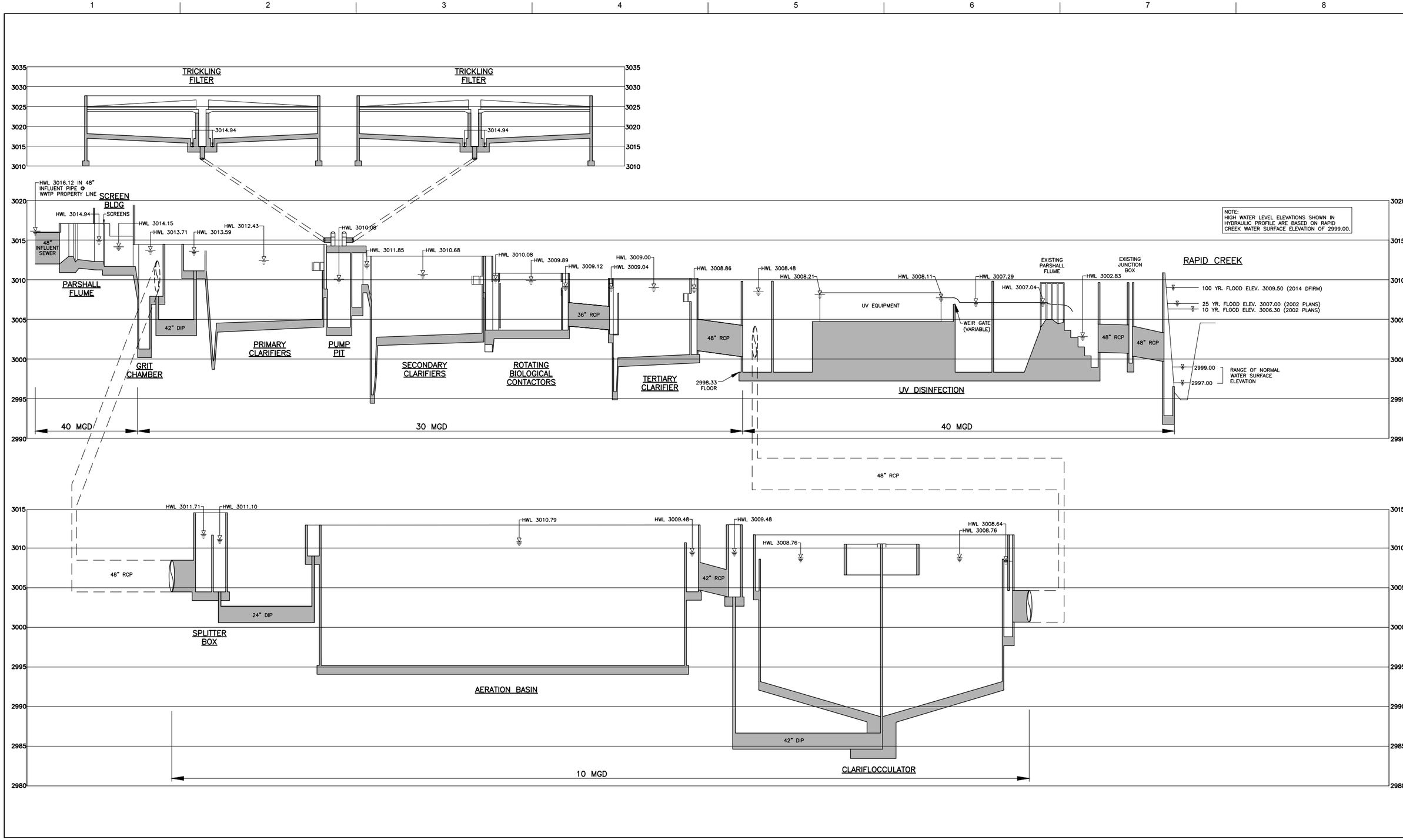
For the hydraulic analysis of the North Plant processes, it was assumed that the South Plant was operated at its original design capacity of 10 MGD. Flows were then increased on North Plant processes until failure occurred. Similarly, for the hydraulic analysis of the South Plant processes, it was assumed that the North Plant was operated at its original design capacity of 40 MGD. Flows were then increased on the South Plant processes until failure occurred.

The hydraulic profile generated by the model is shown in Figure 3.1.4. This profile shows wastewater elevations throughout the existing plant at a plant influent flow rate of 40 MGD (assuming 30 MGD to the North Plant and 10 MGD to the South Plant). A report generated by the hydraulic model program showing the detailed component elevations and losses for the hydraulic profile of the plant is included in Appendix 3.1.A. The report was generated at the 40 MGD plant influent condition (assuming 30 MGD through the North Plant and 10 MGD through the South Plant).

The results of the model runs show that the actual hydraulic capacity at the WRF is governed by the capacity of the piping leaving the clariflocculator and tertiary clarifiers.

At 26 MGD (assuming 16 MGD through the North Plant and 10 MGD through the South Plant), the wastewater level on the downstream side of the tertiary clarifiers is right at the top of the V-notch weirs, which is acceptable for hydraulic performance at that flow rate but does not provide any room for additional flow through the North Plant. The main restriction is the pipe connecting

the clariflocculator effluent and the UV Disinfection Building. To accommodate flows higher than 26 MGD, this pipe needs to be upsized, or a second, parallel pipe needs to be installed. At this flow rate, none of the weirs are submerged, and wastewater is contained within all structures. There is not any one unit process or pipe segment that is limiting the hydraulic capacity of the facility, but rather there are several. Any plan to provide a substantial increase in hydraulic capacity beyond 26 MGD would require significant piping, and structure changes throughout the WRF.



ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

PRELIMINARY
NOT FOR CONSTRUCTION

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

RAPID CITY INCORPORATED 1882 SOUTH DAKOTA

2015

HYDRAULIC PROFILE

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Figure
3.1.4

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3.1.5 Observations and Limitations

3.1.5.1 High Velocity and Headloss Process Elements

Several process elements in the model have excessive velocities, causing abnormally high headloss in the plant hydraulics at higher influent flow rates. The following is a list of those process elements and the associated head loss in feet at a flow rate of 40 MGD (assuming 30 MGD through the North Plant and 10 MGD through the South Plant):

- Clariflocculator inlet piping and ports: 0.90-foot headloss
- Final clarifier effluent launder: 0.43-foot headloss
- Final clarifier inlet adjustable plates: 1.17-foot headloss
- Trickling filter recirculation pit inlet pipe: 0.72-foot headloss
- Trickling filter effluent pipe: 1.2-foot headloss
- Primary clarifier effluent launder: 0.47-foot headloss
- Primary clarifier inlet adjustable plates: 1.17-foot headloss

In addition to the elements listed above, relatively high velocities were noted in the RAS pump discharge piping. At a lower RAS rate of 5,000 gpm to each aeration basin train, the velocity in the pipe is still relatively high at 9.7 ft/sec. It is not recommended to exceed 10 ft/sec.

If the City of Rapid City wanted to increase the hydraulic capacity of the WRF beyond the current capacity, these portions of the plant should be upsized to provide additional flow in these segments.

3.1.5.2 Future Flows Plant Expansion

Alternatives for expanding the WRF to accommodate projected future flows are presented in Chapter 4.2 - Alternative Evaluation with the required hydraulic improvements.

3.1.6 Summary

Based on the analyses performed and the equipment information provided by staff, the hydraulic capacity of the WRF was determined through a combination of a) unit process by unit process analysis and b) hydraulic modeling of the entire WRF. Hydraulic capacity for individual unit processes is presented in Table 3.1.4.

The current 2015 peak hour flow measured at the facility is 30.2 mgd. Hydraulic modeling of the entire WRF identified the limiting hydraulic capacity of the existing WRF to be 26 million gallons per day (MGD) at the Tertiary Clarifiers. The invert of the tertiary clarifier effluent weir becomes submerged at 18 MGD; the top of the weir becomes submerged at 26 MGD with 16 MGD through the North Plant and 10 MGD through the South Plant. While submerged weirs reduce the suspended solids removal efficiency, the clarifiers will continue to operate and flow will continue through the plant. At 26 MGD, hydraulic loadings on individual treatment processes are manageable, and flow can be accommodated without submerging weirs or overflowing structures when all treatment units are in operation. Because flow is split between the north and

south plants, the assumption was made that the South Plant flow is limited to 10 MGD to match the South Plant basis of design.

The second most restrictive bottleneck is just upstream of the grit removal units. At 34 MGD, the freeboard in the channel directly downstream of the screens is less than 0.75 foot. Typically new plant design would be for one foot of freeboard minimum, however, 0.75 foot is acceptable for existing conditions. For a relatively low cost, curb could be added at the upstream channel.

The third most restrictive total plant flow bottle neck is related to exceeding Recommended Ten States Standards recommended maximum surface overflow rates. The plant flow restrictions based on Ten States' Recommendations are tertiary clarifier (16 MGD for total @ 26 MGD), secondary clarifier (27.3 mgd for total @ 37.3 MGD) and clariflocculator (9 MGD for total @ 39 MGD). Refer to Table 3.1.4. The notes below Table 3.1.4 further describe the unit process flow considerations.

Table 3.1.4. WRF Unit Process Hydraulic Capacity Summary

Area of the Facility	Unit Process	Hydraulic Capacity, MGD		
		North Plant	South Plant	Total Plant
Pretreatment Building	WRF Influent Sewer[a]	35	10	45
	Screens[b]	43	10	53
	Grit Removal Units[c]	24	10	34
North Plant	Primary Clarifiers[d]	30	10	40
	Trickling Filter Recycle Pumps[e]	31.7	10	41.7
	Trickling Filter Rotary Distributors[f]	36	10	46
	Secondary Clarifiers[g]	27.3	10	37.3
	Rotating Biological Contactors (RBCs)[h]	38	10	48
	Tertiary Clarifiers[i]	8	10	18
		16	10	26
South Plant	Aeration Basins[j]	30	12	42
	Clariflocculator[k]	30	9	39
UV Disinfection Building	UV Disinfection	30	10	40
	Effluent Flow Measurement[l]	45	10	55

Notes:

45 MGD is the flow at which the influent sewer surcharges at the location of the WRF fence (boundary of study).

[a] *Screens were assumed to be 20 percent blocked. 53 MGD is the flow at which the freeboard in the channel upstream of the screens is less than 0.75 ft.*

[b] *34 MGD is the flow at which the freeboard in the channel directly downstream of the screens is less than 0.75 ft.*

[c] *The primary clarifier effluent weirs become submerged at 40 MGD. Based on the 10 States Standards recommendations, the primary clarifiers are rated for 22.7 MGD average flow and 45.4 MG peak hourly flow.*

[d] *31.7 MGD is the firm capacity of the trickling filter pump station (two pumps in operation with two on standby). The pump station is capable of pumping approximately 45 MGD if all three pumps are in operation.*

[e] *Each trickling filter distributor system is rated for 18 MGD. Flow will begin to back into the trickling filter underdrain at 46 MGD total plant flow.*

[f] *The secondary clarifier effluent weir submerges at 40 MGD. Based on the 10 States Standards recommendations, the secondary clarifiers are rated for 27.26 MGD peak hour loading.*

[g] *The RBC effluent weir submerges at 48 MGD total plant flow.*

[h] *The invert of the tertiary clarifier effluent weir becomes submerged at 18 MGD; the top of the weir becomes submerged at 26 MGD. Based on the 10 States Standards recommendations, the peak hour capacity is 26.2 MGD.*

[i] *The aeration basin effluent weir submerges at 42 MGD total plant flow. The selector cell curtain becomes damaged at flows exceeding 4 MGD.*

[j] *The clariflocculator effluent weir submerges at a total plant flow of 39 MGD. Based on the 10 States Standards loading rates, the clariflocculator has a capacity of 11.4 MGD.*

[k] *The effluent Parshall Flume is rated for 55 MGD. At a Rapid Creek elevation of 2999.0 (the upper end of the typical range), the flume will not submerge at plant flows less than 100 MGD.*

The recommendations and associated timeline for addressing the hydraulic bottlenecks are summarized in Table 3.1.5. A few peak hour capacity limited processes have not been recommended for the reasons given in the table. The trend for flows has been to decrease due to high efficiency fixtures and increased water costs. In addition, as the City grows the peaking factor is expected to decrease due to the different timing in the flow ending up at the WRF. If peak hour flows track with the Chapter 2.1 projections, these processes will reach capacity at the projected peak hour between 2030 and 2035.

- Influent screens: The screens have a combined rated capacity of 37 MGD. However, assuming 20 percent screen blockage, the flow through the screens may be increased to 45 MGD with the upstream channel freeboard at approximately 0.75 foot. This means that the cleaning mechanisms may have to operate continuously during the peak even to keep the screen clean.
- Grit units: The current treatment capacity is 40 MGD while the hydraulic capacity can be increased by simply raising the channel wall. The efficiency may be decreased at flows exceeding 40 MGD.
- UV Disinfection system (current rated capacity is 40 MGD): The actual capacity of the UV unit is dependent on a number of factors including UV transmittance. The activated sludge system is expected to exhibit an improved UV transmittance and will likely increase the process efficiency.

Peak flows should continue to be monitored to determine if improvements to these processes need to be budgeted for. These processes will not be affected at the average day, maximum month or peak day flows.

Table 3.1.6 contains a detailed breakdown correlating the improvements to the projected influent flow and gives the new plant capacity with the improvements incorporated.

Table 3.1.5. Hydraulic Capacity Improvements Summary

Year	Hydraulic Limitation	Addressed
2015	Peak Hour Flow is 30.2 MGD	
	Replace the aeration basin selector curtain with a concrete wall.	Included in Age and Condition
	Add a second 48-inch pipe from the Tertiary Clarifiers to UV. (Option is allow to submerge)	This is not included due to limited treatment impact during peak event.
	Add one clariflocculator for hydraulic capacity reliability.	
2025	Peak Hour Flow is 37.7 MGD	
	Add a 10 MGD in-plant peak flow pump station to pump from grit basin effluent to the aeration basin splitter box.	Included in Regulatory - Activated Sludge Project Costs
	Increase to four (4) clariflocculators.	Included in Regulatory –Activated Sludge Project Costs
	New effluent piping to UV Disinfection.	Included in Regulatory - Activated Sludge Project Costs
	Increase the size of the wall openings in the aeration basin to accommodate anoxic recycle flows.	Included in Regulatory - Activated Sludge Project Costs
	Remove the aeration basin weir plates on the effluent launder.	Included in Regulatory - Activated Sludge Project Costs
	Increase the capacity of the influent screens (currently rated at 37 MGD total combined flow).	Not Included at this time.
2030-2035	Peak Hour Flow is 40.6 - 43.5 MGD	
	Increase capacity of grit units (current capacity is 40 MGD).	Increase upstream channel wall height. Third grit unit not Included at this time. Efficiency will be reduced but can pass flow hydraulically.
	Upgrade UV Disinfection system and effluent flow measurement (current capacity is 40 MGD).	Not included at this time.

Table 3.1.6. Hydraulic Capacity Improvements Matrix

Complete by Year	Projected Population of service area	Maximum Day Flow (mgd)	Projected Peak Hour Influent Flow (mgd)	Required Upgrades				New WRF capacity after upgrade is made (mgd)		
				Headworks	North Plant	South Plant	UV Disinfection	North Plant	South Plant	Total WRF
-	-	-	-	-	-	Replace the aeration basin selector curtain with a concrete wall.	Monitor 500-year flood elevation and associated federal requirements.	17	11	28
-	-	-	-	-	1) Add a second 48-inch pipe from the Tertiary Clarifiers to UV.	-	-	25	11	36
2015	79,855	19.00	30.18	-	-	-	-	25	11	36
2020	85,560	20.77	35.37	-	-	-	-	25	11	36
2025	91,205	22.15	37.7	1) Add a 10 MGD in-plant peak flow pump station to pump from grit basin effluent to the aeration basin splitter box. 2) Increase the capacity of the influent screens (currently rated at 37 MGD total combined flow). 3) Increase channel wall height upstream of the grit units (optional).	1) The North Plant Trickling Filters, Secondary Clarifiers, RBCs and Tertiary Clarifiers will no longer be used. 2) Modify the Primary Clarifier effluent channel; install two 48" diameter pipes from the Primary Clarifiers to the new aeration basin splitter box.	1) Add three clariflocculators with new effluent piping to UV Disinfection. 2) Increase the size of the wall openings in the aeration basin to accommodate anoxic recycle flows. 3) Remove the aeration basin weir plates on the effluent launder.	-	0	40	40
2030	98,195	23.84	40.59	-	-	-	-	0	40	40
2035	105,184	25.54	43.48	Increase capacity of grit units (current capacity is 40 MGD).	Expand capacity of Primary Clarifiers (current capacity is 45 MGD).	-	1) Upgrade UV Disinfection system and effluent flow measurement (current capacity is 40 MGD).	0	55	55
2040	120,674	29.30	49.88	-	-	-	-	0	55	55
2045	131,018	31.81	54.16	-	-	-	-	0	55	55

Notes:

1. *RAS rate is assumed to be 0.75 x aeration basin inlet flow.*
2. *The Primary Clarifier, Secondary Clarifier and Tertiary Clarifier adjustable inlet plates were adjusted to 3 inches in height in the model to prevent them from being a limiting factor in the plant hydraulics.*
3. *The hydraulic modifications are based on Alternate A1.*
4. *Currently, the aeration basins are limited to a capacity of 4 MGD (selector curtain restriction).*
5. *Hydraulics were run assuming that the tertiary clarifier effluent weir is submerged (the downstream water elevation is at the top of the v-notch weir). The invert of the effluent weir becomes submerged at a North Plant flow rate of 8 MGD while 10 MGD is flowing through the South Plant (18 MGD total plant flow).*
6. *Rapid Creek water surface elevation is at 1299.00, which is the upper end of the normal range.*
7. *All phasing is staged to treat peak hour flow projected flows.*

Chapter 3.2 Plant Organic Capacity

This chapter of the facility plan presents the evaluation of the organic capacity of the City of Rapid City WRF. The specific objectives of this chapter are to identify the organic capacity of the WRF for the current effluent limitations, the more stringent future ammonia and the nutrient effluent regulatory limitations as described in Chapter 2.2 – Regulatory Planning.

Organic capacity is the highest organic load at which a sewage treatment facility or a portion thereof is expected to provide a specific predetermined level of treatment independent of flow. The Rapid City WRF has specific designed capacity to treat for Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), ammonia, and disinfection of fecal coliform and E Coli. In the future the WRF will have to treat for nutrients including total nitrogen and total phosphorus.

Biological Oxygen Demand (BOD) is one of the most common measures of pollutant organic material in water. BOD indicates the amount of putrescible organic matter present in water. In other words, the BOD test is performed to determine what effect dirty water, containing bacteria and organic materials, will have on animal and plant life when released into a stream or lake. When there is an abundance of bacteria and organic materials, the bacteria will take in oxygen in order to breakdown these molecules. If bacteria are taking in large amounts of oxygen, this will have a detrimental effect on the surrounding ecosystem. On the contrary, when there are low levels of organic waste in the water, there are fewer bacteria present, the BOD will be lower and the dissolved oxygen levels higher.

The amount of ammonia in the organic loading affects the capacity of the treatment plant to nitrify. Nitrification is the process of converting ammonia in wastewater to nitrate using aerobic autotrophic bacteria in the treatment process.

Wastewater denitrification is a two-step biological process by which denitrifying bacteria convert nitrate ions (NO3-) to nitrogen gas (N2). In the first step the nitrate ions (NO3-) are converted to nitrite ions (NO2-) and in the subsequent step the nitrite ions (NO2-) gets converted to nitrogen gas (N2). Both steps only occur under anoxic conditions. If untreated, nitrate that enters the environment can stimulate eutrophication and algae blooms.

The results have been utilized to identify capital improvements to increase capacity consistent with current and future needs and help develop the long term plan for the WRF.

As total nitrogen removal becomes a permit requirement, the WRF will need to incorporate denitrification into the wastewater treatment process. Total nitrogen removal using biological method employs two distinct processes: nitrification and denitrification. Wastewater denitrification is a sensitive process and requires a specific set of operating conditions, anoxic tankage and recycle and an available carbon source, nitrate, and denitrifying bacteria.

3.2.1 Background

3.2.1.1 Recent Flow and Loading Data

Plant influent flows and loads were calculated based on available data for the past 5.5 years, from January 2010 through June 2015. Influent flows, loads, peaking factors and concentrations based on the statistical analysis are detailed in Table 3.2.1. On a per capita basis, the influent flows and loadings are consistent with text book values and are considered normal relative to expectations for a largely residential/commercial city with limited wet industry.

Table 3.2.1. Influent Flows and Loads (Based on January 2010 thru May 2015 Average)

	Flow/Loading	Peaking**Factor	Per Capita***	Concentration, mg/L
Flow, MGD*				
Average Annual	9.69	1.00	124	-
Maximum Month	12.51	1.29	160	-
Maximum Day	19.00	1.96	243	-
BOD_5, lb/d				
Average Annual	16,553	1.00	0.19	209
Maximum Month	18,084	1.10	0.21	191
Maximum Day	23,267	1.54	0.30	210
TSS, lb/d				
Average Annual	16,061	1.0	0.21	219
Maximum Month	18,392	1.15	0.24	210
Maximum Day	32,582	2.02	0.42	268
Ammonia, lb/d				
Average Annual	1,966	1.00	0.025	27.4
Maximum Month	2,115	1.08	0.027	24.5
Maximum Day	3,002	1.53	0.038	23.8

Notes:
** Based on Monthly Operating Report Data (Influent)*
*** Ratio to average annual value*
**** Based on 5.5 year average population (77,992) and flow or loading.*

3.2.1.2 Supplemental Sampling

Supplemental sampling was utilized to evaluate existing process performance and calibrate the model to more accurately duplicate the secondary treatment system. Detailed supplemental sampling results are shown in Appendix 3.2.A.

The first sampling occurred between June 30th and July 2nd, 2015 which was during a sustained high flow period, due to near record releases from Pactola Dam. The test results indicated significant dilution and inert solids due to inflow and infiltration. Sampling data was assessed as a check to see what occurs during this type of event but was not used for final calibration of the model.

Additional sampling was conducted between July 31st, 2015 and August 27th, 2015 to capture data points after inflow and infiltration had subsided. The additional supplemental sampling gave results at WRF flow rates between 10 MGD and 12 MGD. This flow range remained elevated, but gave a stronger baseline from which to support the analysis. Conclusions from the second round of sampling include:

- The flow rate remains elevated, but the loading data are consistent with the operating data analysis.
- The influent organic fractions continued to reflect a slightly solids dominated influent with inert (unreactive) material; as previously indicated, this takes additional aeration volume.
- The TP concentration remains between 2 and 3 mg-P/L, which reflects a weak waste, but the TP loading in terms of pounds is consistent with what would be expected from the contributing population.
- The ammonia component of the TN is reasonable and consistent with a typical waste stream.
- The BOD_5 ratio to TN is low, but should support TN removal with little to no chemical addition.

3.2.2 Unit Process Descriptions and Analysis

As part of determining the organic treatment capacity of the Rapid City WRF, an evaluation of current treatment performance was performed. The performance characteristics of the plant processes are important for both determining plant capacities and identifying potential process improvements. The following sections summarize current performance data for the primary clarifiers, trickling filters, RBCs, aeration basins and the clariflocculator.

The loading and removal efficiency tables in the following section were compiled using data from 2014. The 2014 data was used because it was a typical year of operation, as the trickling filters were in operation the entire year.

3.2.2.1 North Plant

PRIMARY CLARIFIER PERFORMANCE

The physical and design operational parameters of the primary clarifiers are presented in Table 3.2.2 along with the current Biological Oxygen Demand (BOD_5) and Total Suspended Solids (TSS) removal efficiencies. The clarifier performance for BOD_5 and TSS removal are important for sizing the trickling filter and activated sludge processes.

Table 3.2.2. Primary Clarifiers Physical Parameters

Unit	Dimensions (each)	Dimensions (total)
Number	4	
Unit Length	142 ft	
Unit Width	40 ft	
Surface Area (gross)	5,680 ft^2	22,720 ft^2
Weir Length	219 LF	876 LF
BOD_5 Removal	46% (Average)	
TSS Removal	73% (Average)	

The performance of the primary clarifiers has been adequate in for TSS and BOD_5 removal even with the fixed film humus return included. The average 2014 primary clarifier BOD_5 removal rate was 46% which is greater than the 25-40% typically expected for primary clarifiers.

The average weekly 2014 primary clarifier TSS removal rate ranged from 65-82%. The average removal rate was 73%, which is slightly above the typical removal rate range of 50-70%.

Even though the clarifiers are shallow relative to current design standards, the performance exceeds industry standard design expectations and no major modifications are necessary.

TRICKLING FILTER PERFORMANCE

The physical and design operational parameters of the trickling filters are presented in Table 3.2.3.

The average loading in 2014 ranged from 2,600 to 5,800 lb/day with an average loading of 4,300 pounds per day, which equates to 11.3 lb BOD/1,000 cu ft-day.

Table 3.2.3. Trickling Filter Parameters

Unit	Value
Number	2
Diameter	200 ft
Media Depth	6 ft
Media Volume - Each	188,500 ft^3
BOD_5 Removal (Average)	60%
NH_3 Removal (Average)	46%

The trickling filters are sized for an influent loading of 20,400 lb BOD /day at 50 lb BOD/1,000 cu ft-day. Currently the trickling filters are loaded well below those criteria and, as a result, partial ammonia conversion is occurring. The removals are within the calculated range for this type of trickling filter process. Additional detail on trickling filter performance is shown in Appendix 3.2.B.

ROTATING BIOLOGICAL CONTACTORS PERFORMANCE

The physical and design operational parameters of the RBCs are presented in Table 3.2.4.

Table 3.2.4. RBC Parameters

Unit	Value
Number of Banks	4
Units per Bank	8
Diameter of each RBC	12 ft
Length of each RBC	25 ft approx.
NH_3 Removal (Average)	90%

The RBCs are intended to act as a tertiary polishing system that treats and removes ammonia, which is the key loading criterion for this process. The current ammonia loading on the RBCs is 140-150 lb/d, and 90% of the ammonia is removed as intended by the design.

3.2.2.2 South Plant

AERATION BASINS AND CLARIFLOCCULATOR PERFORMANCE

The physical and design operational parameters of the aeration basins are presented in Table 3.2.5, and Table 3.2.6 presents the physical parameters of the clariflocculator.

Table 3.2.5. Aeration Basins Parameters

Unit	Value
Number of Basins	2
Number of Cells per Basin	4
Basin Width	69.5 ft
Basin Length	140 ft
Side Water Depth	16 ft
Total Aeration Basin Volume	3,600,000 GAL

Table 3.2.6. Clariflocculator Physical Parameters

Unit	Dimensions
Number	1
Diameter	110 ft
Side Water Depth	16 ft
Area (gross)	9,500 ft^2
Weir Length	350 LF

The aeration basins each operate as a plug flow system with each basin divided into four zones. The dissolved oxygen (DO) concentration averages about 5-6 mg/L, but ranges from about 0.5 to 10 mg/L, primarily due to variations in influent loading and wastewater temperatures.

The data show that the activated sludge system BOD_5 loading ranged between 2,800 and 6,000 lb/day and averaged 3,900 lb/day. This is well below the system design capacity of 17,900 lb/day. Therefore, as expected, the BOD_5 removal rates averaged 98% and were fairly consistent throughout the year.

The TSS loading averaged 3,900 lb/day removal in the aeration basin system, and TSS removal rates averaged 97.9% and were also fairly consistent throughout the year.

Ammonia loading averaged 173 lb/day removal in the aeration basin system, and ammonia removal rates averaged 99.7%. Current ammonia removal efficiency is more than sufficient as it is expected to be in the high 90 plus percentile for a stable activated sludge system.

Engineering standards dictate providing either multiplicity or duplicity for critical processes. The South Plant has inadequate reliability in existing process since there is no redundant clarifier. The activated sludge system has additional capacity for aeration, RAS pumping, and WAS pumping. The sedimentation basin solids loading capacity is checked in the plant BioWin modelling is detailed in later sections.

SLUDGE HANDLING

The organic capacity of individual sludge handling unit processes has been evaluated against engineering standards, and capacity has been evaluated for individual unit processes to better understand potential limiting factors for plant-wide capacity. A check of solids handling process capacity has been conducted including digestion, sludge storage and sludge dewatering.

The findings are summarized for each process as follows:

- Anaerobic Digestion:
    - Adequate capacity through 2035-2045 for continued use in treating primary solids for landfill disposal with composting.
- Sludge Storage:
    - Current storage capacity is 10 to 13 days.
    - Additional storage capacity of 0.34 million gallons is required.
- Biosolids Dewatering:
    - Existing dewatering system does not have adequate capacity for current biosolids production and should be expanded by at least 15%.
    - The capacity can be increased by 20% by correcting limiting discharge conditions outlined in the asset assessment chapter.

A detailed unit process capacity evaluation is available in Appendix 3.2.B.

3.2.3 Process Modeling

Process modeling has been conducted to provide a comprehensive evaluation of overall treatment plant and unit process efficiency, and to obtain an understanding of the effects of changing conditions (including flows and loads, permit requirements, additional processes) on the ability of the system to continue to perform adequately. The output from the calibrated WRF model then provides a well-defined basis for decision-making and investment.

3.2.3.1 WRF Model

Wastewater characteristics were evaluated by breaking the pollutants into individual fractions supportive of comprehensive Biowin™ modeling variables including COD species, nitrogen species, and phosphorus species. The supplemental test results were used to provide improved fractionation to mirror existing loading variables. The first round of supplemental testing was conducted during a period of elevated creek flow, and the results are reflective of a high flow condition. The second round of testing was conducted to refine the characterization, and the results largely supported the preliminary analysis and assumptions; however, some tweaking to the analysis was conducted incorporating the most up to date data.

Influent flows and loads, and the corresponding model input for the 2035 maximum month, design condition (as defined in Chapter 2.1), are shown in Table 3.2.7. Table 3.2.7 aligns the maximum month influent flow and concentrations of several state variables with the projected flows and loads identified previously. Details regarding the wastewater characterization are provided in the Appendix 3.2.C, Tables 3.2.C.2 and 3.2.C.3.

Table 3.2.7. COD Influent Data for Rapid City, 2035 Maximum Month Flow & Load

Name	Value
Flow	16.8
Total COD, mg/L	320
Total Kjeldahl Nitrogen, mg-N/L	30
Total Phosphorus, mg-P/L	10
Nitrate, mg-N/L	0
pH	7.0
Alkalinity, mmol/L	5.8
Inorganic Suspended Solids, mg/L	45.8
Calcium, mg/L	80
Magnesium, mg/L	15
Dissolved Oxygen, mg/L	0

3.2.3.2 Preliminary Model Calibration and Evaluation

EXISTING SYSTEM CALIBRATION

Calibration has been performed in order to improve the model match against actual available performance data, and to gain confidence in the accuracy of modelled alternatives. As shown in Figure 3.2.1, the existing system comprises a north, fixed film treatment process and a south, activated sludge treatment process. The trickling filter is included in the Biowin™ model as a standard unit module. The RBCs were modeled as a modified media bioreactor model. All other unit processes are represented by standard Biowin unit modules.

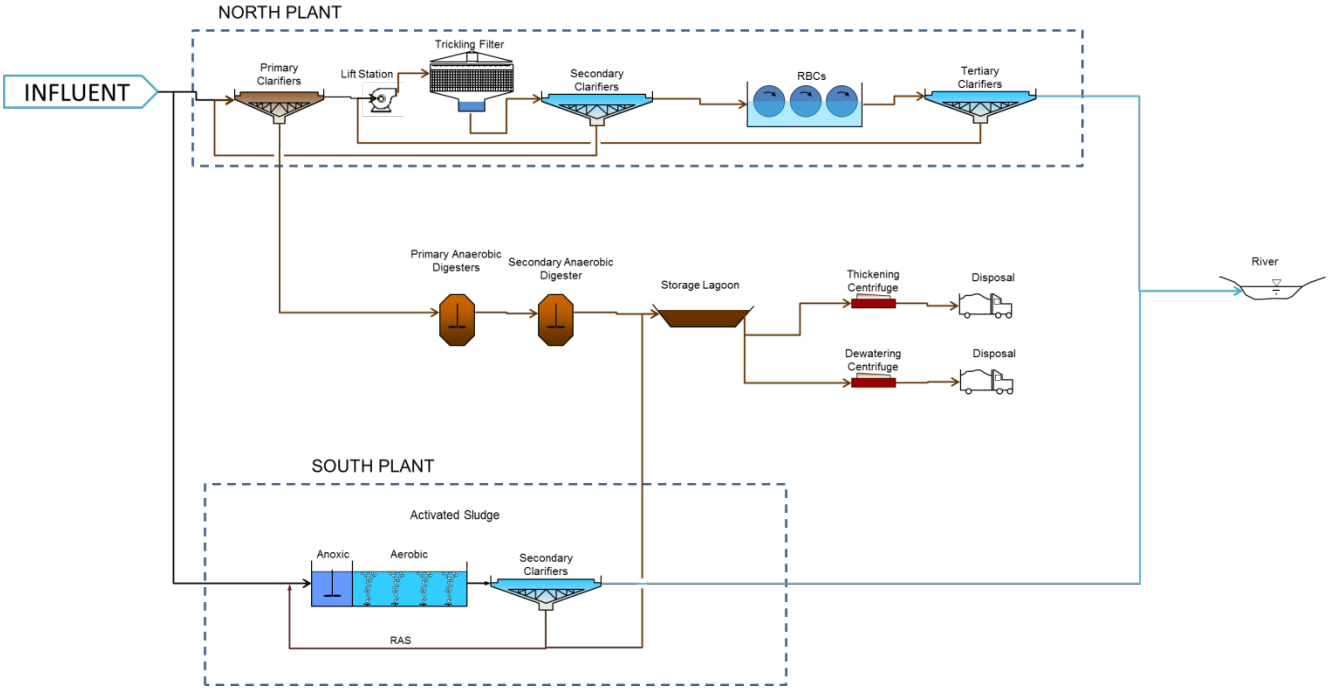


Figure 3.2.1. Existing Process Schematic

North and south plant effluent quality are presented independently, at the end of each process train, then as a combined effluent. The modelled north plant gives an effluent ammonia concentration of 2.2 mg-N/L showing reasonably good treatment efficiency nearly matching the concentration in the real-life data (2.1 mg-N/L), but reflecting the (mass transfer) limitations of fixed-film nitrification. The solids retention time (SRT) for the activated sludge process is a good match at roughly 30 days. Detailed model output and results are summarized in Appendix 3.2.C.

For reference, a typical target SRT for cold-weather nitrification is between 10 and 12 days. SRT sets the growth rate of microorganisms in an activated sludge process, thereby selecting the microbial composition of the mixed liquor. For consistent wastewater treatment, SRT must be controlled at a level that oxidizes pollutants, e.g. nitrifies, while providing "bugs" that flocculate and settle. While treatment is enhanced with longer SRTs, settling and biosolids separation is typically more challenging.

The model for the south plant indicates an effluent ammonia concentration of 0.1 mg-N/L or less, which is typical of a stable activated sludge process with a good nitrifier population. The blended effluent ammonia concentration is higher at 1.9 mg-N/L; this is reflective of the high fraction of flow handled by the north plant at a relatively high organic loading relative to capacity.

3.2.4 Capacity Evaluation

3.2.4.1 Whole Plant Capacity Evaluation

The existing Rapid City WRF has been modeled to test the critical flows and loads at which expansion of the system is needed for the system as a whole.

Based on the analyses performed and process performance information provided by WRF staff, the organic capacity of the WRF was determined through a combination of a) process modeling of the entire WRF as a whole system and b) individual unit process to compare against engineering industry standards.

Capacity limitations in this section are evaluated in terms of organic loading based on 5-day, biochemical oxygen demand (BOD_5), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), and ammonia (NH_3). The detailed organic capacity analysis of the existing WRF is presented in Appendix 3.2.C.

As expected, the controlling regulatory condition for capacity of the existing facility is based on meeting the permitted effluent ammonia concentration. Table 3.2.8 summarizes the existing capacity analysis for both current permit limits and potential lower ammonia permit limits based on mussel toxicity (2013 EPA Water Quality Rule).

Table 3.2.8. Organic Capacity Summary

	Current Loadings	Capacity 2016 Current Ammonia Permit Limits	Total Equivalent Population Capacity	Capacity Permit # 2 – New Ammonia Limits	Total Equivalent Population Capacity
BOD_5, lb/day	16,600	17,600		15,900	
TSS, lb/day	16,100	19,600		17,600	
TKN, lb/day	2,810	3,210		2,880	
NH_3-N, lb/day	1,970	2,240		2,020	
Overall Capacity Remaining,[a] %		14.1	91,155	2.4	81,855

Note:
[a] *Capacity reduction reflects aeration capacity and reliability related to ammonia limit (nitrifier sensitivity).*

From Table 3.2.8, the total equivalent population capacity is 91,155, with the current pending permit limitations. This equates approximately to year 2025 which has a projected population of 91,205. Second, if Permit #2 (2025) ammonia permit limits are implemented, the equivalent population capacity would be 81,855. In terms of equivalent population growth, this equates to approximately 2 years of growth from the 2014 base population of 79,855. Therefore,

improvements will need to be in place when Permit #2 limits are applied, which is expected to be 2025.

If the nature of the facility's incoming wastewater significantly changes and impacts the ratio of BOD5 to ammonia or Total Kjeldahl Nitrogen (TKN); the modelled capacities should be rechecked. TKN is the combination of organically bound nitrogen and ammonia in wastewater.

Table 3.2.8 does not include capacities for nutrients, total nitrogen (TN) and total phosphorus (TP) removal; because permit requirements are over 10-years into the future and the existing facility is not physically designed to treat for TN and TP.

3.2.5 Capacity Evaluation with Selected Improvements

3.2.5.1 Whole Plant Capacity Evaluation

A whole plant capacity evaluation was also completed with selected improvements to meet the 2013 EPA Ammonia Water Quality regulations. The expectation is that these limits could be incorporated into the City's permit as early as 2025.

Selected improvements were identified as process limitations, or "bottlenecks", from the plant capacity modelling. The selected improvements include various south plant improvement combinations including: additional aeration tankage, one additional secondary clarifier (2 total) and modifying the process to include primary clarified effluent (PE) to the south plant.

The following model evaluations have been conducted:

- Existing, Raw (*Match Current Operation*): This is the baseline evaluation of the existing system capacity with one secondary clarifier, raw influent to the south plant, and primary effluent to the north plant to match current operation.
- PE to South Plant: This alternative includes evaluation of existing system with the major change of modifying the process to include primary clarified effluent to the South Plant.
- Additional Aeration Tankage & New Clarifier, Raw to South Plant: This alternative includes evaluation of the existing system capacity with additional aeration tankage, one additional secondary clarifier (2 total), and maintaining raw influent to the south plant and primary effluent to the north plant.
- Additional Aeration Tankage & New Clarifier, PE to South Plant: This alternative includes evaluation of the existing system capacity with additional aeration tankage, one additional secondary clarifier (2 total) and modifying the process to include primary clarified effluent to the south plant, and primary effluent to the north plant.

Evaluations of existing processes were targeted toward achieving high level nitrification with low effluent ammonia concentrations (< 0.1 mg-N/L on a maximum month, steady-state basis); however, dynamic models to evaluate peaking conditions have been tested as well to ensure maximum daily permit compliance to meet the expected the future ammonia permit limitations.

Table 3.2.9 shows the flow capacity of the improved system for both the maximum month (MM) and maximum day (MD) conditions. The table includes whether or not an additional clarifier was added and the volume of additional activated sludge tankage. The lowest capacity alternative is "Existing, Raw" using the existing system and feeding raw wastewater to the activated sludge system, and the highest capacity comes from "Additional Aeration Tankage & New Clarifier, PE to South Plant" routing primary effluent to the expanded activated sludge system with an additional clarifier. A more detailed discussion of the capacity related technical analysis may be found in Appendix 3.2.C.

The "Total Equivalent Population Capacity" column indicates when the capacity of the WRF is reached in based on the organic loading from the reflected equivalent population. In other words, if the nature of the loading to the WRF continues to be the same, capacity will be reached at this population. Also note the capacity is presented based on flow; however, this represents an organic loading capacity evaluation based on the wastewater characterization previously described. The system is limited to design flows based on the pollutant levels in the wastewater in addition to the required improvements to allow the plant to pass peak hydraulic flows. The improvements support Permit #2, with future provisions for Permit # 3.

Table 3.2.9. Summary of Capacity and Process Limitations for Existing System Capacity Evaluation at Anticipated Permit #2 Discharge Limits – Expected 2025 Permit

	Added South Plant Clarifies	Added Tank Volume, MG	Limiting Factor	South Plant Flow*, MGD	Total Plant Flow*, MGD	Total Equivalent Population Capacity
Existing, Raw (Matches Current Operation)	None	---	Clarifier Surface Area	MM = 8.0 MD = 8.0	MM = 12.8 MD = 19.4	81,855
PE to South Plant	None	---	Clarifier Surface Area	MM = 10.8 MD = 10.8	MM =16.0 MD = 24.2	97,100
Additional Aeration Tankage & New Clarifier, Raw to South Plant	One added	1.1	Clarifier	MM = 10.0 MD = 10.0	MM = 14.8 MD = 22.4	105,000
Additional Aeration Tankage & New Clarifier, PE to South Plant	One added	1.1	None (2035) Aeration + Clarifier (2045) Anoxic (TN removal)	MM = 14.7 MD = 17.3	MM =16.8 MD = 25.5	110,200

Note:
** Capacity presented based on flow; however, this represents an organic loading capacity evaluation based on the wastewater characterization previously described. While the plant can pass additional flow hydraulically, the system is limited to these design flows based on the pollutant levels in the wastewater.*

Chapter 4.1 Alternatives Evaluation

4.1.1 Objective

The objective of this chapter is to review the baseline secondary treatment alternatives and screen alternatives from further consideration which have significantly higher initial costs and/or do not meet the non-monetary criteria developed by the planning team, i.e. acceptable process reliability. The remaining alternatives are identified for subsequent development and detailed evaluation.

4.1.2 Summary of Treatment Planning Basis

Water quality issues in the Gulf of Mexico prompted the formation of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, and are driving efforts to reduce nutrient discharges throughout the upstream watershed.

Table 4.1.1 presents an overview of nutrient removal capabilities of advanced wastewater treatment technology for Total Nitrogen (TN) and Total Phosphorus (TP) removal. As shown for Secondary Effluent (No Nutrient Removal), primary and secondary treatment processes only remove a limited fraction of nutrients from wastewater – a portion of the insoluble TN and TP taken out with primary solids and nutrient uptake required for biological growth. It is anticipated that the plan for point source discharges in South Dakota will be focused on achieving nutrient removal to 10 mg/l total nitrogen and 1 mg/l total phosphorus; a level of removal associated with typical biological nutrient removal (BNR). Enhanced nutrient removal treatment levels increase the complexity of plant operations and require considerably more capital investment, energy, chemicals, maintenance materials and labor.

Table 4.1.1. Summary of Treatment Approaches for Nutrient Removal

Parameter	Typical Municipal Raw Wastewater, mg/l	Secondary Effluent (No Nutrient Removal), mg/l	Advanced Wastewater Treatment			Typical In-Stream Nutrient Criteria, mg/l
			Typical Biological Nutrient Removal (BNR), mg/l	Enhanced Nutrient Removal (ENR), mg/l	Limits of Treatment Technology, mg/l [1]	
Total Phosphorus	4 to 8	4 to 6	1	0.25 to 0.50	0.05 to 0.07	0.02 to 0.05
Total Nitrogen	25 to 35	20 to 30	10	4 to 6	3 to 4	0.300 to 0.600

[1] *Ignoring Considerations of Variability and Reliability of Wastewater Treatment Performance*

Water Environment Research Foundation (WERF) "*Nutrient Management: Regulatory Approaches to Protect Water Quality, Volume 1 – Review of Existing Practices*," Project #NUTR1R06i

As detailed in the regulatory chapter of this facility plan, it is anticipated that the plan for ammonia removal to meet the Permit #2 (2025) Water Quality Standards will be one-half of the current ammonia limits. The WRF has a flow based ammonia limitation varying on a month by month basis. This variable limit allows for flexible permit conditions at higher creek flows and the ability to utilize peaking facilities with only partial treatment capacity for ammonia. A detailed statistical analysis of plant versus Rapid Creek flow was conducted to determine critical months and the corresponding critical flows and applied to the respective modelled alternatives.

4.1.3 Evaluation Process

Alternatives were identified and evaluated through an interactive process involving City and consultant staff. Major elements of the process are described below.

4.1.3.1 Define Process Methodology and Evaluation Criteria

To provide a consistent planning basis, HDR, WRF and City staff developed an evaluation methodology for the WRF. This process defined evaluation criteria, outlined the decision-making process, and prescribed cost estimating procedures. Except for cost, these criteria were applied on a non-weighted, qualitative basis.

4.1.3.2 Brainstorm and Screen Ideas

A workshop was conducted to identify any and all potential alternatives for expanding or improving the WRF facility. Following the initial brainstorm session, an initial screening step was conducted to eliminate ideas that were fatally flawed, technically unproven, excessively expensive or otherwise unworthy of detailed evaluation.

4.1.3.3 Detailed Development and Evaluation

Alternatives surviving the initial screening step were developed in detail. Facility sizing and cost estimating were conducted for modular expansion of plant capacity to match up with expected regulatory changes, with Phase 1 with facilities to treat for Permit #2 (2025) ammonia and Phase 2 with facilities to treat for the Permit #3 additional nutrient criteria to the 2035 design year flow and loadings. Alternatives were compared based on cost and non-economic criteria. Based on this analysis, preliminary recommendations for facility improvements were made. Detailed results were summarized in the appendices.

4.1.3.4 Review Workshops

During the development process, meetings were conducted with City and WRF staff to review interim findings and refine the alternatives being evaluated. In addition, population projections were reviewed with other City departments. These workshops presented information on the evaluation process and gained input regarding the technical issues being considered and the planning process used.

4.1.3.5 Triggers

Improvements to secondary treatment at the Rapid City WRF are needed to provide reliable treatment and pumping capacity, to comply with regulatory requirements, to improve operational efficiency and to provide the ability to pass higher flows through the plant. The key driving forces, or triggers, behind the needed improvements are summarized below.

- **Age and Condition**. A number of the treatment facilities are 30 to 50 years old and have reached their useful life to provide reliable service. Some plant components suffer from deteriorated condition, fail to comply with current codes or provide unsatisfactory and possibly unsafe working environments for the operations staff. The following have been incorporated as key cost components in the alternative life cycle evaluations.
    - All secondary treatment, age-related improvements recommended within the next 10 years from Chapter 1.1 are included in the alternative evaluations. The existing sludge handling system age and condition issues are addressed in a similar manner in Chapter 4.2. Major improvement items include:
        - Aeration blower replacement.
        - Aeration basin curtain replacement.
        - North Plant secondary clarifier sludge pumping replacement.
        - Trickling filter pumping improvement options: The trickling filter pump station is a prime example of both unreliability and an unsafe working environment. Identifying the longer term role of the trickling filters and the timing for implementation of future nutrient control requirements are critical to determine whether the City should spend on the order of $7 million to replace Trickling Filter pump station in the short term or make provisional improvements to the existing station to manage for the next 10 years.
        - Mechanical HVAC, Structural and Architectural, Electrical and SCADA Improvements
    - The existing RBCs have been eliminated from future treatment alternatives due to age and condition issues and required additional capacity. In fact, the age and condition could prompt significant rehabilitation efforts in the short term and could be a trigger towards investment in treatment facilities even prior to planned alternative implementation.
- **Operations & Energy Improvements.** Some process improvements will reduce operational costs and/or delay the need for capacity expansions in other portions of the treatment systems.
- **Capacity for Projected Peak Flows.** While some peak flow reduction may be achieved through improvements to the collection system, this will not be enough to offset the need to increase the peak flow capacity of the plant. In particular, increasing the peak flow capacity of the South Plant is necessary to provide the necessary treatment during high flow events and provide for the high recycle flows necessary to provide nitrogen removal. In addition, conversion of the North Plant to a peaking facility is vetted in the alternative evaluations.

- **Capacity for Organic loading from Service Area Growth.** Rapid City's service population is projected to grow at an average annual rate of 1.9 percent; increasing wastewater loadings to the treatment plant (see Chapter 2.1). At this rate of growth, in addition to the hydraulically-limited components of the plant, the organic capacity of several major biological treatment components will be reached in five to eight years. Without improvements, the plant could risk permit violations.
- **Regulatory.** The regulatory triggers matching up with the timing and activities required are outlined in Table 4.1.2 which is reiterated from Chapter 2.2. The intent of this facility planning effort is to define the longer term path forward for future ammonia and nutrient control so that shorter term modifications are consistent with the long term plan.

Table 4.1.2. Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit 2016	New Ammonia Standards based on updated Rapid Creek water quality	Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability. Establish schedule for construction – assume major projects are 5 years from study completion unless other justification (i.e. Trickling Filter Pump Station type trigger).
Permit #1 2020	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project to be constructed by 2025. Ammonia standards will become part of the SD Water Quality Standards After 2017 and new treatment process is required to meet proposed Ammonia limits.
Permit #2 2025	New Ammonia Standards	Assuming required improvements for ammonia removals complete. Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2030.
Permit #3 2030	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty. Track potential for more stringent nutrient standards.
Permit #4 2035	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

An illustrative graphic showing specific examples of these triggers is shown in Figure 4.1.1.

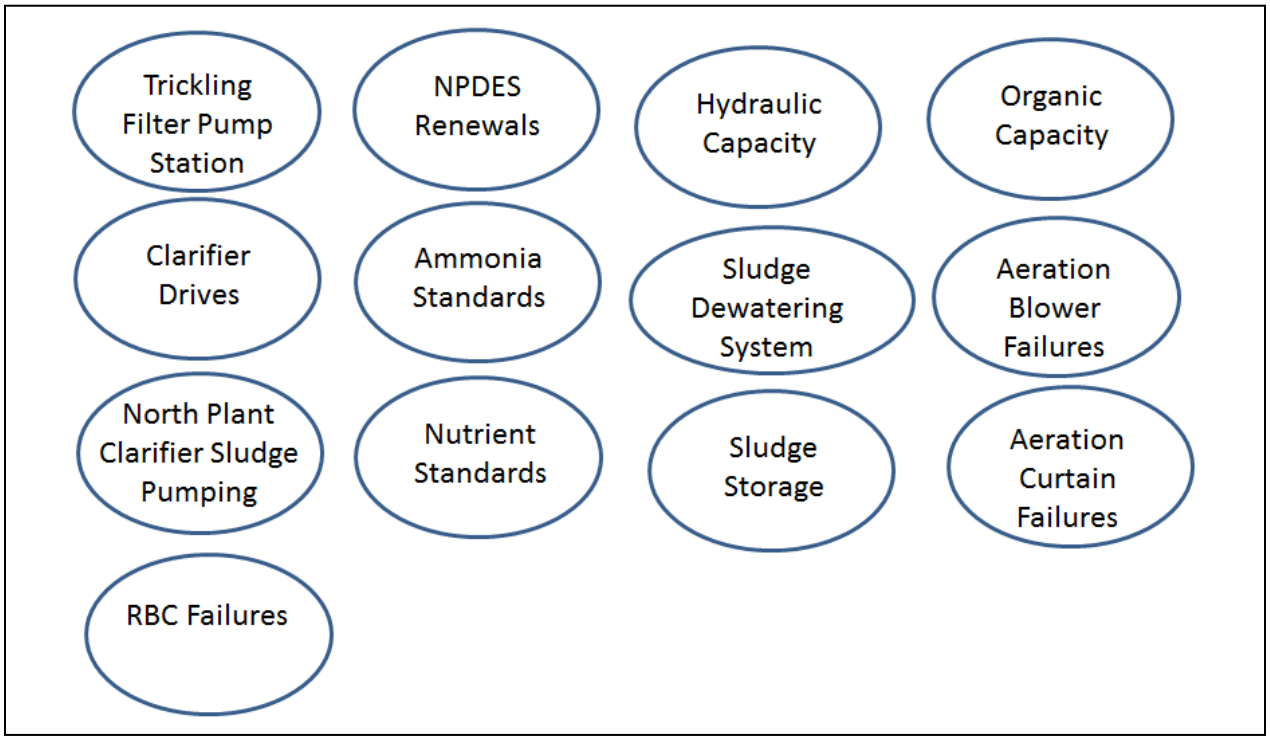


Figure 4.1.1. Triggers

4.1.3.6 Development of Costs

Capital costs are expressed in 2015 dollars. The accuracy of all costs is order of magnitude. These estimates are approximations made without detailed engineering or site-specific data. Estimates of this type can be expected to vary from 30 percent less than to 50 percent more than actual final project costs.

ACCURACY AND NEED FOR FUTURE ANALYSIS

This report is based on limited plant data received from WRF personnel and observations during the site visit. It is a planning level document, and the measures recommended should be implemented after conducting pre-design and design level analysis. This document uses equipment and construction cost estimates consistent with a level of accuracy corresponding to a Class 4 according to the Association for the Advancement of Cost Engineering (AACE) International Recommended Practices and Standards, No 18R-97.

The sources of construction cost data are:

- Construction cost data for the recent Rapid City WRF improvements, adjusted to 2015 dollars.
- Recent construction costs for other, similar facilities, adjusted to regional market conditions and 2015 dollars.
- Equipment pricing from manufacturers, including installation, structure, and housing costs.

Category of Capital Cost Estimates

Estimate Class	Primary Characteristic	Secondary Characteristic			
	Level of Project Definition Expressed As Percent of Complete Definition	End Usage	Methodology (Typical Estimating Method)	Expected Accuracy Range (Typical Variation in Low and High Ranges[1])	Preparation Effort (Typical Degree of Effort Relative to Least Cost Index of 1[2])
Class 5	0 to 2	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% - +100%	1
Class 4	1 to 15	Study or Feasibility	Equipment Factored or parametric Models	L: -15% to -30% H: +20% - +50%	2 to 4
Class 3	10 to 40	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% - +30%	3 to 10
Class 2	30 to 70	Control or Bid/Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: - 5% to -15% H: +5% - +20%	4 to 20
Class 1	50 to 100	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% - +15%	5 to 100

1. *The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after applying contingency (typically at a 50 percent level of confidence) for a given scope.*
2. *If the range index value of "1" represents 0.005 percent of project costs, then an index value of 100 represents 0.5 percent. Estimate preparation effort is highly dependent on project size and the quality of estimating data and tools.*
3. *Class 4 estimates prepared for this Facility Plan.*

All capital costs include allowances for site work and yard piping; contractor mark-up; contingencies; and engineering, legal and administration costs. Present worth costs are calculated using a 3% discount rate. Present worth O&M costs are based on 20 years of operation.

The cost estimating procedure is presented in below:

Illustration of Cost Estimating Procedure

Cost Item	Cost
Base Construction Cost	$1,000,000
Site work	$100,000
Electrical and Controls	$150,000
Subtotal A	**$1,250,000**
Mobilization and Bonds (5% of A)	$62,500
Contractor's Overhead and Profit (10% of A)	$125,000
Subtotal B	**$1,437,500**
Miscellaneous Costs Not itemized (20% of B)	$287,500
Subtotal C	**$1,725,000**
Engineering, Legal, Administration (25% of C)	$431,300
Total Capital Cost	**$2,156,300**

4.1.3.7 Alternatives

SCREENED PROCESS ALTERNATIVES

Given that the RBCs have reached their expected service life, the organic modelling evaluation included a review of expanding the existing North Plant system with a Moving Bed Biofilm Reactor (MBBR) process in place of the RBCs and additional TN control.

In addition, building nutrient removal around the trickling filters would result in separate BOD removal, nitrogen removal (nitrification and denitrification) and phosphorous removal stages. Ultimately, to achieve nutrient removal, primary and tertiary additions of aluminum sulfate (alum), the addition of a denitrifying filter and tertiary addition of methanol as a supplemental BOD source would be required. Alum and methanol addition would increase sludge production by an estimated 7 to 12 percent. Due to a significant amount of new tankage and the capital cost of these improvements, the following North Plant improvement options became clearly cost prohibitive and were eliminated:

- Trickling filter with MBBR and activated sludge
- Trickling filter with MBBR, denitrifying Biologically Active Filter (BAF) and activated sludge (MLE)
- Activated sludge with integrated trickling filter and MBBR

In addition, an activated sludge (MLE) which integrated trickling filter treatment was reviewed. The planning team determined that the piping flow scheme requirements were too complex and this alternative was also eliminated.

Instead, the models were updated to include alternatives with the trickling filters as a parallel peaking facility. This addressed long-term plans, which are focused on achieving steady-state effluent quality meeting permit limits while maintaining stable operation during dynamic peaking events.

In summary, from the evaluation, the following alternatives were modified or eliminated:

- Trickling filter with MBBR and activated sludge
  - Eliminated due to inability to incorporate in the existing RBC basins.
- Trickling filter with MBBR, denitrifying BAF and activated sludge (MLE)
  - Eliminated due to inability to incorporate the existing RBC basins and complexity for denitrifying BAF with the dual treatment trains.
- Activated sludge Biological Nutrient Removal (BNR) system with integrated trickling filter
  - Modified to incorporate trickling filters as parallel peaking treatment.
- Activated sludge with integrated trickling filter and MBBR
  - Eliminated as preliminary costs were not competitive.
- Activated sludge system
  - Included in refined alternatives with option for biological phosphorus removal.
- Prenitrifying activated sludge system with trickling filter peak flow processing
  - Included in refined alternatives.

For reference, the eliminated alternative model results and reviews are included in Appendix 4.1.A.

4.1.3.8 Refined Alternatives for Increasing Capacity

This section describes and presents a conceptual plan for alternatives to achieve future ammonia removals and nutrient removal. The following long-term expansion refined alternatives have been evaluated:

- Alternative A1 - Activated Sludge: Convert Plant to Only Activated Sludge, Blend Raw Influent with Primary Effluent
- Alternative A2 - Activated Sludge, with Biological Nutrient Removal: Convert Plant to Only Activated Sludge with full Biological Nutrient Removal for Nitrogen and Phosphorus
- Alternative B - Activated Sludge, Trickling Filter Peaking: Activated Sludge with Trickling Filter Peaking Alternative, Blend Raw Influent with Primary Effluent
- Alternative C – Activated Sludge with Prenitrification with Trickling Filter Peaking: Prenitrification Activated Sludge with Trickling Filter Peaking Alternative, Blend Raw Influent with Primary Effluent

New treatment process alternatives included the Permit #2 (2025) ammonia design target as well as the Permit #3 (2030) Total Nitrogen (TN) design target (< 10 mg-N/L). However, only

Alternative A2 includes a design component for biological phosphorus removal. The remaining alternatives include chemical phosphorus removal. Long-term plans are focused on achieving steady-state effluent quality meeting permit limits while maintaining stable operation during dynamic peaking events. Preliminary site layout figures can be found in the Appendix 4.1.B.

4.1.3.9 Alternative A1 – Activated Sludge (MLE)

Expanding activated sludge gives the simplest flow scheme with only an activated sludge (MLE) process –South Plant expanded. Refer to Figure 4.1.2. The primary process limitation to shifting to an activated sludge process is that the process must then be sized to handle peak flows through the South Plant system, which requires additional clariflocculators; particularly for a peak day. Four clarifiers are required to handle the peak flow. A high quality effluent is generated meeting current and future permit requirements. The existing activated sludge process would need to be expanded to meet the target design year requirements (2035) with further expandability to the future (2045).

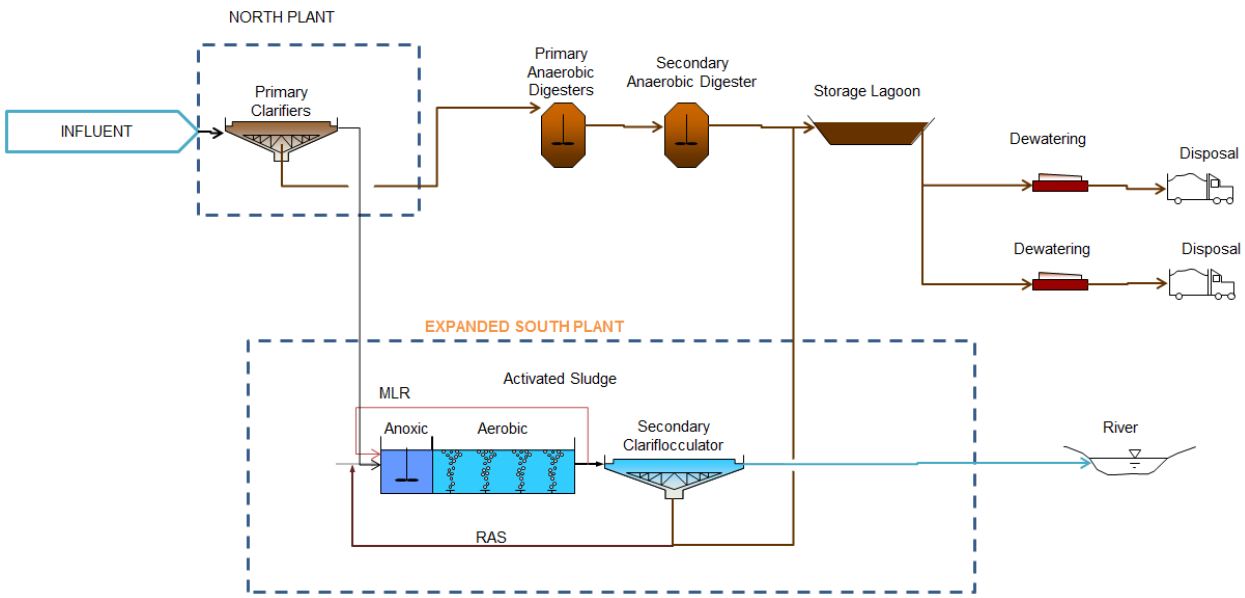


Figure 4.1.2. Alternative A1 – Activated Sludge (MLE) Process

4.1.3.10 Alternative A2 – Activated Sludge (MLE) With BNR

Alternative A2 offers a Biological Nutrient Removal (BNR) alternative as an approach to achieve biological phosphorus removal. Refer to Figure 4.1.3. For this flow scheme, an additional basin is required to give the anaerobic zone and an additional return pumping flow stream is added to return mixed liquor to the anaerobic zone.

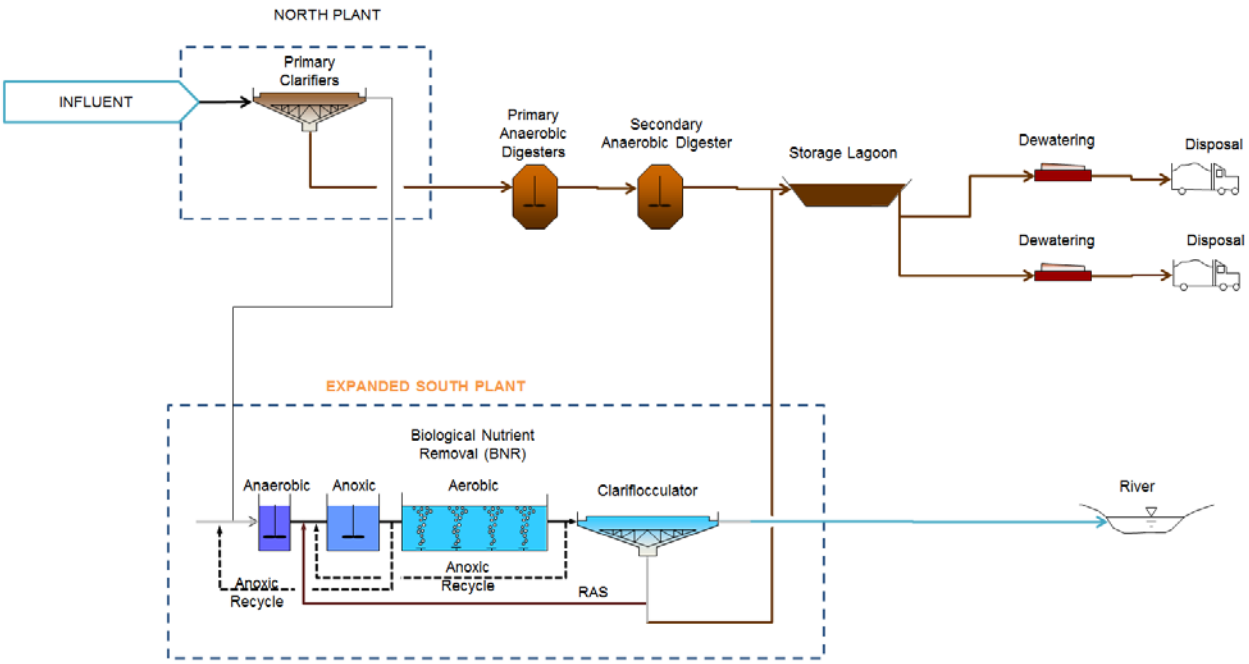


Figure 4.1.3. Alternative A2 – Activated Sludge, BNR Process Flow Diagram

4.1.3.11 Alternative B – Activated Sludge with Trickling Filter Peaking Alternative

Alternative B shows the trickling filter peaking facility parallel to the expanded activated sludge process. Refer to Figure 4.1.4. For this process, a base flow of 2.5 MGD is sent to the trickling filter facility to maintain biological activity. The remainder of the flow is routed to the activated sludge process up to a peak flow of 18.5 MGD; giving a total influent flow of 21.0 MGD (2045 design). Peaking flows above 18.5 MGD are routed to the trickling filter for treatment.

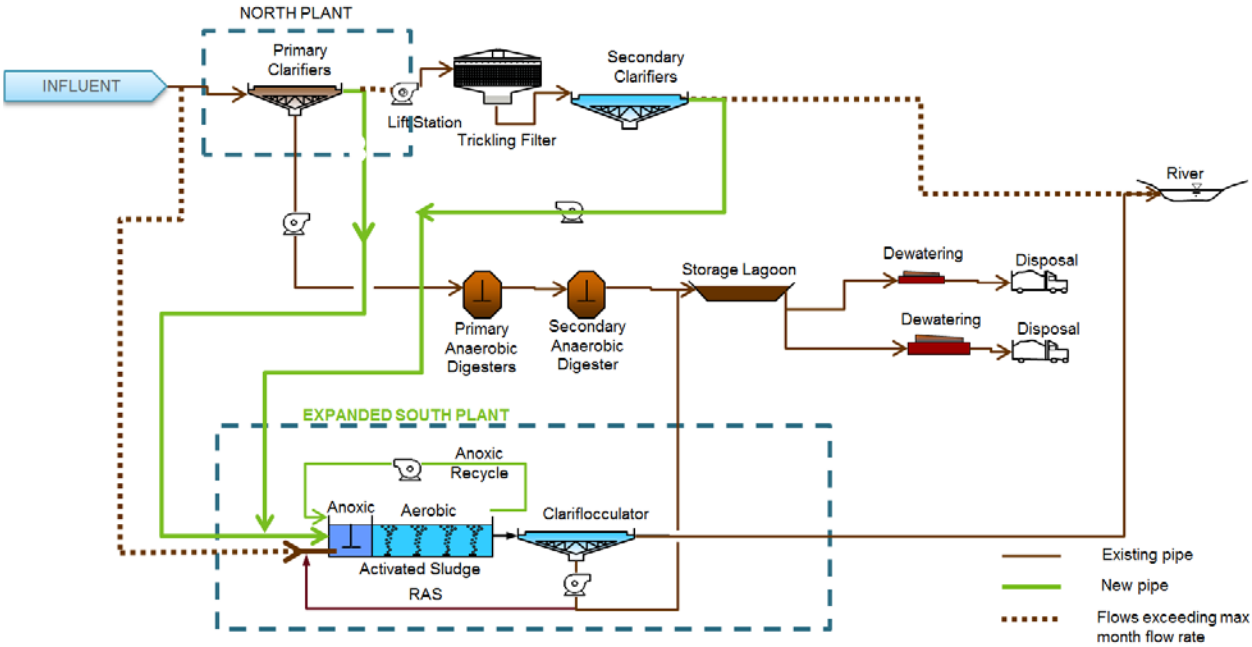


Figure 4.1.4. Alternative B – Activated Sludge with Trickling Filter Peaking Alternative

4.1.3.12 Alternative C – Split Treatment, Prenitrification Activated Sludge (MLE)

One modification to the activated sludge (MLE) process relies on the incorporation of a prenitrification basin to process RAS and high strength return flows (primarily from solids processing). This modification has also been incorporated as a trickling filter peaking facility parallel to the expanded activated sludge process. Refer to Figure 4.1.5. In an effort to best use existing infrastructure, it was assumed that dedicated new tanks would be utilized with the potential that the RBC tanks could be recommitted as prenitrification basins. Then, new clarifiers were added due to the hydraulic profile and limited depth and sludge removal mechanisms in the existing tertiary clarifiers.

This approach gives a high quality effluent capable of meeting future ammonia permit limits with heavy reuse of existing infrastructure. Additional expansion would be needed to meet future nutrient discharge limits and the continued use of two facilities increases operations and maintenance effort and costs.

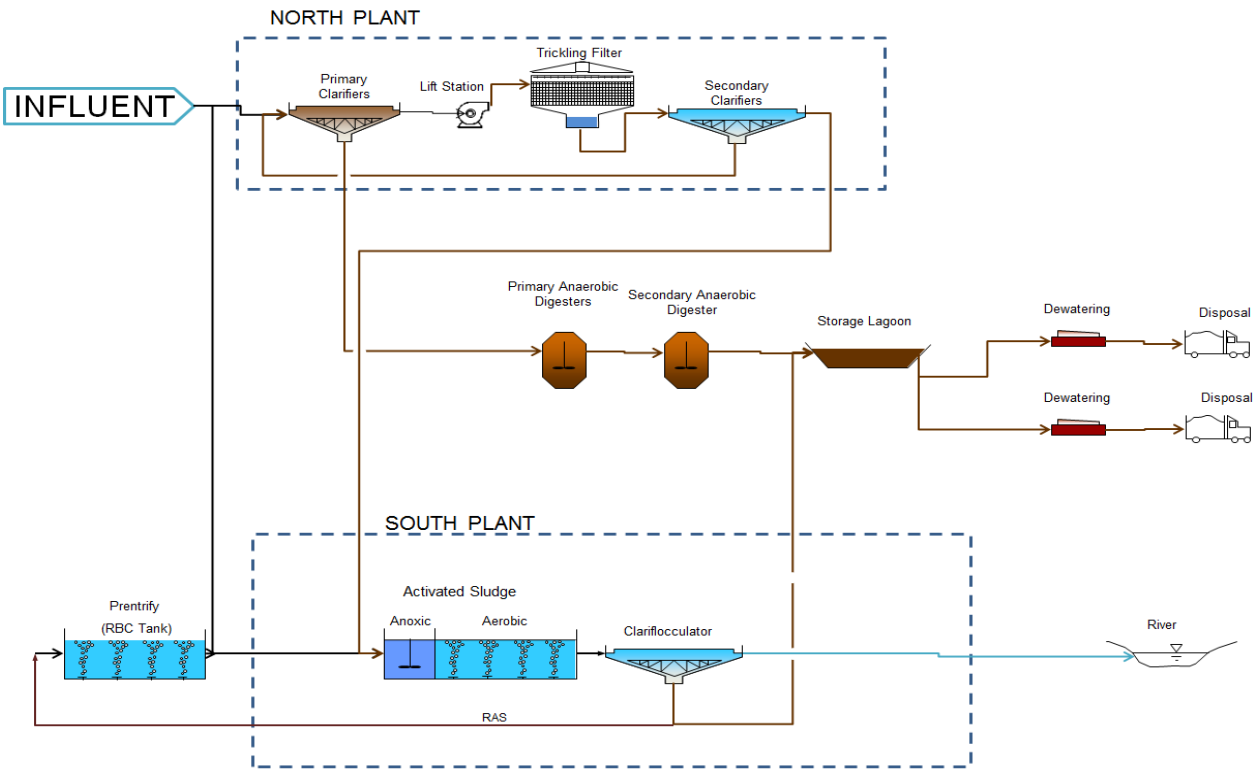


Figure 4.1.5. Alternative C – Prenitrification Activated Sludge (MLE) with Trickling Filter Peaking

4.1.3.13 Process Evaluation Summary

The results of the analysis (Table 4.1.3) show the additional tank needs, applicable limiting factors and flow capacities. Alternative A1 meets treatment objectives for ammonia and total nitrogen; chemical addition is used for TP removal as discussed in the next section. Alternatives B and C are less reliable for more stringent ammonia limits due to the limitation with the fixed-film process, but meet the Permit #2 pending ammonia and outlined nutrient criteria -10 mg/l TN, 1 mg/l TP. Alternative A2 also meets all treatment objectives; however, the added tankage is substantially greater than for the other alternatives.

Table 4.1.3. Process Evaluation Summary

Alternative	Added Tanks[d]	Added Tank Volume, MG	Process Limiting Factor	AS Flow, MGD	Total Plant Flow, MGD	Total Population Capacity
Alternative A1 - Activated Sludge	Anoxic Aerobic Clarifier	1.2 0.9 4.4 (4 units)	None (2025-2045)	MM[a] = 21.0 MD[b] = 31.8	MM = 21.0 MD = 31.8	131,000
Alternative A2 - Activated Sludge, BNR	Anaerobic Anoxic Aerobic Clarifier	1.5 1.7 1.9 4.4 (4 units)	None (2025-2045) Some chemical polish may be needed to achieve TP limits.			
Alternative B - AS, TF Peaking	Anoxic Aerobic Clarifier	1.4 1.2 2.2 (2 units)	Ammonia Removal[C]	MM[a] = 18.5 MD[b] = 18.5		
Alternative C - Prenit., TF Peaking	Prenit. Anoxic Aerobic Clarifier	0.25 1.2 0.6 2.2 (2 units)	Ammonia Removal[C]			

Notes:

[a] *MM -Maximum month flows and loads result in an effluent that meets treatment objectives.*

[b] *MD -Maximum day flows and loads result in an increase in discharge BOD_5, TSS, and ammonia during the maximum day flow.*

[c] *Limited to ammonia removal efficiency of existing permit limit due to mass transfer limitations with fixed film treatment. Existing north plant does not provide equal reliability with south plant for more stringent effluent ammonia limits.*

[d] *One clarifier needs to be added immediately to provide reliable treatment in the case that one clarifier needs to be maintained.*

4.1.3.14 Chemical Phosphorus Removal

Chemical phosphorus removal is usually accomplished with the addition of metal salts [alum ($Al_2(SO_4)_3 \cdot 14H_2O$) or iron salts such as ferric chloride ($FeCl_3$)]. An evaluation was performed for chemical phosphorus removal with influent concentrations of total phosphorus and orthophosphate of 3.3 mg-P/L and 1.1 mg-P/L, respectively, based on the data from the supplemental testing. Several key findings have been identified, which are bulleted below based on alum use.

- Alum Salt Feed Rate = 250-300 gpd
- Average Dose = 10-13 mg/L
- 30-day storage requirement = 7,500-10,000 gallons
- Chemical Sludge Generated = 600-625 lb/d
- Precipitate Concentration = 4-6 mg/L

Metal salts may be dosed ahead of the primary clarifier or the secondary clarifier. When dosed ahead of the secondary clarifier, the precipitate accumulates in the activated sludge system as part of the MLSS; capacity has been included to accommodate the solids in the system.

4.1.3.15 Alternatives – Phasing for Regulatory Trigger Points

Table 4.1.4 identifies the additional anoxic, aerobic and final clarifier tankage requirements for the South Plant. The improvements were divided into the phases triggered by the permit cycles identified in Table 4.1.2. Phase 1 consists of the design and construction of modifications required to achieve Permit #1 Ammonia removals - to be constructed by 2025. The costs presented assume that mussels are present. Phase 1 and 2 costs were then combined and included in the Total Added Tank Volume column. The combination of Phase 1 and Phase 2 includes designing and constructing modifications to achieve both future ammonia removals and BNR (TN 10 / TP 1) to be constructed by 2030. Note that Alternative A2 is the same as Alternative A1 for Phase 1 as the nutrient removal requirement is not yet in the permit.

Table 4.1.4. Recommended Additional Capacity Improvements

Alternative	Added Tanks*	Phase 1 Tank Volume, MG	Phase 2 Tank Volume, MG	Total Added Tank Volume, MG
Alternative A1 - Activated Sludge	Anoxic		1.2	1.2
	Aerobic	0.9		0.9
	Clarifier	2.2 (2 Units)	2.2 (2 Units)	4.4 (4 Units)
Alternative A2 - Activated Sludge, BNR	Anaerobic		1.5	1.5
	Anoxic		1.7	1.7
	Aerobic	0.9	1.0	1.9
	Clarifier	2.2 (2 Units)	2.2 (2 Units)	4.4 (4 Units)
Alternative B – AS, TF Peaking	Anoxic		1.4	1.4
	Aerobic	1.2		1.2
	Clarifier	2.2 (2 Units)		2.2 (2 Units)
Alternative C - Prenit., TF Peaking	Prenit.	0.25		0.25
	Anoxic		1.2	1.2
	Aerobic	0.6		0.6
	Clarifier	2.2 (2 Units)		2.2 (2 Units)

* Note: One clarifier needs to be added immediately to provide reliable treatment in the case that one clarifier needs to be maintained.

4.1.3.16 Monetary Screening

Comparative order of magnitude construction costs, operations and maintenance costs, and total present value have been estimated for each of the alternatives as described below.

PHASE 1 CONSTRUCTION COSTS – PERMIT #1 AMMONIA CRITERIA @ 2025 FLOW & LOADINGS

An order of magnitude opinion of comparative construction costs for the four alternatives are presented in Table 4.1.5 for Phase 1.

- Alternative A has the lowest comparative Phase 1 construction cost at $23.2 million. However, the construction costs for the alternatives are essentially the same with less than 1% difference.
- In 2025, Alternative A2 is the same as Alternative A1 since nutrient removal is not yet incorporated.

Alternatives A1 and A2 include $1.4 million plus contractor mark-up and contingencies in interim provisional pump and piping improvements for the existing trickling filter pump station as the station is currently unreliable.

The Alternatives A1 and A2 are higher primarily because three (3) new clarifiers are required to handle the peak hydraulic flow. One clarifier needs to be added immediately for all of the alternatives, therefore only two new clarifiers are used in the alternative analyses. The benefit is that no new clarifiers are required for Phase 2.

Table 4.1.5. Phase 1 – 2025 Opinion of Comparative Construction Cost

Description	Percentage Applied	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Trickling Filter Pump Sta.	-	$1,385,000	$1,385,000	$4,242,000	$4,242,000
Peak Flow Pump Station	-	$1,515,000	$1,515,000	$0	$0
Prenitrification Basins	-	$0	$0	$0	$853,000
Anaerobic Basins	-	$0	$0	$0	$0
Anoxic Basins	-	$0	$0	$0	$0
Aerobic Basins	-	$1,596,000	$1,596,000	$1,939,000	$1,253,000
Aeration Basin Blowers	-	$826,000	$826,000	$826,000	$794,000
Clariflocculator(s)	-	$4,230,000	$4,230,000	$2,644,000	$2,538,000
Site Work	-	$1,255,000	$1,255,000	$965,000	$968,000
Site Piping	-	$787,000	$787,000	$787,000	$787,000
Miscellaneous Improvements[1]	-	$2,226,000	$2,226,000	$2,437,000	$2,437,000
Const. Subtotal w/o Cont.	**-**	$13,669,000	$13,669,000	$13,840,000	$13,873,000
Contingency	25%	$3,417,000	$3,417,000	$3,460,000	$3,468,000
Const. Subtotal w/ Cont.	**-**	$17,086,000	$17,086,000	$17,300,000	$17,342,000
General Conditions, Mob	5%	$854,000	$854,000	$865,000	$867,000
Sales Tax (Allowance)	5%	$897,000	$897,000	$908,000	$910,000
Overhead & Profit	15%	$2,826,000	$2,826,000	$2,861,000	$2,868,000
Bonds & Insurance	2%	$433,000	$433,000	$439,000	$440,000
Construction Subtotal	**-**	$22,097,000	$22,097,000	$22,373,000	$22,427,000
Construction Contingency	5%	$1,105,000	$1,105,000	$1,119,000	$1,121,000
Total Construction Cost	**-**	$23,200,000	$23,200,000	$23,500,000	$23,500,000

Notes:

1 *Miscellaneous Improvements include: architectural, structural, HVAC, electrical, SCADA, miscellaneous site structures totaling just over $1 million and also $1 million in process-related improvements identified during the condition assessment (only equipment cost associated with the alternatives are included and those with a replacement timeframe of ten years or less).*

2 *One clarifier needs to be added immediately for all of the alternatives, therefore only two new clarifiers are used in the alternative analyses.*

PHASE 2 CONSTRUCTION COSTS – PERMIT #2 NUTRIENT REMOVAL @ 2035 FLOW & LOADINGS

Order of magnitude opinion of comparative construction costs for the four alternatives are presented in Tables 4.1.6 for Phase 2.

- Alternative C has the lowest comparative construction cost at $7.5 million.
- Alternative A2 is nearly double Alternative B as anaerobic basins are required for biological phosphorus removal.
- Alternatives A1, B & C are closely comparative in cost at $7.8, 7.9 and 7.5 million, respectively.

Order of magnitude opinion of comparative construction costs including Phases 1 & 2 are presented in Table 4.1.7.

- Alternative A1 has the lowest comparative construction cost at $31.0 million.
- Alternative A2 has a higher comparative construction cost at 23.5% higher than Alternative A1 at $38.3 million.
- Alternatives A1, B & C are closely comparative in cost at $31.0, 31.4 and 31.1 million, respectively.

Alternatives A1 and A2 include $1.4 million in interim pump and piping improvements for the existing trickling filter pump station as the station is currently unreliable.

The Alternatives B and C are higher primarily because of the new construction cost associated with the new trickling filter pump station and piping.

Alternative A2 is higher than Alternatives A1, B and C because it requires significantly more anoxic and anaerobic aeration basin volume to achieve phosphorus removal.

Table 4.1.6. Phase 2 – 2035 Opinion of Comparative Construction Cost

Description	Percentage Applied	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Trickling Filter Pump Sta.	-	$0	$0	$0	$0
Peak Flow Pump Station	-	$0	$0	$0	$0
Prenitrification Basins	-	$0	$0	$0	$0
Anaerobic Basins	-	$0	$2,311,000	$0	$0
Anoxic Basins	-	$3,616,000	$4,239,000	$3,862,000	$3,616,000
Aerobic Basins	-	$0	$1,217,000	$0	$0
Aeration Basin Blowers	-	$110,000	$2,000	$17,000	$50,000
Clariflocculator(s)	-	$0	$0	$0	$0
Site Work	-	$373,000	$627,000	$388,000	$367,000
Site Piping	-	$393,000	$393,000	$393,000	$393,000
Miscellaneous Improvements	-	$111,000	$111,000	$0	$0
Const. Subtotal w/o Cont.	-	$4,604,000	$8,900,000	$4,661,000	$4,426,000
Contingency	25%	$1,151,000	$2,225,000	$1,165,000	$1,107,000
Const. Subtotal w/ Cont.	-	$5,755,000	$11,125,000	$5,826,000	$5,533,000
General Conditions, Mob	5%	$288,000	$556,000	$291,000	$277,000
Sales Tax (Allowance)	5%	$302,000	$584,000	$306,000	$290,000
Overhead & Profit	15%	$952,000	$1,840,000	$963,000	$915,000
Bonds & Insurance	2%	$146,000	$282,000	$148,000	$140,000
Construction Subtotal	-	$7,442,000	$14,388,000	$7,534,000	$7,155,000
Construction Contingency	5%	$372,000	$719,000	$377,000	$358,000
Total Construction Cost	-	$7,800,000	$15,100,000	$7,900,000	$7,500,000

4. Note:

1 Miscellaneous Improvements include: architectural, structural, HVAC, electrical, SCADA, miscellaneous site structures and process related improvements identified during the condition assessment (only equipment cost associated with the alternatives are included and those with a replacement timeframe of ten years or less).

2 One clarifier needs to be added immediately for all of the alternatives, therefore only two new clarifiers are used in the alternative analyses.

5.

Table 4.1.7. Phases 1 & 2 – 2035 Opinion of Comparative Construction Cost

Description	Percentage Applied	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Trickling Filter Pump Sta.	-	$1,385,000	$1,385,000	$4,242,000	$4,242,000
Peak Flow Pump Station	-	$1,515,000	$1,515,000	$0	$0
Prenitrification Basins	-	$0	$0	$0	$853,000
Anaerobic Basins	-	$0	$2,311,000	$0	$0
Anoxic Basins	-	$3,616,000	$4,239,000	$3,862,000	$3,616,000
Aerobic Basins	-	$1,596,000	$2,813,000	$1,939,000	$1,253,000
Aeration Basin Blowers	-	$936,000	$828,000	$843,000	$844,000
Clariflocculator(s)	-	$4,230,000	$4,230,000	$2,644,000	$2,538,000
Site Work	-	$1,628,000	$1,882,000	$1,353,000	$1,335,000
Site Piping	-	$1,180,000	$1,180,000	$1,180,000	$1,180,000
Miscellaneous Improvements	-	$2,337,000	$2,337,000	$2,437,000	$2,437,000
Const. Subtotal w/o Cont.	-	$18,273,000	$22,569,000	$18,501,000	$18,300,000
Contingency	25%	$4,568,000	$5,642,000	$4,625,000	$4,575,000
Const. Subtotal w/ Cont.	-	$22,841,000	$28,212,000	$23,126,000	$22,875,000
General Conditions, Mob	5%	$1,142,000	$1,411,000	$1,156,000	$1,144,000
Sales Tax (Allowance)	5%	$1,199,000	$1,481,000	$1,214,000	$1,201,000
Overhead & Profit	15%	$3,777,000	$4,666,000	$3,824,000	$3,783,000
Bonds & Insurance	2%	$579,000	$715,000	$586,000	$580,000
Construction Subtotal	-	$29,539,000	$36,484,000	$29,907,000	$29,582,000
Construction Contingency	5%	$1,477,000	$1,824,000	$1,495,000	$1,479,000
Total Construction Cost	-	$31,000,000	$38,300,000	$31,400,000	$31,100,000

Note:

1. *Miscellaneous Improvements include: architectural, structural, HVAC, electrical, SCADA, miscellaneous site structures and process related improvements identified during the condition assessment (only equipment cost associated with the alternatives are included and those with a replacement timeframe of ten years or less)*
2. *One clarifier needs to be added immediately for all of the alternatives, therefore only two new clarifiers are used in the alternative analyses.*

OPERATIONS AND MAINTENANCE COSTS

Order of magnitude opinions of comparative O&M costs for Phase 1 are presented in Table 4.1.8. The O&M costs presented are the costs associated with the alternative treatment processes only. O&M costs associated with the rest of the WRF (e.g. pretreatment, UV disinfection, digestion) are not included in this cost comparison.

The primary observations include the following:

- Total annual O&M costs for Alternatives B and C are approximately 20% and 24% greater than Alternative A1, respectively. The additional cost includes collectively higher power, material and labor costs to maintain the North Plant pumping and secondary clarifiers. The additional labor equates to approximately two additional workers at 1,800 hours per year for alternatives B & C. Additional material costs are approximately $53,000 per year to maintain North Plant facilities.
- Alternative A2 is the same as Alternative A1 in Phase 1.

Table 4.1.8. Phase 1 Comparative Operations and Maintenance Annual Cost

Description	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Process energy cost	*$309,249*	*$309,249*	*$339,517*	*$333,504*
Building energy cost	*$339*	*$339*	*$345*	*$344*
Energy Costs	$309,587	$309,587	$339,863	$333,849
Material Costs	$37,594	$37,594	$90,003	$90,006
Labor Hours	*14,000*	*14,000*	*16,500*	*17,325*
Labor Costs	$1,050,000	$1,050,000	$1,237,500	$1,299,375
Annual Operations & Maintenance	**$1,397,181**	**$1,397,181**	**$1,667,365**	**$1,723,230**
Operations & Maintenance - 20 Year Present Value, 3%	$20,300,000	$20,300,000	$24,200,000	$25,100,000

Order of magnitude opinions of comparative O&M costs for the total project, including Phase 1 & 2, are presented in Table 4.1.9. The O&M costs presented are the costs associated with the alternative treatment processes only. O&M costs associated with the rest of the WRF (e.g. pretreatment, UV disinfection, sludge handling) are not included in this cost comparison. The primary observations include the following:

- Total O&M costs for Alternatives B and C are approximately 15 and 17% greater than Alternative A1, respectively. The additional cost includes collectively higher power, material and labor costs to maintain the North Plant pumping and secondary clarifiers.

The additional labor equates to approximately 2.1 to 2.7 additional workers at 1,800 hours per year for alternatives B & C, respectively. Additional material costs are approximately $57,000 per year to maintain North plant facilities.

- Alternative A2 life cycle operations cost is approximately 9% less than Alternative A1 because less alum is required for phosphorus removal.
- Achieving scenario 1 level phosphorus for Alternatives A1, B and C has a notably higher chemical cost at $392,000 annually versus approximately one-third that amount for Alternative A2 at $131,000. This is because of the supplemental alum addition required for phosphorus removal.

Table 4.1.9. Phase 1 & 2 Comparative Operations and Maintenance Annual Cost

Description	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Process energy cost	$708,500	*$659,521*	*$763,265*	*$724,038*
Building energy cost	$376	*$364*	*$393*	*$384*
Energy Costs	$708,800	$659,885	$763,658	$724,423
Chemical Costs	$392,400	$130,791.67	$392,375	$392,375
Material Costs	$54,000	$54,439	$111,587	$110,980
Labor Hours	19,950	*21,000*	*23,700*	*24,885*
Labor Costs	$1,496,300	$1,575,000	$1,777,500	$1,866,375
Annual Operations & Maintenance	$2,652,000	**$2,420,116**	**$3,045,121**	**$3,094,153**
Operations & Maintenance – 20 Year Present Value, 3%	$38,600,000	$35,200,000	$44,300,000	$45,000,000

TOTAL PRESENT VALUE

Table 4.1.10 presents a summary of the order of magnitude comparative present values for the Phase 1 alternatives. As indicated in Table 4.1.10:

- Alternative A1 is the same as Alternative A2 in Phase 1.
- In terms of total present value, Alternatives B and C with the trickling filters incorporated have only a slightly higher present value at 10% and 12%, respectively.
- Maintenance cost is $4 to $5 million more for Alternatives B and C on a 20-year present value basis.

Table 4.1.10. Phase 1 Life Cycle Analyses

Description	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Total Construction Cost	$23,200,000	$23,200,000	$23,500,000	$23,500,000
Operations & Maintenance - 20 Year Present Value, 3%	$20,300,000	$20,300,000	$24,200,000	$25,100,000
Construction & Operations & Maintenance Present Value	**$43,500,000**	**$43,500,000**	**$47,700,000**	**$48,600,000**

Table 4.1.11 presents a summary of the order of magnitude comparative present value for the complete project. As indicated in Table 4.1.11:

- Alternative A1, activated sludge, has the lowest comparative present value at approximately $69.6 million and is 6% less than Alternative A2.
- Alternative A2 has the present value at $73.5 million, but has the lowest present value for operation and maintenance at $35.2 million.
- Alternatives B and C with the trickling filters incorporated have a higher overall present value at approximately 9%. As noted previously, total construction costs are about a wash.
- Operations and maintenance costs account for approximately $5.7 to $6.4 million of the incremental present values for Alternatives B and C, respectively.

Table 4.1.11. Phase 1 & 2 Life Cycle Analyses

Description	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Total Construction Cost	$31,000,000	$38,300,000	$31,400,000	$31,100,000
Operations & Maintenance - 20 Year Present Value, 3%	$38,600,000	$35,200,000	$44,300,000	$45,000,000
Construction & Operations & Maintenance Present Value	**$69,600,000**	**$73,500,000**	**$75,700,000**	**$76,100,000**

4.1.3.17 Non-Monetary Screening

Besides costs, other non-monetary considerations are important in screening and eventually selecting an alternative for implementation.

Table 4.1.12 presents non-monetary criteria for screening the four alternatives. It includes non-monetary criteria similar to those used previously by the City for the disinfection alternatives study, but tailored to this Project per planning team discussions.

As indicated by Table 4.1.12, the activated sludge alternatives (without trickling filters) were rated highest; followed by the alternatives with trickling filters incorporated.

The activated sludge-based alternatives are rated highest for flexibility because at more stringent discharge requirements the process can be reconfigured for varied arrangements of anaerobic, anoxic, and aerobic basins and recycle flows for additional nutrient removal capability and/or capacity expansion. In short, activated sludge based alternatives are more amenable to reconfiguration compared to the trickling filter alternatives.

The activated sludge-based alternatives A1 and A2 also win in the reliability category as activated sludge is more consistent and reliable in meeting lower ammonia and nutrient levels. Activated sludge Alternatives A1 and A2 were rated highest for system reliability, primarily due to cold weather concerns associated with the trickling filters. Low temperatures reduce biological activity for all treatment systems, but trickling filters are more exposed and vulnerable to low temperatures than activated sludge systems, resulting in a particular concern for the nitrification (ammonia removal) rate.

Table 4.1.12 Non-Monetary Criteria Ranking[a]

	Alternative A1 - Activated Sludge	Alternative A2 - Activated Sludge, BNR	Alternative B - AS, TF Peaking	Alternative C - Prenit., TF Peaking
Flexibility for More Stringent Discharge Requirements	8	9	6	6
Reliable (Bullet Proof)	9	8	6	6
Process Operational Requirements	7	5	6	6
Maintenance Requirements	7	8	6	6
Impact to Operations during Construction	7	7	8	8
Resource Recovery (Green)	8	9	7	7
Impact on Biosolids	7	8	7	7
Total	**53**	**54**	**46**	**46**

3. *Note:*
[a] *Ranking from 1 to 10, with 1 worst and 10 best.*

Maintenance requirements are significant considerations for the screening and evaluation of the alternatives. Alternative A2 has a slight edge as the trickling filter process is eliminated from the maintenance schedule and biologic phosphorus removal requires less chemical.

4.1.4 Recommendations

The existing trickling filters are very efficient for BOD and ammonia removal and have served the City of Rapid City well in terms of permit compliance for the last 50 years. Likewise, it is a familiar technology to operations staff and reduces the impact of future biosolids production. However, fixed film is not effective for nutrient removal without chemical addition (methanol). Secondly the trickling filters were evaluated as a peaking facility and the advantages of keeping the trickling filters do not outweigh the disadvantages.

Costs for the four alternatives with two options to achieve the effluent limits for Permit #2 and #3 for both future ammonia and Level 1 nutrient control of 10 mgl/l TN and 1 mg/l TP indicate the following:

- Alternative A1 without the existing trickling filters is ultimately the lowest cost alternative whether it be construction cost, energy cost, chemical cost, operations and maintenance cost, or overall present value. On a total present value basis, it is approximately $6.4 million less expensive than the next alternative.
- Alternatives B, C and A2 are approximately the same on a present worth basis.
- Alternative A2 with biological phosphorus removal has the highest cost with respect to initial capital cost.
- Alternate A1 is consistent with the 2000 Facility Plan as this plan recommended expanding the activated sludge treatment for additional capacity with provisions for denitrification and phosphorus removal.

The non-monetary evaluation for the four alternatives indicates that the activated sludge based alternatives were rated highest.

Alternative A1, activated sludge, has the lowest comparative present value at approximately $69.6 million and is 6% less than Alternative A2 and has the lowest total construction cost.

Therefore, the activated sludge Alternative A1 is the recommended alternative. The proposed treatment is sized for and can include means for Simultaneous Nitrification and Denitrification (SND).

Chapter 4.2 Solid Handling Evaluation

4.2.1 Background and Purpose

The City of Rapid City Water Reclamation Facility (WRF) provides secondary treatment to municipal, commercial, and industrial wastewater in the City of Rapid City, South Dakota, service area though primary sedimentation, fixed-film, activated sludge, and ultraviolet (UV) disinfection. Treated effluent is discharged into Rapid Creek.

Waste activated sludge and anaerobically digested primary sludge are pumped to a holding cell for temporary storage prior to dewatering or thickening in the solids handling building.

Dewatered sludge is defined as a solid residue (12% total solids by weight or greater – typically 20% at the WRF) remaining after removal of water from a liquid biosolids by pressing or centrifuging. Dewatering is distinguished from thickening in that dewatered biosolids may be transported by solids handling procedures. Thickened sludge (11% total solids by weight or less – typically 4-6% at the WRF) retains liquid viscous properties and is typically handled with pumps and tanker trucks.

The Rapid City WRF uses two centrifuges to either dewater or thicken biosolids. Dewatered biosolids are either directly disposed to the Rapid City Regional Landfill or delivered to the Rapid City Material Recovery Facility (MRF) for composting. Thickened biosolids are delivered to the MRF for composting. Each centrifuge has a 100 horsepower (HP) bowl drive motor and 25 HP back drive motor. The centrifuges are operated 10 to 14 hours per day, 4 to 5 days per week, and require continuous monitoring during operation. The centrifuges require frequent overhauls; with each overhaul costing cost approximately $80,000 per unit.

In 2014, the Rapid City WRF produced approximately 1,627 dry tons of primary biosolids that were sent to the anaerobic digesters. Following digestion, approximately 785 dry tons of solids were pumped to the sludge holding cell. In addition, 518 dry tons of waste activated sludge was pumped to the sludge holding cells, giving a total of 1,303 dry tons of biosolids for thickening and dewatering.

The purpose of this chapter of the facility plan is to review alternatives for upgrades or improvements to the existing solids dewatering and thickening facilities as the existing processing equipment has become unreliable and reached the end of its useful service life. In addition, the selected alternatives have been up-sized to meet the projected design loading.

Manufacturers' equipment is listed by name throughout this section. Manufacturers' equipment is only listed as typical equipment used for this purpose, an in-depth study will be prepared to select equipment and listing specific manufacturers is not an endorsement or recommendation of one manufacturer over another.

Cost comparisons for alternative dewatering units are presented in this chapter along with an initial non-economic evaluation. However, pilot testing and further investigation, which is beyond the scope of this chapter, is recommended before final selection of a solids dewatering system is made.

4.2.2 Current Solids Handling System

The Rapid City WRF solids handling system consists of the following:

- Anaerobic digestion includes two primary anaerobic digesters and one secondary anaerobic digester.
- Digested solids pumping to sludge holding pond.
- Waste activated sludge pumping from clariflocculator to sludge holding pond.
- Three sludge pond mixers, each rated at 25 HP
- Sludge feed pumps that pump from the holding pond to the centrifuges.
- Two centrifuges for dewatering and thickening.
- Polymer feed system.
- Dewatered cake conveyor for transport to load out.
- Thickened sludge conveyor to holding tank.
    - Thickened sludge holding tank and load out pumping.
    - Dewatered cake load out.
    - Truck hauling and disposal.

4.2.2.1 Existing Solids Handling Building

The lower level of the solids handling building was constructed for solids load out in 1985 along with the solids storage pond. Modifications to the solids handling building were made in 2002 including the addition of the upper level and thickened sludge holding tank on the lower level. The 2002 modifications also included the construction of a centrate storage tank with piping to discharge to pretreatment. The following equipment was provided with the 2002 modifications:

- Centrifuges
- Centrifuge feed pumps and grinders
- Polymer feed system
- Dewatered cake and thickened solids conveyors
- Blower for aeration and mixing of the thickened sludge holding tank
    - Thickened sludge load out pump

4.2.2.2 Centrifuge Dewatering and Thickening

Two centrifuges dewater or thicken waste activated sludge (WAS) and anaerobically digested solids at the Rapid City WRF. The centrifuges were installed in 2002 and have been performing successfully; however, they have needed significant maintenance. Maintenance requires the centrifuges to be disassembled and sent to the manufacturer for service. Conducting this maintenance (refurbishment and high-speed balancing) cannot be performed in-house.

Centrifuge service typically takes several months. As the WRF has only two centrifuges, this is a critical vulnerability in process reliability. The design parameters for the existing solids handling system are shown in Table 4.2.1.

Table 4.2.1. Existing Solids Dewatering and Thickening System Design Parameters

Item	Value
Andritz 5DLL centrifuges	2
Dewatered cake solids concentration	25%
Thickened solids concentration	6%
Operation time	50 to 56 hours per week
Design maximum dewatering feed rate	200 gallons per minute
Design maximum thickening feed rate	250 gallons per minute
Polymer consumption	16 pounds per dry ton of solids

Note: Polymer is added to the blended sludge prior to the centrifuges using mechanical flocculation.

4.2.2.3 Thickened Solids and Dewatered Cake Collection and Conveyance

Thickened solids are conveyed from the discharge of the centrifuges through a shaftless screw conveyor and deposited into a thickened sludge holding tank. Dewatered solids are conveyed from the discharge of the centrifuges through a separate shaftless conveyor and deposited directly into truck roll-off containers. For dewatered solids, the system only provides one drop point; therefore, the roll-off containers must be moved periodically to allow for complete filling.

4.2.3 Design Criteria for New Dewatering System

The Rapid City WRF is projected to have increased influent flows and loads for the 20-year planning period. To properly size the dewatering system, historical data were reviewed and flow and load projections were developed to size equipment.

4.2.3.1 Review of Historical Solids Flow and Load Data

Historical records of the annual sludge production from 2012 to 2015 were reviewed and are presented in Table 4.2.2. Table 4.2.2 shows a summary of the primary sludge produced, which includes trickling filter humus, WAS produced, and the total sludge produced.

Table 4.2.2. Historic Sludge Production

Year	Primary Sludge Produced				Waste Activated Sludge Produced				Total Sludge Produced	
	Average Annual (GPD)	Average Annual (PPD)	Maximum Month (GPD)	Maximum Month (PPD)	Average Annual (GPD)	Average Annual (PPD)	Maximum Month (GPD)	Maximum Month (PPD)	Annual Average Dry Sludge Produced (PPD)	Maximum Month Dry Sludge Produced (PPD)
2012	25,390	8,148	35,284	10,388	33,414	3,665	43,950	3,665	11,859	14,053
2013	22,078	6,992	25,341	7,989	30,483	4,827	50,739	6,444	11,442	14,433
2014	27,800	8,915	33,950	10,646	22,052	2,838	39,776	5,114	11,834	15,760
2015	25,340	6,974	27,661	12,665	16,000	2,082	20,100	2,777	9,056	15,442
Average	**25,125**	**7,757**	**30.559**	**10.422**	**25,487**	**3,353**	**38,641**	**4,500**	**11,048**	**14,922**

Notes:
gallons per day (GPD)
pounds per day (PPD)

Primary sludge is sent to the anaerobic digesters for stabilization prior to being pumped to the sludge holding pond. Through anaerobic digestion, the pounds of solids contained in the sludge are reduced by 55 to 60 percent. However, the volume of sludge remains approximately the same. Table 4.2.3 shows a summary of the quantity of sludge that was sent to the sludge holding pond for dewatering from 2012 to 2015.

Table 4.2.3. Historic Sludge to Holding Pond

Year	Digested Sludge to Holding Pond				Total Sludge to Holding Pond, Including Waste Activated Sludge and Digested Sludge			
	Average Annual (GPD)	Average Annual (PPD)	Maximum Month (GPD)	Maximum Month (PPD)	Average Annual (GPD)	Average Annual (PPD)	Maximum Month (GPD)	Maximum Month (PPD)
2012	23,930	3,666	32,670	5,354	57,344	7,331	76,620	9,019
2013	23,950	2,033	28,350	4,540	54,433	6,860	79,089	10,984
2014	35,680	4,301	29,500	4,896	57,732	7,139	69,276	10,010
2015[1]	25,960	3,486	34,970	5,891	41,960	5,568	55,070	8,668
Ave	27,380	3,372	31,373	5,170	52,867	6,725	70,014	9,670

Notes:
[1] Partial year data (January through May).
Gallons per day (GPD)
pounds per day (PPD)

4.2.3.2 Solids Flow and Load Projections

The design criteria for solids dewatering is typically the maximum week or maximum month flow and load. Rapid City has a current sludge holding capacity that provides storage for approximately 13 days at current average day sludge flows. Therefore, the maximum week flow and load has been used as the design criteria. In calculating the maximum week flow and load, the maximum month daily flow was multiplied by 7 days. A review of historical records indicates that the daily flow for the maximum months averaged 70,014 gallons per day. Multiplying the maximum month's average (70,014) by 7 days per week gives a maximum week flow of 490,000 gallons per week. The maximum solids loading are calculated to 67,700 pounds per week.

The sludge feed rate to the existing centrifuges is limited to approximately 160 gallons per minute (gpm), because at higher flows foaming will occur in the centrate discharge lines. At a sludge feed rate of 160 gpm, 51 hours of operation per week is required to process the 490,000 gallons of sludge.

Historic sludge flow and loadings can be used as a base line for projecting future solids flow and loadings. However, the type of future treatment processes need to be considered in future flow projections. Suspended growth (activated sludge) systems will produce approximately twice the

amount of solids per biochemical oxygen demand (BOD) reduced in comparison to the trickling filter system. Further, chemical addition in the primary clarifiers will enchance settling and create additional solids that are sent to the anaerobic digesters. Table 4.2.4 summarizes the projected solids production and solids flow to the sludge holding ponds based on expansion of the Activated Sludge System under Alternative A described in Chapter 4.1.

Table 4.2.4. Projected Sludge Production and Loading to Storage and Dewatering

		Current		2025		2035		2045	
Sludge Type	Unit	Average Annual	Maximum Month	Average Annual	Maximum Month	Average Annual	Maximum Month	Average Annual	Maximum Month
Primary Sludge	PPD	7,757	10,422	15,200	16,420	17,260	18,650	21,850	23,220
	GPD	25,125	30,559	45,560	49,230	51,740	55,910	65,500	69,600
Waste Activated Sludge	PPD	3,353	4,500	5,240	6,350	5,870	7,120	7,160	8,370
	GPD	25,487	38,641	62,830	76,210	70,380	85,370	85,850	100,360
Total Raw Sludge	PPD	11,110	14,922	20,440	22,770	23,130	25,770	29,010	31,590
	GPD	50,612	69,240	108,390	125,390	122,120	141,280	151,350	169,960
Digester HRT (Primary Sludge)	Days								
Primary Digester		42.2	34.6	23.2	21.5	20.4	18.9	16.1	15.2
Secondary Digester		14.0	11.5	7.7	7.1	6.8	6.3	5.4	5.1
Total Sludge to Holding Pond for Dewatering	**PPD**	**6,725**	**9,670**	**15,200**	**16,780**	**17,210**	**19,000**	**21,150**	**23,190**
	GPD	**52,867**	**70,014**	**108,390**	**125,390**	**122,120**	**141,280**	**151,350**	**169,960**
	% Solids	**1.5%**	**1.6%**	**1.7%**	**1.6%**	**1.7%**	**1.6%**	**1.7%**	**1.6%**

Notes:
pounds per day (PPD)
gallons per day (GPD)

As indicated in Table 4.2.4, the 2035, 20-year project sludge loading to dewatering is 19,000 pounds per day on maximum month and the sludge volume is 141,280 gallons per day. On a weekly basis, this would give a maximum weekly loading and sludge volume to dewatering of 133,000 pounds per week and 988,960 gallons per week, respectively.

4.2.4 Dewatering System Alternatives

The solids handling facilities currently thicken sludge to 6 percent solids and dewater sludge to 25 percent solids. However, after reviewing the current Rapid City Regional Landfill composting operations, it was determined that moving forward with dewatering only (no thickening) will not adversely impact the Rapid City MRF composting operations and therefore only dewatering

system alternatives were evaluated for future solids handling at the Rapid City WRF. The Rapid City MRF will require 12,000 to 15,000 gallons per day of unthickened sludge. Both the Rapid City Regional Landfill and Rapid City WRF personnel felt that at least 50,000 gallons of liquid storage would be extremely beneficial to operations to provide scheduling relief for the Rapid City WRF and an as needed supply for the Rapid City Regional Landfill; the Rapid City WRF could deliver in 1 day and have this task completed for the week.

In addition to conventional dewatering equipment, such as centrifuges, alternative dewatering devices have been developed and offered to the marketplace over the last few years. These devices offer some significant cost savings in operations and maintenance due to their slow speed as well as other performance factors. The main devices that have been reviewed in this chapter are centrifuges, screw presses, rotary fan presses, and volute presses; liquid sludge storage options are also reviewed.

4.2.4.1 Dewatering Equipment Technologies

CENTRIFUGE

Centrifuges separate heavier solids from lighter liquids through centrifugal force. There are three types of centrifuges used in municipal wastewater biosolids processes: basket, disc, and decanter. Only decanter centrifuges are discussed because they are the only ones appropriate for the Rapid City WRF solids dewatering application.

Decanter centrifuges are comprised of a horizontal scroll or conveyor within a hollow cylinder as shown in Figure 4.2.1. There are two types of decanter centrifuges; co-current and counter current. Co-current centrifuges introduce the feedstock at the end of the centrifuge opposite the cake discharge and have ports along the length of the centrifuge to collect centrate. Counter current centrifuges introduce the feedstock at the intersection of the conical and cylindrical portions of the scroll. The centrifuge shown in Figure 4.2.1 is a counter current type. Decanter centrifuges are the most common type of centrifuge in use today. They are often referred to as high solids centrifuges due to their ability to impart more than 3,000 Gs, and produced a cake with 25 percent solids or more

The primary difference between thickening and dewatering centrifuging at the WRF is the speed of rotation and polymer feed rate.

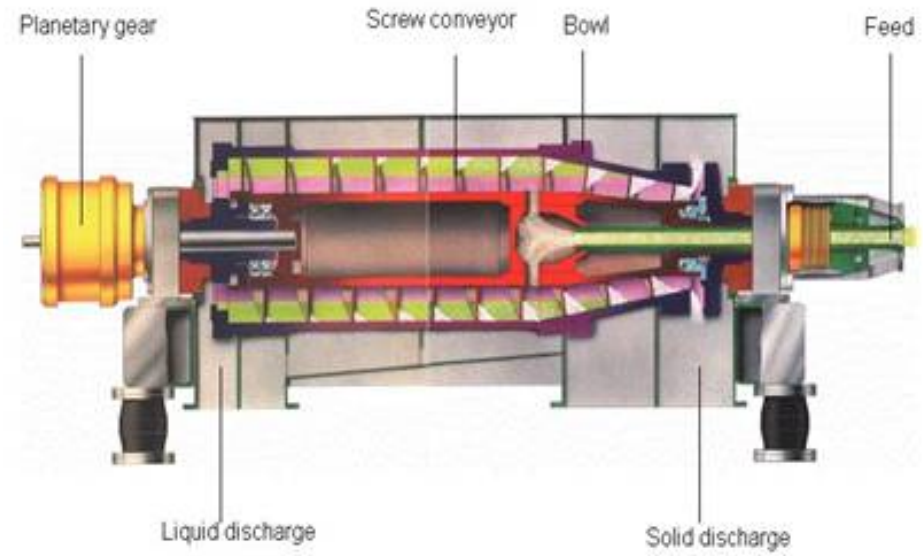


Figure 4.2.1. Schematic of a Decanter Centrifuge

The correct choice of polymer type, dilution rate, and application point(s) is critical to optimal centrifuge performance. Other operational considerations include bowl speed, scroll and bowl speed differential, weir setting, and loading rate. Upon startup, centrifuges will produce a sloppy product that must be collected and (usually) returned to the feed tank or other point for recycle. Centrifuges should be flushed with water when shut down and hot water is often required to remove grease buildup. Proper lubrication and preventative maintenance are important because the machine operates at high speeds and failures could be catastrophic. The equipment requires periodic major maintenance to sustain performance.

The most common manufacturers of centrifuges are Andritz, Alfa Laval, Westfalia, and Centrisys.

SCREW PRESS

A screw press is a mechanical device used for liquid and solid separation for various types of sludge. Liquid and solid separation is accomplished by gradually reducing the volume available for the solids as they are conveyed from the inlet to the outlet end of the screw press. The reduction in volume is achieved by using a tapered shaft that is larger in diameter at the discharge end than at the inlet end, as shown in Figure 4.2.2.

A typical FKC installation is shown in Figure 4.2.3. FKC can provide screw presses from 4 inches to 53 inches in diameter, with wetted lengths up to 30 feet. The wetted parts of the presses are manufactured from stainless steel. The base is typically manufactured from carbon steel, but is available in stainless steel.

The shaft is surrounded by a screen system that contains small (less than 1/8-inch diameter) punched holes. A typical screen is shown in Figure 4.2.4. The screen support housing includes adjustment nuts to correct the screen position to achieve the proper clearance from the screw

flights. Steam can be provided to the screw in conjunction with lime stabilization system for producing Class A biosolids; however, this is generally not recommended in combination with anaerobic digestion.

There are several drive systems available, but the most typical has a VFD-driven motor, cyclogear to reduce speed, and a chain drive. This combination provides for a final rotational speed in the range of 0.05 to 1.5 revolutions per minute (rpm). With the slow speed and automation provided, screw presses can be operated unattended, which provides a significant savings in operations costs. Maintenance requirements are relatively low as reported by numerous owners of operating screw press facilities. However, one installation reported problems with hair accumulating on the screw openings.

The inlet to the screw press can be piped directly into the press or introduced through an inlet box. In either case, the inlet box is required to allow waste solids to back up into the box, which places a hydraulic head on the material to force it into the screw area.

FKC builds their screw presses in Japan with lead times of up to 9 months after a purchase order.

Based on pilot testing at other facilities, cake solids will vary from 17.5 to 23 percent and active polymer dose rate varied from 18.4 to 22.4 pounds of active polymer per dry ton of solids.

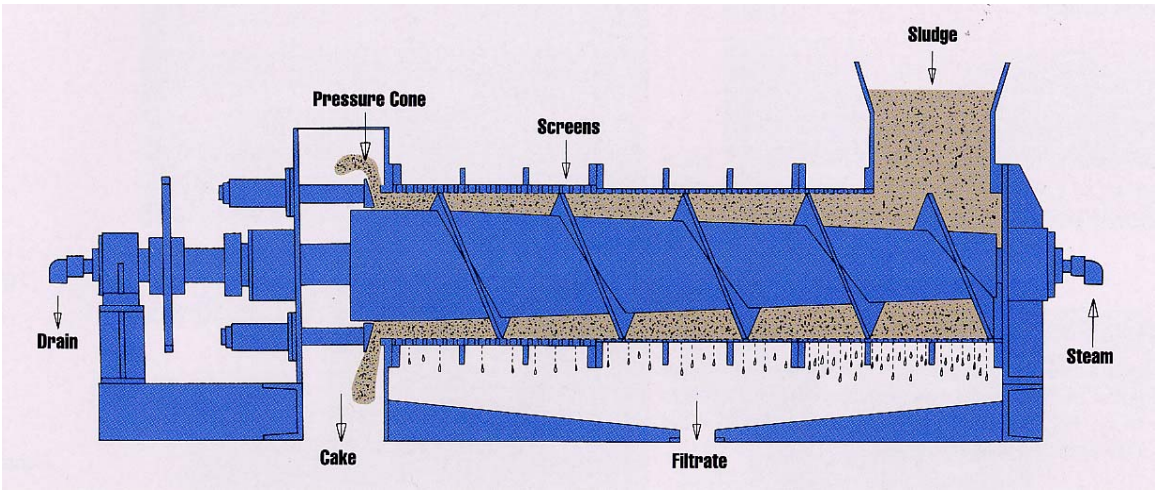


Figure 4.2.2. Cross-Section Schematic of Screw Press (courtesy of FKC)

Figure 4.2.3. FKC Screw Press Operating in Sequim, Washington

Figure 4.2.4. Typical Screw Press Screen

ROTARY FAN PRESS

The rotary fan press is a relatively simple device with low energy requirements. Solids are fed to a rectangular channel and then rotated between two parallel revolving screens. Rotation is typically less than 3 rpm, which is slower than the rotation of a centrifuge. Filtrate is squeezed out to the sides of the screen and collected. Sludge is increasingly dewatered as it travels around the circular channel. Figure 4.2.5 shows the principle of operation with two cross-section views of the rotary press. A rotary press relies on internal pressure to force the sludge through the circular channels. As such, back pressure must be provided to the press in the form of a high-pressure feed pump.

Rotary presses provide optimal dewatering on sludges that have a significant portion of primary sludge or significant fibrous material. With the relatively slow speed and the high level of automation provided, rotary presses can typically be operated unattended. Maintenance requirements are low as reported by owners of operating rotary press facilities.

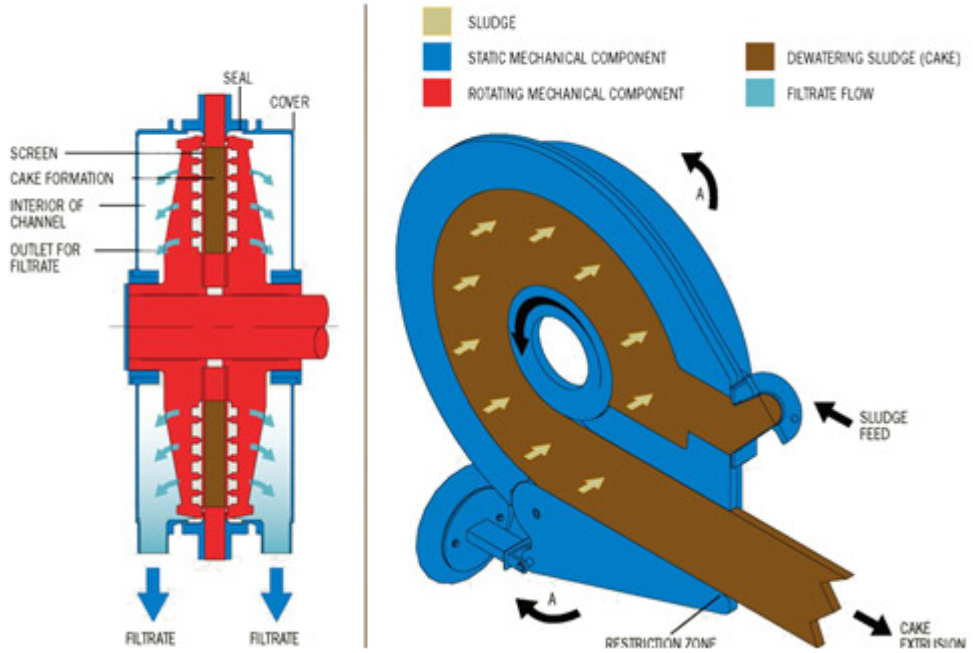


Figure 4.2.5. Schematics of Rotary Press Showing Principle of Operation (courtesy of Fournier)

FOURNIER

Fournier produces presses with 1, 2, 3, 4, 5, or 6 channels, with each having a diameter of 32 or 36 inches. Figure 4.2.6 shows a six-channel unit.

Pneumatic by-pass valves and pressure control flow balancing on multi-channel units are required for the Fournier rotary press.

Figure 4.2.6. Multi-Channel Rotary Press (courtesy of Fournier Industries)

PRIME SOLUTIONS

Prime Solutions offers a similar rotary press as Fournier. A schematic of the Prime Solutions rotary press is shown in Figure 4.2.7, and an exterior view is shown in Figure 4.2.8.

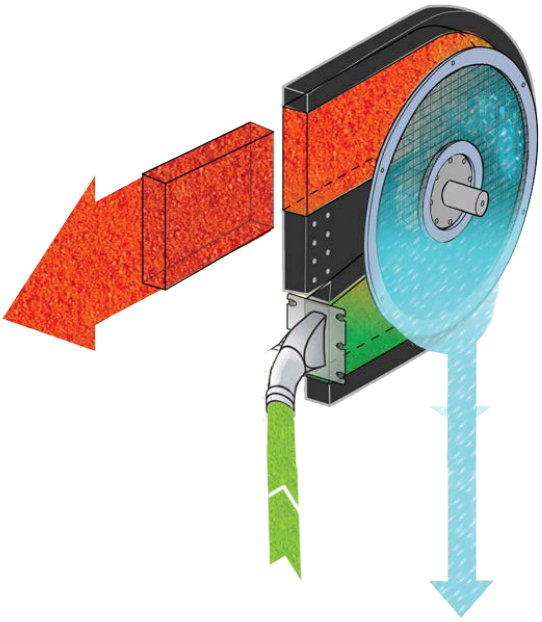


Figure 4.2.7. Schematic of Prime Solutions Rotary Press

Figure 4.2.8. Exterior View of Prime Solutions Rotary Press

VOLUTE PRESS

The volute dewatering press consists of a dewatering drum, which houses spacers, fixed rings, and moving rings. The initial section of the unit is the thickening zone where the threads are

spaced further apart and the gaps between the rings are larger. The distance between the screw threads decreases with the gaps between the rings as the sludge is moved down the drum and into the dewatering zone. This operation squeezes water from the sludge as it travels down toward the end-plate where the solids are discharged. The volute press, similar to the screw press has a low rotational speed, low power, and low spray water requirements. PWTech offers volute presses. An example of a PWTech volute press is shown in Figure 4.2.9.

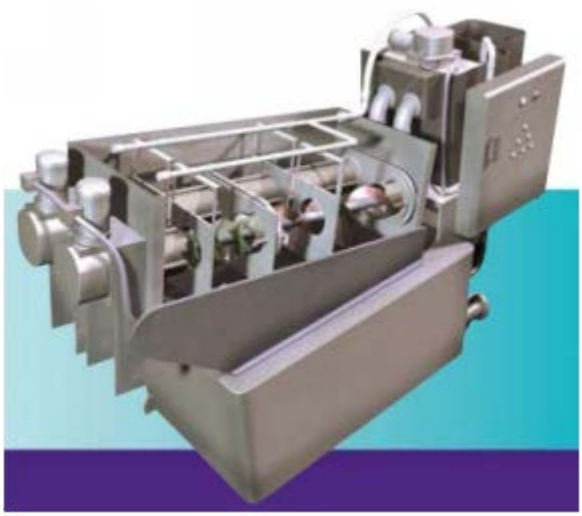


Figure 4.2.9. Example Volute Press

DEWATERING EQUIPMENT COMPARISON

Table 4.2.5 presents a comparison of model, capacity, and other features of the screw presses, rotary press, and an example centrifuge under consideration.

Table 4.2.5. Comparison of Alternative Dewatering Devices

Device Type	Centrifuge	Screw Press	Rotary (fan) Press	Volute Press
Manufacturer	ANDRITZ or Alfa Laval	FKC	Fournier	PWTech
Model/Capacity	Andritz – D5LL Alfa Laval–G3 95 1,750/ pounds per hour/200 gpm	BHX-1100x6000L 1,000 pounds per hour/125 gpm	6-900 /6000 CV 600 pounds per hour/67 gpm	ES353 2,100 pounds per hour/200 gpm
Main drive horsepower	100 (25 back drive)	5 (2 flocculator)	20 (1 flocculator)	12.4 (1.5 flocculator)
Main drive speed	3,600	0.03–0.3 rpm	0.5–3 rpm	0.5–3 rpm
Back pressure	None required	None required	Up to 10 psi	None required
Cost (one unit)	$425,000	$236,720	$425,000	$527,500

Device Type	Centrifuge	Screw Press	Rotary (fan) Press	Volute Press
Manufacturer	ANDRITZ or Alfa Laval	FKC	Fournier	PWTech
Cake solids concentration	25	15–20	15–20	25
Active polymer dose (pound active/ dry ton based on pilot test results)	16–20	20–25	35	23–27
Wash water requirements	35–70 gpm @ 40–60 psi for shift cleaning	Up to 140 gpm at 50 psi Three locations 15 to 60 second bursts 10 to 30 minute cycles	60 psi 5 minutes per 24-hour cycle	15 gpm at 20 psi for 15 to 20 seconds, 3 to 8 times per hour for housekeeping wash.
Weight	13,889 pounds	21,495 pounds (25,904 pounds operating)	13,649 pounds (16,675 pounds operating)	7,480 pounds (11,550 pounds operating)

Notes:
gallons per minute (gpm)
rotations per minute (rpm)
pounds per square inch (psi)

CAKE SOLIDS PERFORMANCE

As shown in Table 4.2.5, the centrifuge and volute press are capable of producing higher cake solids of approximately 25 percent, with the screw press and rotary fan press in the same order of magnitude at approximately 20 percent solids. A criterion during pilot testing of the dewatering technologies will be to confirm that dewatering performance meets the landfills or MRFs requirements for no free liquid remaining in the cake solids.

FEED PUMPING REQUIREMENTS

The existing feed pumps are approximately 15 years old and replacement is recommended as part of a solids dewatering upgrade project. The centrifuge, FKC screw press and volute press do not require backpressure to operate, while the rotary press requires up to 10 pounds per square inch (psi). Backpressure may require larger feed pumps and will use more energy.

POWER REQUIREMENTS

The centrifuge has the highest total power requirement at a combined 125 HP (100 + 25), as well as requiring more sophisticated electronics and larger panels. The existing power supply in the centrifuge room would not require significant upgrades for new centrifuges. However, modifications would be required to the existing motor control centers (MCCs) to add additional centrifuges or to adjust for the lower power requirements of the other devices.

POLYMER REQUIREMENTS

Polymer requirements can vary widely between sludges and dewatering devices. The best information available for this study is the results of pilot testing from other solids facilities for the devices under consideration. Table 4.2.5 presents the polymer requirements from pilot testing at other facilities. The centrifuge and screw press have the lowest polymer requirements, with the rotary fan press having the higher requirements.

WASH WATER REQUIREMENTS

The FKC screw press requires the most instantaneous wash water, while the PWTech volute press requires the lowest amount of wash water.

4.2.4.2 Location of New Dewatering System

The existing centrifuge room houses two existing centrifuges and has space for one more identically sized centrifuge for future dewatering use. Conceptually, up to three screw presses, up to six, six-channel rotary presses, or three volute presses would fit within the footprint of the existing centrifuge room. However, the cost to retrofit the existing building to accommodate the dewatering devices, removing and replacing the roof system for equipment installation, architectural improvements, and temporary solids dewatering during construction would be nearly as expensive as constructing a new building. Therefore, a new building is recommended for solids dewatering facilities. The following is assumed to be provided with the new building:

- A two-story building with dewatering equipment on the upper floor.
- Approximately 2,000 square feed of space on each floor.
- A bridge crane for removal of internal parts for maintenance.
- Three separate rooms on the upper floor:
    - Electric/MCC equipment.
    - Control room.
    - HVAC or storage.
- An internal stairway to connect the floors.
- Liquid polymer feed and storage system located on the first floor.
- Shaftless screw conveyors to transfer cake from the dewatering devices to the storage hopper and truck load out area.

4.2.5 New Cake Load Out

A new cake truck load out system is recommended that would allow the City of Rapid City to better manage dewatered cake from the dewatering device to the point it leaves the site on trucks.

Desired features in a cake load out system are:

- Ability to load roll–off containers evenly, unattended, and in a relatively short amount of time.
- Ability to positively determine the roll-off container weight or alternatively the weight transferred to the roll–off container from the dewatered cake storage bin; this can be accomplished by load cells in the hoppers.
- Ability to use enclosures to control odors, to enhance aesthetic features, protect electrical control equipment, and provide a more palatable work environment.

There are several commercially available load out systems that could satisfy these goals. Typically, sliding frames or live bottom load out systems are employed to evenly spread cake solids across a particular shape. For the roll–off containers employed by the City of Rapid City, a rectangular discharge area is required.

Figure 4.2.10 shows a rectangular sliding frame. As can be seen, sliding frames typically require more space on the side (perpendicular to truck length) than other types of positive control load outs.

Figure 4.2.11 shows a typical bottom portion of a screw conveyor-type live bottom system. This type of system uses multiple screw conveyors to cover the bottom opening of the storage hopper and distribute the material throughout the length of the screws. The figure does not show opening gates below and the hopper above.

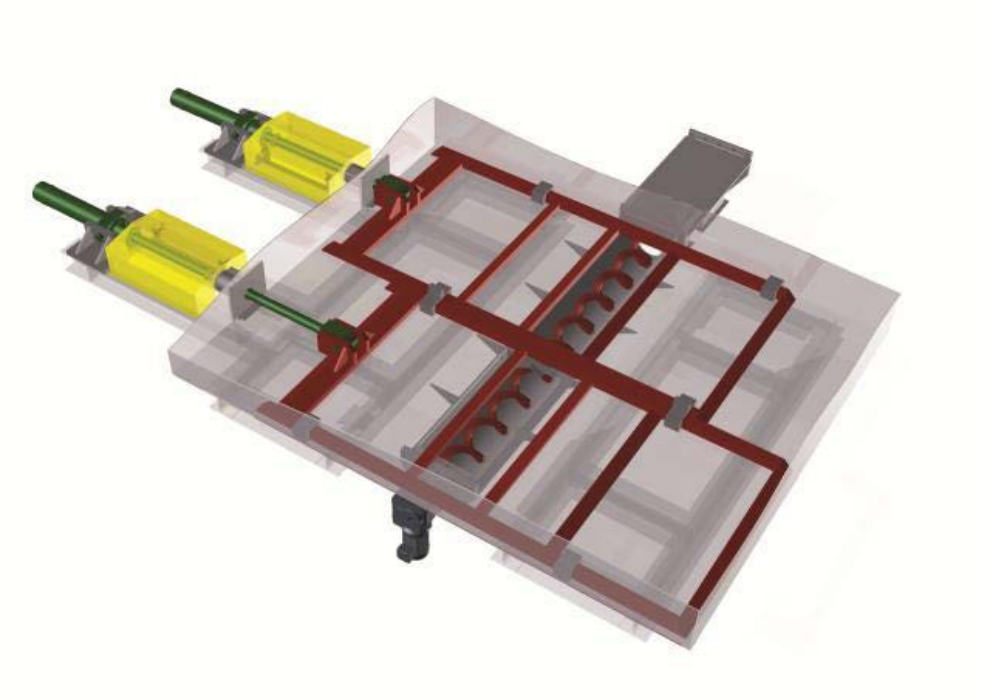


Figure 4.2.10. Rectangular Sliding Frame for Solids Removal and Distribution (courtesy of Asdor)

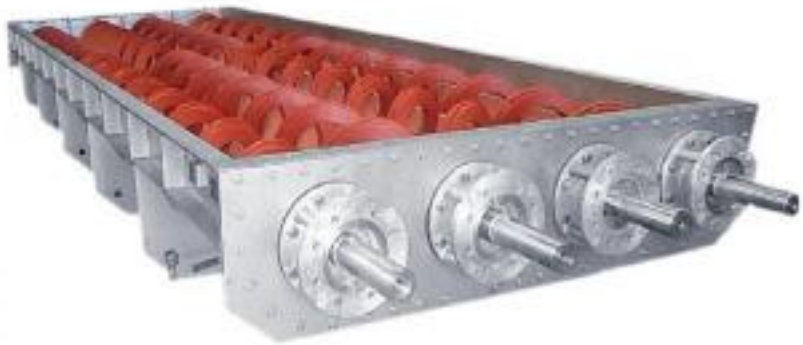


Figure 4.2.11. Live Bottom Screw Assembly (courtesy of Asdor)

4.2.6 Liquid Sludge Storage

WAS and anaerobically digested primary sludge are pumped to a lined earthen holding basin for temporary storage prior to dewatering or thickening in the solids handling building. The sludge holding basin is divided into two cells. Assuming 1 foot of freeboard, the west cell has a total volume of approximately 740,000 gallons and the east cell has a total volume of approximately 53,000 gallons. Based on the bottom slope of the west cell, it is assumed the low sludge level is 4 feet and the total useable volume is 661,800 gallons. Assuming a low sludge level of 2 feet in the east basin, the useable volume is approximately 45,700 gallons. The total useable volume between the west and east cells is 707,500 gallons. At the current average annual sludge volume to the holding cells of 52,900 gallons per day, the existing holding cell has approximately 13.4 days of storage. At the current maximum month sludge volume to the holding cells of 70,000 gallons per day, the existing holding cell has approximately 10 days.

Because the dewatering equipment have been sized based on maximum week sludge volume, a minimum of 15 days of liquid storage at maximum month sludge volume is recommended for emergency shut downs and maintenance of the dewatering equipment. At a projected maximum month flow of 141,280 gallons per day the recommended storage volume would be 2.12 million gallons. With 707,500 gallons of existing sludge storage, 1.5 million gallons of additional sludge storage would be needed. 1.2 million gallons of additional storage would be needed by 2020 and the remaining 300,000 gallons of additional storage needed by 2025. Two lined earthen basins similar in size to the existing basin would provide the total additional storage requirements.

The existing trickling filter structures, rotating biological contactors (RBC) basins and rectangular final clarifiers have also been considered as alternatives for providing additional sludge storage once they are abandoned. Table 4.2.6 shows the estimated sludge storage volume available for each of the existing structures.

Table 4.2.6. Estimate of Available Sludge Storage Volume for Existing Structures

Existing Structure	Total Depth (Feet)	Operating Depth (Feet)	Storage Area (Square Feet)	Approximate Storage Volume, (Million Gallons)
Trickling filter 1	10	6	31,416	1.41
Trickling filter 2	10	6	31,416	1.41
RBC basins	7.17	3.67	18,037	0.495
Tertiary clarifiers	9.5	5.67	22,490	0.95

4.2.7 Alternatives Analysis

The following alternatives were evaluated for the solids handling facilities:

- Alternative 1A: Two Centrifuges/One Operating and One Standby
- Alternative 1B: Three Centrifuges/Two Operating and One Standby
- Alternative 2A: Two Screw Presses/One Operating and One Standby
- Alternative 2B: Three Screw Presses/Two Operating and One Standby
- Alternative 3A: Four Rotary Fan Presses/Three Operating and One Standby
- Alternative 3B: Six Rotary Fan Presses/Five Operating and One Standby
- Alternative 4A: Two Volute Presses/One Operating and One Standby
- Alternative 4B: Three Volute Presses/Two Operating and One Standby

Layouts are conceptual only and are not intended to be construction drawings or final design. They were developed to include major dewatering equipment. There was no piping, no access platforms, nor other structural elements such as monorails or electrical equipment included in the layouts.

4.2.7.1 Alternative 1A: Two Centrifuges/One Operating and One Standby

The layout of Alternative 1A with two new centrifuges located in a new solids dewatering building is shown in Figure 4.2.12. The capacity of each centrifuge with a feed sludge of 1.6 percent and cake solids of 25 percent would be 200 gpm. With a projected future maximum week sludge volume of 988,960 gallons, one centrifuge would need to be operated 12 hours per day for 6.8 days per week, for a total of 82 hours per week to process the sludge.

4.2.7.2 Alternative 1B: Three Centrifuges/Two Operating and One Standby

A conceptual layout of Alternative 1B, which includes three centrifuges in a new solids dewatering building, is shown in Figure 4.2.13. As with Alternative 1A, the capacity of each centrifuge with a feed sludge of 1.6 percent and cake solids of 25 percent would be 200 gpm. With two centrifuges operating together, the combined capacity would be 400 gpm. With a projected future maximum week sludge volume of 988,960 gallons per week, two centrifuges would need to be operated 12 hours per day for 3.4 days per week to process the sludge.

4.2.7.3 Alternative 2A: Two Screw Presses/One Operating and One Standby

A conceptual layout of Alternative 2A in a new solids dewatering building is shown in Figure 4.2.14. The layout is based on FKC screw presses. The capacity of each screw press with a feed sludge of 1.6 percent and cake solids of 20 percent would be 125 gpm. For this alternative, it was assumed that operation would be for 24 hours per day. At the projected future maximum week sludge volume of 988,960 gallons, one screw press would need to be operated 24 hours per day for 5.5 days per week for a total of 132 hours per week to process the sludge. Because the units will run 24 hours per day, cake storage is required during the period when staff is not available to move and change out roll-off containers. Assuming dewatering operations are monitored 8 hours per day, storage would be required for 16 hours per day. At a dewatered cake discharge rate of 2.9 cubic yards per hour, 46 cubic yards per day would need to be stored. With dewatering operations running 5.5 days per week, the total recommended minimum storage is 256 cubic yards. A building with dimensions of approximately 40 feet by 50 feet, located near the dewatering building is assumed for dewatered sludge storage. A conveyor to transport dewatered sludge from the new solids dewatering building to the sludge storage building is included in this alternative.

4.2.7.4 Alternative 2B: Three Screw Presses/Two Operating and One Standby

A conceptual layout of Alternative 2B in a new solids dewatering building is shown in Figure 4.2.15. As with Alternative 2A, the capacity of each screw press with a feed sludge of 1.6 percent and cake solids of 25 percent would be 125 gpm. With two screw presses operating together the combined capacity would be 250 gpm. With this alternative, the screw presses could be operated 12 to 24 hours per day. With a projected future maximum week sludge volume of 988,960 gallons, two screw presses operated 24 hours per day would need to be run 2.7 days per week for a total of 66 hours per week to process the sludge. If operated 12 hours per day, the units would need to run 5.5 days per week. Dewatered sludge storage would be required for this alternative. The total recommended minimum storage is 255 cubic yards. A building with dimensions of approximately 40 feet by 50 feet, located near the dewatering building is assumed for dewatered sludge storage. A conveyor to transport dewatered sludge from the new solids dewatering building to the sludge storage building is included in this alternative.

4.2.7.5 Alternative 3A: Four Rotary Fan Presses/Three Operating and One Standby

A conceptual layout for this alternative in a new solids dewatering building is shown in Figure 4.2.16. The capacity of each six-channel rotary fan press with a feed sludge of 1.6 percent and cake solids of 20 percent would be 67 gpm. The ability to run the fan presses 24 hours per day is also assumed for this alternative. With a projected future maximum week sludge volume of 988,960 gallons, three rotary fan presses would need to be operated 24 hours per day for 3.4 days per week, for a total of 82 hours per week to process the sludge. Because the units will run 24 hours per day, cake storage is required during the period when staff is not available to move and change out roll-off containers. The total recommended minimum storage is 255 cubic yards. A building with dimensions of approximately 40 feet by 50 feet, located near the dewatering building is assumed for dewatered sludge storage. A conveyor to transport dewatered sludge from the new solids dewatering building to the sludge storage building is included in this alternative.

4.2.7.6 Alternative 3B: Six Rotary Fan Presses/Five Operating and One Standby

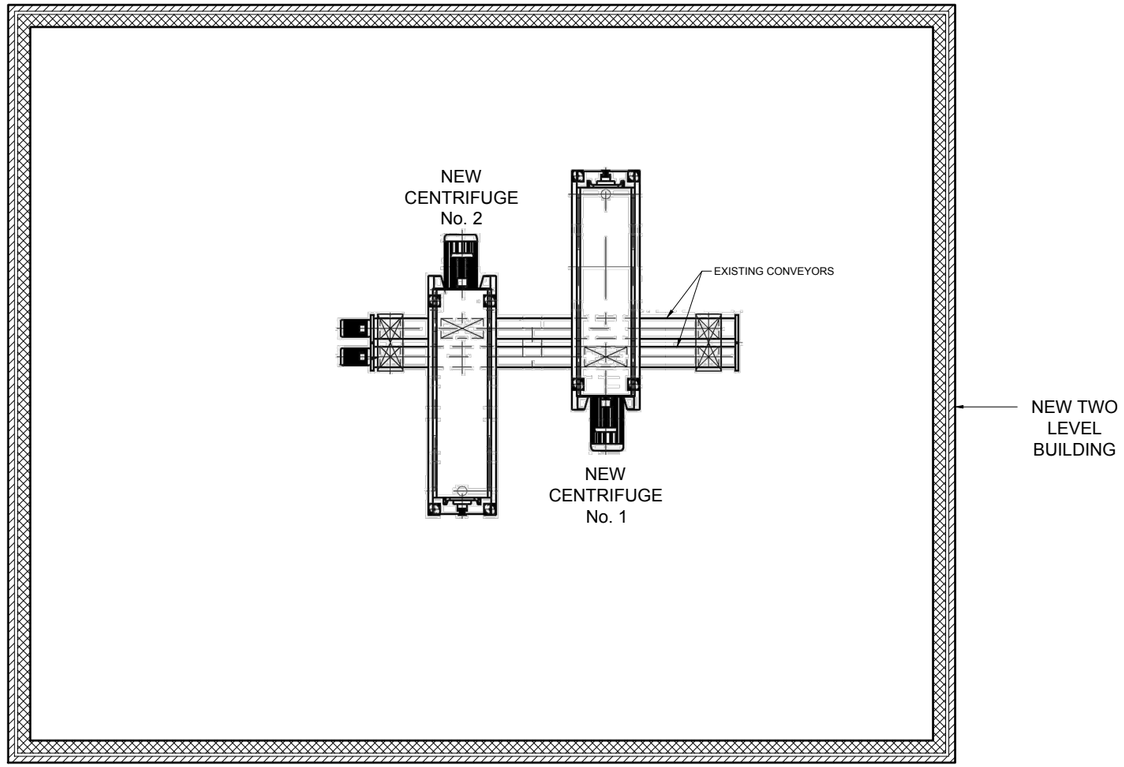
A conceptual layout of this alternative in a new solids dewatering building is shown in Figure 4.2.17. As with Alternative 3A, the capacity of each six-channel rotary fan press with a feed sludge of 1.6 percent and cake solids of 25 percent would be 67 gpm. With five rotary fan presses operating together, the combined capacity would be 335 gpm. With this alternative, it is assumed the fan presses could be operated 12 to 24 hours per day. With a projected future maximum week sludge volume of 988,960 gallons, five fan presses would need to be operated 24 hours per day for 2.1 days per week, for a total of 49 hours per week to process the sludge. If operated 12 hours per day, the units would need to run 4.1 days per week. For this alternative, dewatered sludge storage would be needed. The total recommended minimum storage is 255 cubic yards. A building with dimensions of approximately 40 feet by 50 feet, located near the dewatering building is assumed for dewatered sludge storage. A conveyor to transport dewatered sludge from the new solids dewatering building to the sludge storage building is included in this alternative.

4.2.7.7 Alternative 4A: Two Volute Presses/One Operating and One Standby

A conceptual layout for this alternative in a new solids dewatering building is shown in Figure 4.2.18. The capacity of each volute press with a feed sludge of 1.6 percent and cake solids of 20 percent would be 200 gpm. The ability to run the volute presses 24 hours per day is assumed for this alternative. With a projected future maximum week sludge volume of 988,960 gallons, one volute press would need to be operated 24 hours per day for 3.4 days per week, for a total of 82 hours per week to process the sludge. Because the units will run 24 hours per day, cake storage is required during the period when staff is not available to move and change out roll-off containers. The total recommended minimum storage is 255 cubic yards. A building with dimensions of approximately 40 feet by 50 feet, located near the dewatering building is assumed for dewatered sludge storage. A conveyor to transport dewatered sludge from the new solids dewatering building to the sludge storage building is included in this alternative.

4.2.7.8 Alternative 4B: Three Volute Presses/Two Operating and One Standby

A conceptual layout of this alternative in a new solids dewatering building is shown in Figure 4.2.19. As with Alternative 4A, the capacity of each volute press with a feed sludge of 1.6 percent and cake solids of 25 percent would be 200 gpm. With two volute presses operating together, the combined capacity would be 400 gpm. With this alternative, it is assumed the volute presses would be operated 12 to 24 hours per day. With a projected future maximum week sludge volume of 988,960 gallons per week, two volute presses would need to be operated 24 hours per day for 1.7 days per week, for a total of 41 hours per week to process the sludge. If operated 12 hours per day, the units would need to run 3.4 days per week. Because the units could run 24 hours per day, cake storage is required during the period when staff is not available to move and change out roll-off containers. The total recommended minimum storage is 255 cubic yards. A building with dimensions of approximately 40 feet by 50 feet, located near the dewatering building is assumed for dewatered sludge storage. A conveyor to transport dewatered sludge from the new solids dewatering building to the sludge storage building is included in this alternative.



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STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

PRELIMINARY
NOT FOR CONSTRUCTION

WATER RECLAMATION FACILITY
FACILITY PLAN

RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 1A
TWO CENTRIFUGES
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 12 AND 13.DWG
SCALE 1/4" = 1'-0"

FIGURE
4.2.12

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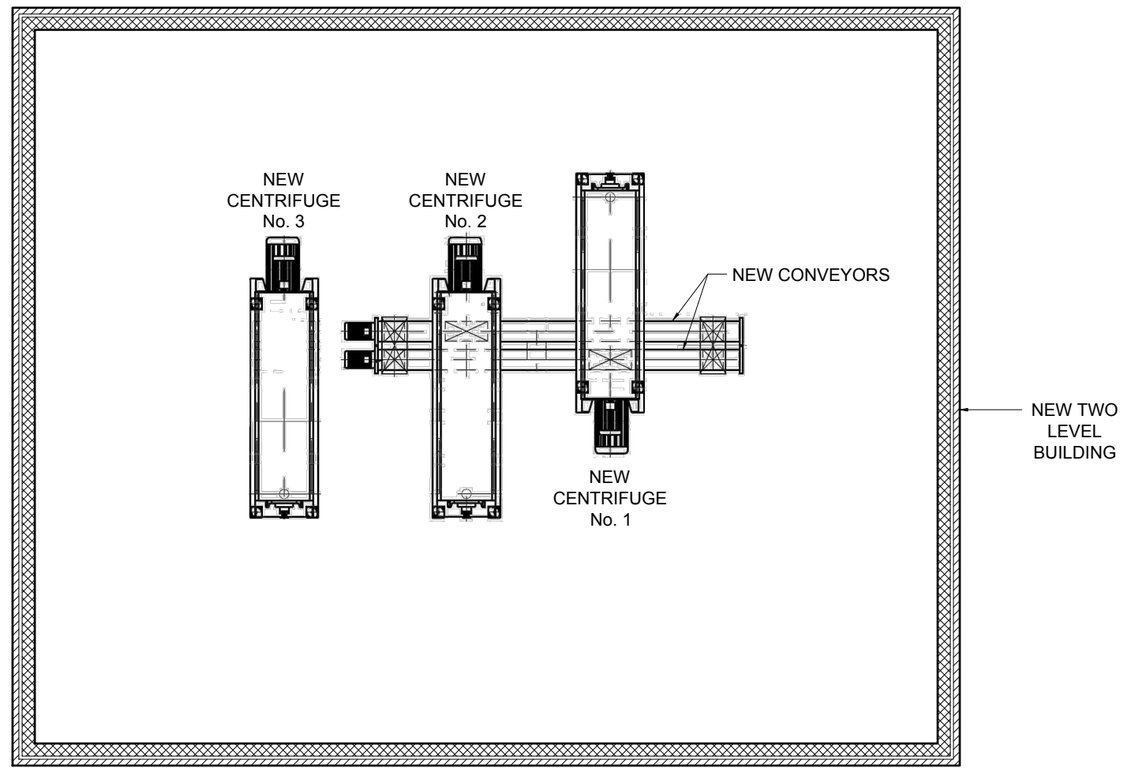

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ELECTRICAL	-
PROJECT NUMBER	255661

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WATER RECLAMATION FACILITY
FACILITY PLAN

RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 1B
THREE CENTRFUGES
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 12 AND 13.DWG
SCALE 1/4" = 1'-0"

FIGURE
4.2.13

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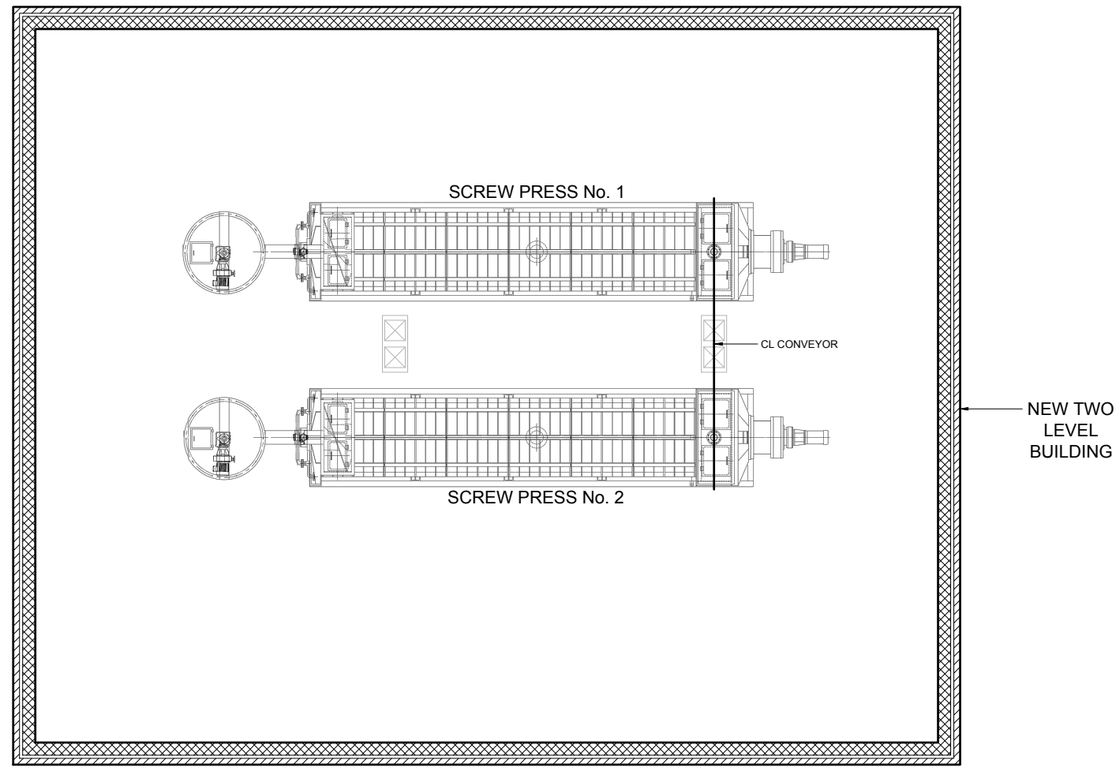

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WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 2A
TWO SCREW PRESSES
DEWATERING ONLY
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 14 AND 15.DWG
SCALE 1/4" = 1'-0"

FIGURE 4.2.14

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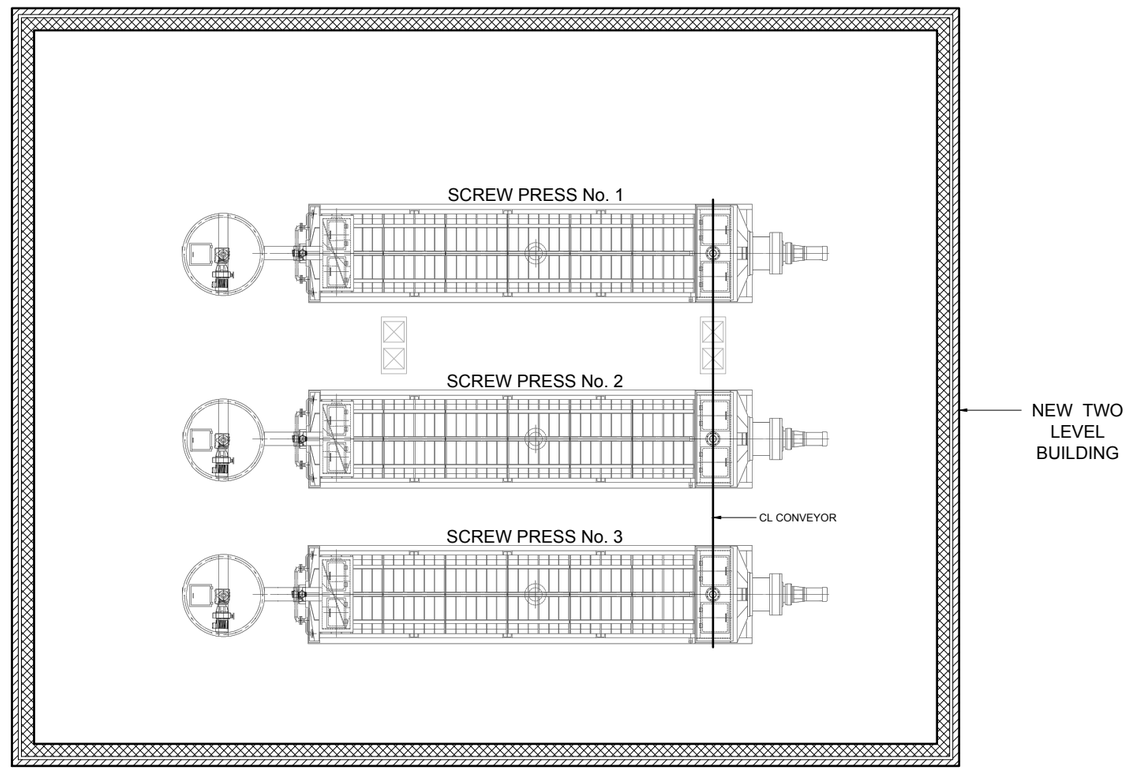

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STRUCTURAL	-
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MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

PRELIMINARY
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WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

RAPID CITY INCORPORATED 1882 SOUTH DAKOTA
2015

ALTERNATIVE 2B
THREE SCREW PRESS
DEWATERING ONLY
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 14 AND 15.DWG
SCALE 1/4" = 1'-0"

FIGURE 4.2.15

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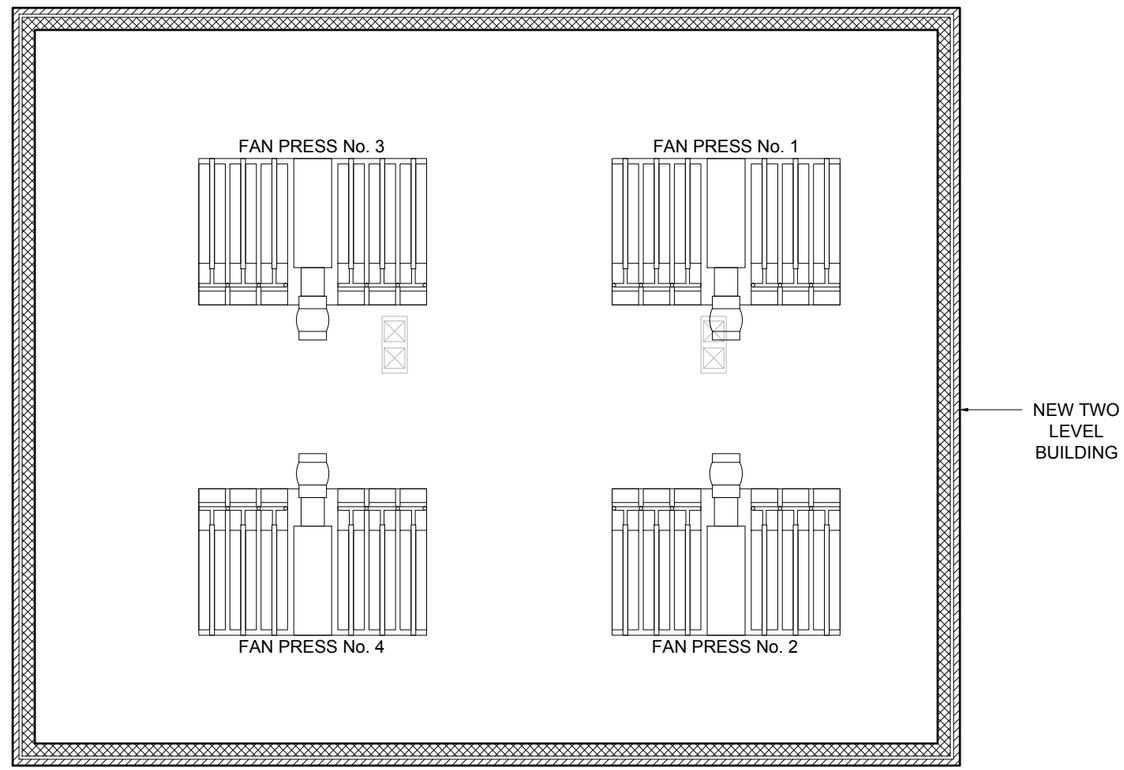

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WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 3A
FOUR FAN PRESSES
DEWATERING ONLY
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 16 AND 17.DWG
SCALE 1/4" = 1'-0"

FIGURE 4.2.16

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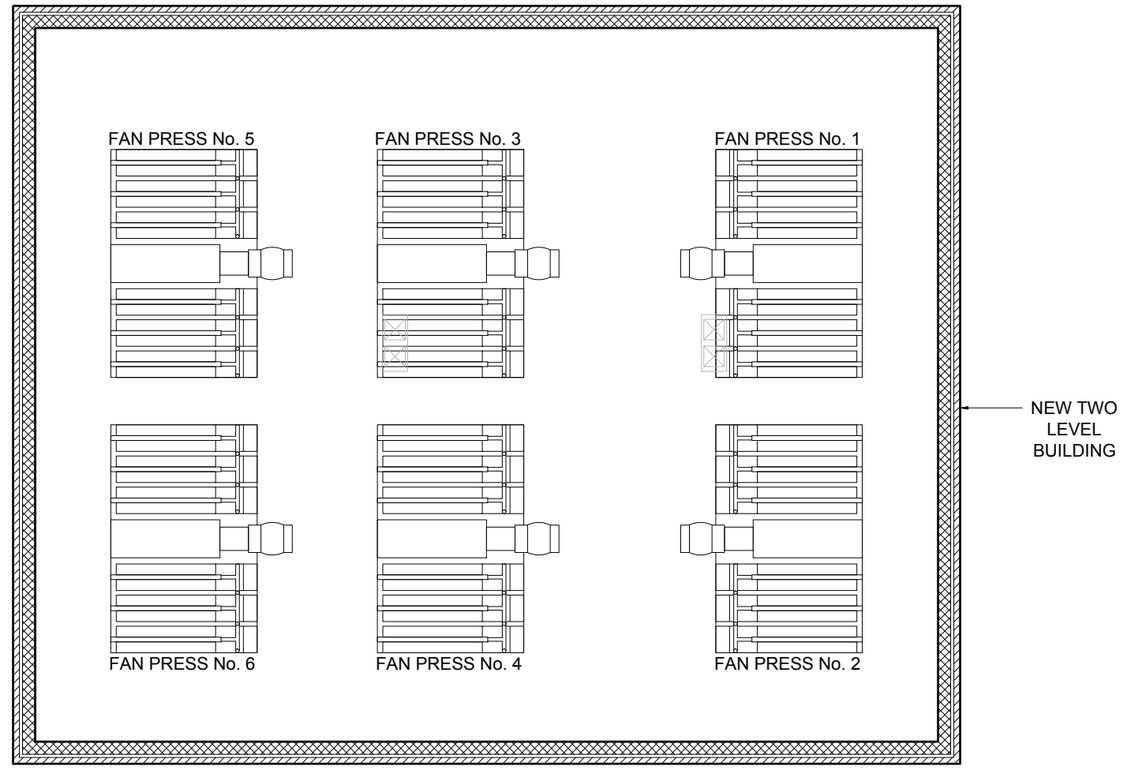

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ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

PRELIMINARY
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WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 3B
SIX FAN PRESSES
DEWATERING ONLY
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 16 AND 17.DWG
SCALE 1/4" = 1'-0"

FIGURE 4.2.17

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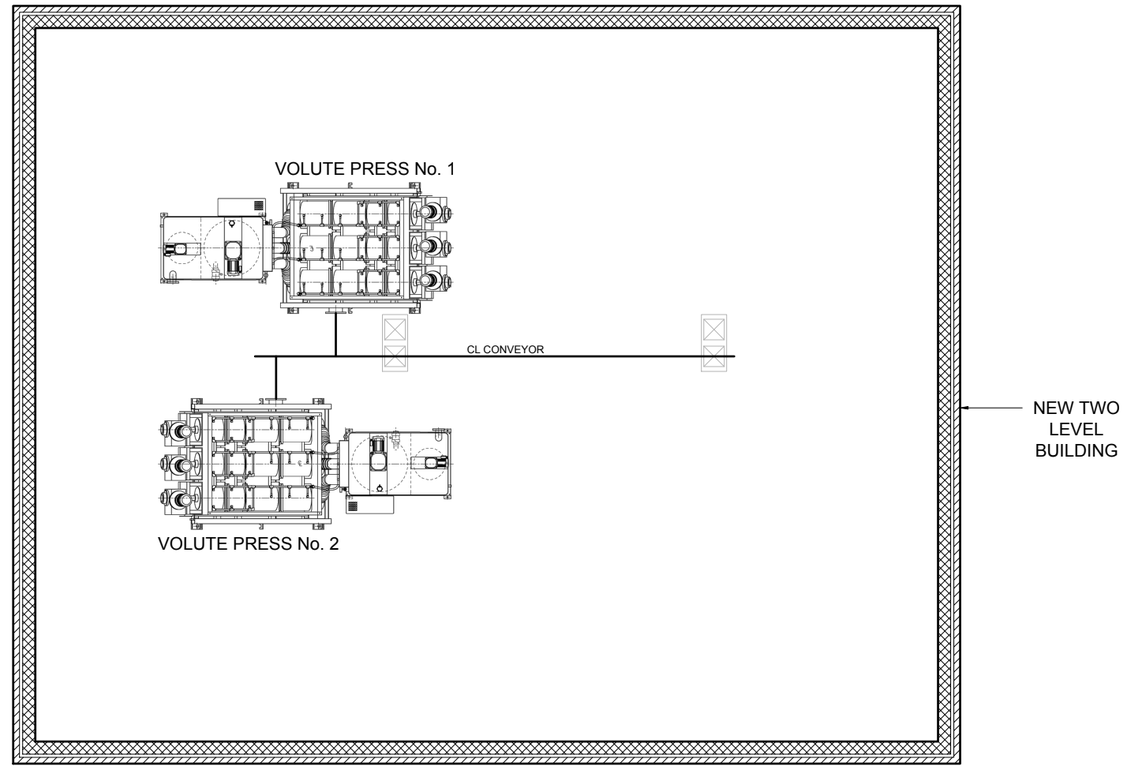

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FIRE PROTECTION	-
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PROJECT NUMBER	255661

PRELIMINARY
NOT FOR CONSTRUCTION

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 4A
TWO VOLUTE PRESSES
DEWATERING ONLY
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 18 AND 19.DWG
SCALE 1/4" = 1'-0"

FIGURE 4.2.18

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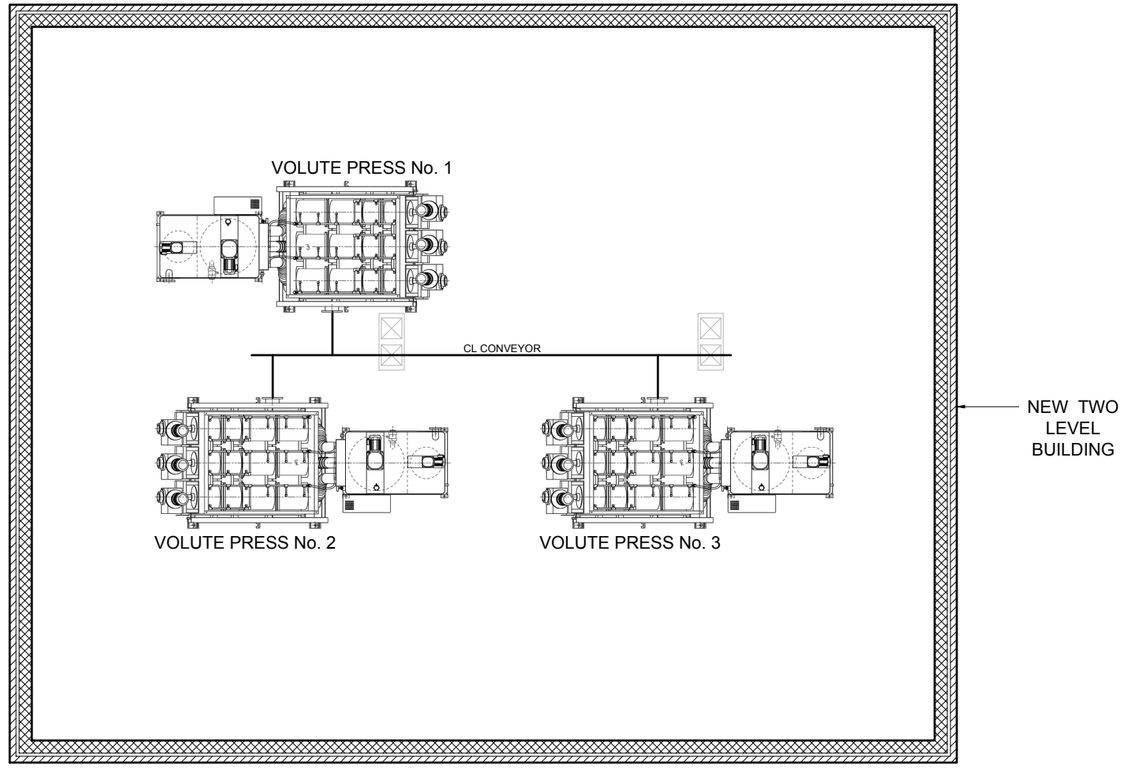

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

ISSUE	DATE	DESCRIPTION
-	-	-

PRELIMINARY
NOT FOR CONSTRUCTION

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

ALTERNATIVE 4B
THREE VOLUTE PRESSES
DEWATERING ONLY
CONCEPTUAL EQUIPMENT LAYOUT

0 1" 2"

FILENAME FIGURE 18 AND 19.DWG
SCALE 1/4" = 1'-0"

FIGURE 4.2.19

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4.2.8 Cost Estimates

Construction, project, annual operations and maintenance (O&M), and life cycle cost estimates were developed for comparison of final alternatives.

4.2.8.1 Cost Estimate Assumptions and Methodology

Opinions of probable construction costs (OPCC) were developed by HDR. Annual O&M costs were estimated based on the following assumptions:

- Average annual sludge volume – 108,390 gallons per day (758,730 gallons per week). Average annual sludge volume is used for O&M cost analysis, whereas maximum month was used in sizing the solids dewatering equipment.
- City hauling and biosolids management – $12.64 per wet ton solids
- Centrifuge and volute press cake solids – 25 percent
- Screw press and rotary fan press cake solids – 20 percent
- O&M labor – $45.00 per hour
- Administration labor – $50 per hour
- Polymer – $2.27 per pound active
- Polymer dose, all alternatives – 23 pounds active per dry ton solids
- Unit power rate – $0.084 per kilowatt per hour

4.2.8.2 Construction Costs

Construction cost estimates were developed for the dewatering alternatives and are presented in Table 4.2.7. The costs are broken out by existing building modifications, dewatering equipment, conveyance, electrical and instrumentation, liquid sludge storage upgrades, dry cake storage, conveyance and truck load out improvements, and equipment replacement and upgrades.

Costs were estimated based on conceptual layouts and not for design. Also included in the cost estimates are the following:

- New two-level solids dewatering building for housing the dewatering devices.
- New conveyors to transfer cake from the dewatering unit to the sludge load out area, plus additional conveyors as needed for additional dewatering unit. The assumption is that each dewatering unit will have a dedicated conveyor for transfer of cake to the sludge load out area.
- Sludge load out conveyor to even distribution of dewatered sludge in the roll-off containers.
- New liquid polymer feed and storage system, plus additional liquid polymer feed and storage system for additional dewatering units. The assumption is that each dewatering unit would have a dedicated polymer feed system.

- New dewatering unit feed pumps, plus additional feed pumps for additional dewatering units. The assumption is that each dewatering unit would have a dedicated sludge feed pump.
- 1.5 million gallons of additional liquid sludge storage are included assuming the construction of two new lined earthen basins with new mixing and aeration equipment.
- Electrical and instrumentation costs for new equipment are estimated as a percentage of other construction costs.
- Replacement of the existing mixing/aeration equipment in the west cell of the existing sludge storage basin.
- Automation of the controls for the centrate flow; addition of a centrate flow meter; and replacement of the ultrasonic level sensor in the centrate storage tank.
- Replacement of the sludge holding pond control panel.
- Replacement of the solids handling building standby generator and automatic transfer switch (ATS).
- Dry cake storage with conveyance is included with alternatives 2A, 2B, 3A, 3B, 4A, and 4B.

A 25 percent markup was applied to the direct construction costs for contingencies. A 5 percent markup was the applied to for general conditions and mobilization, a 5 percent markup was applied for sales taxes, a 15 percent markup was applied for overhead and profit, and a 2 percent markup was applied for bonds and insurance to arrive at the estimated subtotal construction cost. A 5 percent markup was applied to the subtotal construction cost to arrive at the total estimated construction costs. A 24 percent markup was then applied to the total estimated construction costs to account for the City of Rapid City's administrative, engineering, permitting, and other non-construction costs that would be associated with the project.

4.2.8.3 Annual Operations and Maintenance Costs

Table 4.2.8 and Figure 4.2.20 present the annual O&M cost estimates for the dewatering alternatives. O&M costs are for comparison of the dewatering alternatives and only include the dewatering units, sludge feed pumps, polymer feed systems, and the dry cake conveyors. The O&M costs do not include mixing and aeration in the liquid sludge storage ponds. Centrifuge alternatives have lower hauling and management costs due to higher cake solids concentrations, but have higher labor and maintenance materials costs due to the need to continuous monitoring during operation and the need for frequent overhauls. The rotary fan press alternatives have low labor cost, but high maintenance materials and replacement costs due to the number of units that need to operate to process the sludge. Overall, the screw press and volute press alternatives have the lowest annual O&M costs.

4.2.8.4 Life Cycle Costs

Life cycle costs, which add the project cost and present value of O&M cost, provides the best overall economic comparison of alternatives. For this analysis, a 20-year period at a discount rate of 3.3 percent was assumed. Table 4.2.8 and Figure 4.2.21 present the estimated life cycle costs in tabular and graphic form. Figure 4.2.22 presents the estimated equivalent annual costs in graphic form.

4.2.8.5 Summary of Design Basis and Costs

Table 4.2.9 shows a summary of the design basis, operating parameters, and comparative cost evaluation for each alternative.

Table 4.2.7. Opinion of Probable Total Construction Costs and Total Project Costs

Description	Alt 1A: Two Centrifuges-Dewater Only	Alt 1B: Three Centrifuges-Dewater Only	Alt 2A: Two Screw Presses-Dewater Only	Alt 2B: Three Screw Presses-Dewater Only	Alt 3A: Four Fan Presses-Dewater Only	Alt 3B: Six Fan Presses-Dewater Only	Alt 4A: Two Volute Presses-Dewater Only	Alt 4B: Three Volute Presses-Dewater Only
New Solids Dewatering Building	$1,507,716	$1,420,216	$1,507,716	$1,595,216	$1,682,716	$1,682,716	$1,507,716	$1,595,216
Dewatering Equipment	$1,470,200	$1,958,600	$672,000	$1,181,600	$2,562,000	$3,934,000	$1,477,000	$2,389,100
Conveyance and Sludge Load out Equipment	$744,002	$811,503	$884,002	$951,503	$875,000	$1,001,000	$884,002	$951,503
Electrical and Instrumentation	$880,496	$1,003,526	$777,536	$885,634	$1,120,336	$1,449,448	$926,656	$1,102,984
Liquid Sludge Storage Upgrades	$712,002	$712,002	$712,002	$712,002	$712,002	$712,002	$712,002	$712,002
Dry Cake Storage	$0	$0	$267,000	$267,000	$267,000	$267,000	$267,000	$267,000
Equipment Replacement/Upgrades	$710,444	$875,644	$875,644	$875,644	$875,644	$1,206,044	$875,644	$875,644
Contingency (25%)	$1,506,214	$1,695,372	$1,423,974	$1,617,149	$2,023,674	$2,563,052	$1,662,504	$1,973,362
Const. Subtotal w/Cont.	$7,540,000	$8,480,000	$7,120,000	$8,090,000	$10,120,000	$12,820,000	$8,320,000	$9,870,000
General Conditions, Mobilization (5%)	$380,000	$420,000	$360,000	$400,000	$510,000	$640,000	$420,000	$490,000
Sales Tax Allowance (5%)	$400,000	$450,000	$370,000	$420,000	$530,000	$670,000	$440,000	$520,000
Overhead and Profit (15%)	$1,250,000	$1,400,000	$1,180,000	$1,340,000	$1,670,000	$2,120,000	$1,380,000	$1,630,000
Bonds and Insurance (2%)	$190,000	$220,000	$180,000	$210,000	$260,000	$320,000	$210,000	$250,000
Construction Subtotal	$9,760,000	$10,970,000	$9,210,000	$10,460,000	$13,090,000	$16,570,000	$10,770,000	$12,760,000
Construction Contingency (5%)	$490,000	$550,000	$460,000	$520,000	$520,000	$830,000	$540,000	$640,000
Total Construction Cost	$10,250,000	$11,520,000	$9,670,000	$10,980,000	$13,610,000	$17,400,000	$11,310,000	$13,400,000
Project Cost								
Total Construction Cost	$10,250,000	$11,520,000	$9,670,000	$10,980,000	$13,610,000	$17,400,000	$11,310,000	$13,400,000
Engineering, Admin, Legal, Permitting (24%)	$2,460,000	$2,760,000	$2,320,000	$2,640,000	$3,270,000	$4,180,000	$2,710,000	$3,220,000
Total Project Cost	$12,710,000	$14,280,000	$11,990,000	$13,620,000	$16,880,000	$21,580,000	$14,020,000	$16,600,000

Table 4.2.8. Opinion of Probable Operation and Maintenance Costs and Life Cycle Costs

Description	Alt 1A: Two Centrifuges-Dewater Only	Alt 1B: Three Centrifuges-Dewater Only	Alt 2A: Two Screw Presses-Dewater Only	Alt 2B: Three Screw Presses-Dewater Only	Alt 3A: Four Fan Presses-Dewater Only	Alt 3B: Six Fan Presses-Dewater Only	Alt 4A: Two Volute Presses-Dewater Only	Alt 4B: Three Volute Presses-Dewater Only
Annual O&M Cost								
Biosolids hauling and disposal	$138,100	$138,100	$172,600	$172,600	$172,600	$172,600	$172,600	$172,600
General Permit, Admin, Sampling/Analysis	$24,600	$24,600	$24,600	$24,600	$24,600	$24,600	$24,600	$24,600
Power	$37,000	$35,400	$17,900	$15,300	$45,100	$43,800	$12,800	$13,300
Labor	$148,000	$74,000	$78,900	$39,500	$49,100	$29,400	$49,300	$24,700
Polymer	$142,600	$142,600	$142,600	$142,600	$142,600	$142,600	$143,000	$143,000
Equipment Replacement	$116,600	$142,300	$99,000	$119,600	$166,200	$231,500	$127,700	$162,700
Maintenance Materials	$76,600	$86,900	$39,600	$47,800	$49,800	$69,400	$38,300	$48,800
Total Annual O&M Cost	$683,500	$643,900	$575,200	$562,000	$650,000	$713,900	$568,300	$589,700
Project Cost	$12,700,000	$14,280,000	$12,000,000	$13,620,000	$17,030,000	$21,560,000	$14,010,000	$16,600,000
Equivalent Annual of Project Cost	$877,491	$986,660	$829,126	$941,058	$1,176,668	$1,489,662	$968,004	$1,146,957
Annual O&M	$683,500	$643,900	$575,200	$562,000	$650,000	$713,900	$568,300	$589,700
Present Value of O&M	$9,892,000	$9,319,000	$8,325,000	$8,134,000	$9,408,000	$10,332,000	$8,225,000	$8,535,000
Life Cycle	$22,592,000	$23,599,000	$20,325,000	$21,754,000	$26,438,000	$31,892,000	$22,235,000	$25,135,000
Total Equivalent Annual Cost	$1,560,967	$1,630,545	$1,404,332	$1,503,067	$1,826,702	$2,203,540	$1,536,301	$1,736,673
Assumptions								
20	Life							
3.3%	Discount rate							

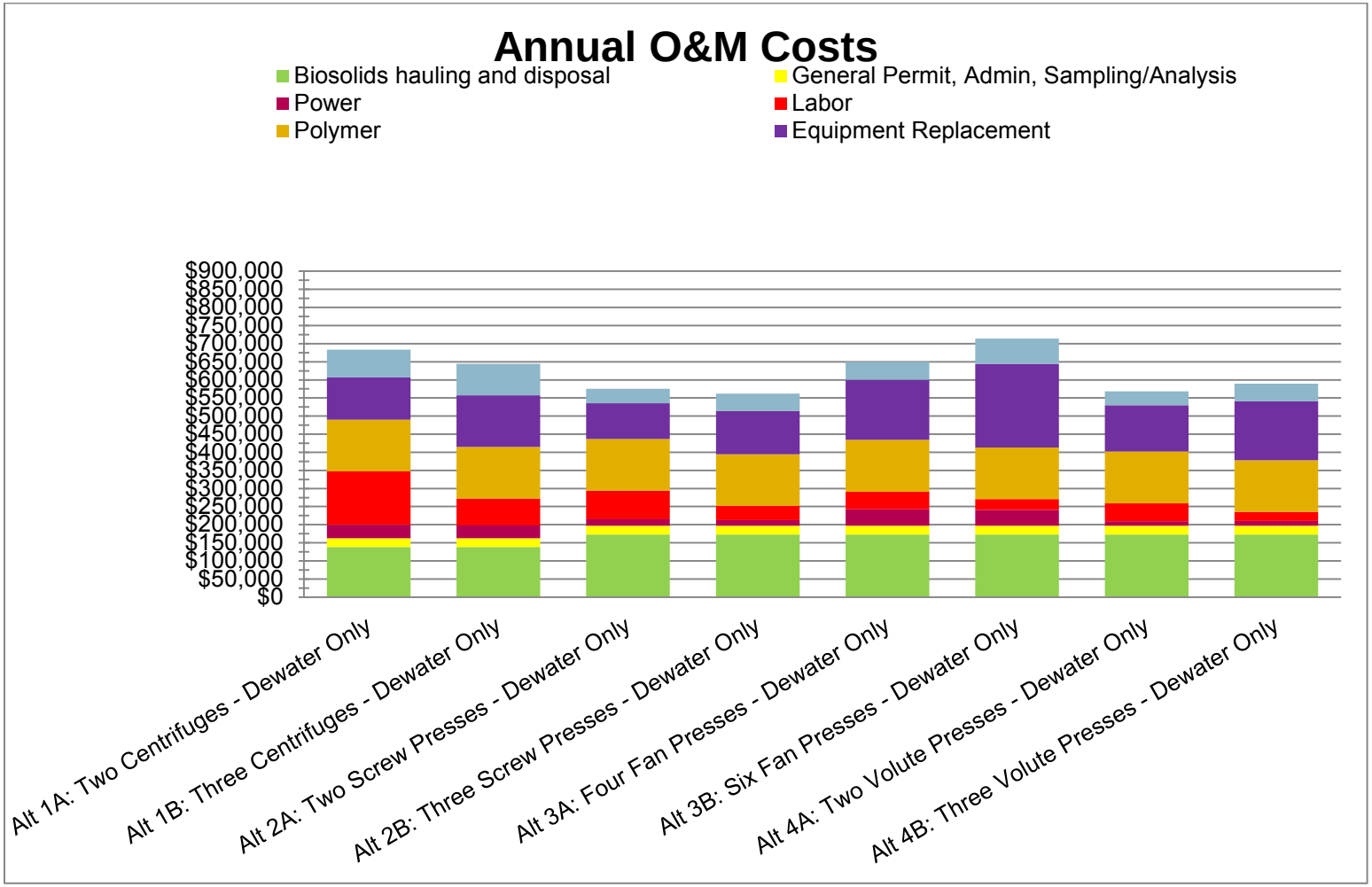


Figure 4.2.20. Annual O&M Cost Estimates by Category for Dewatering Alternatives

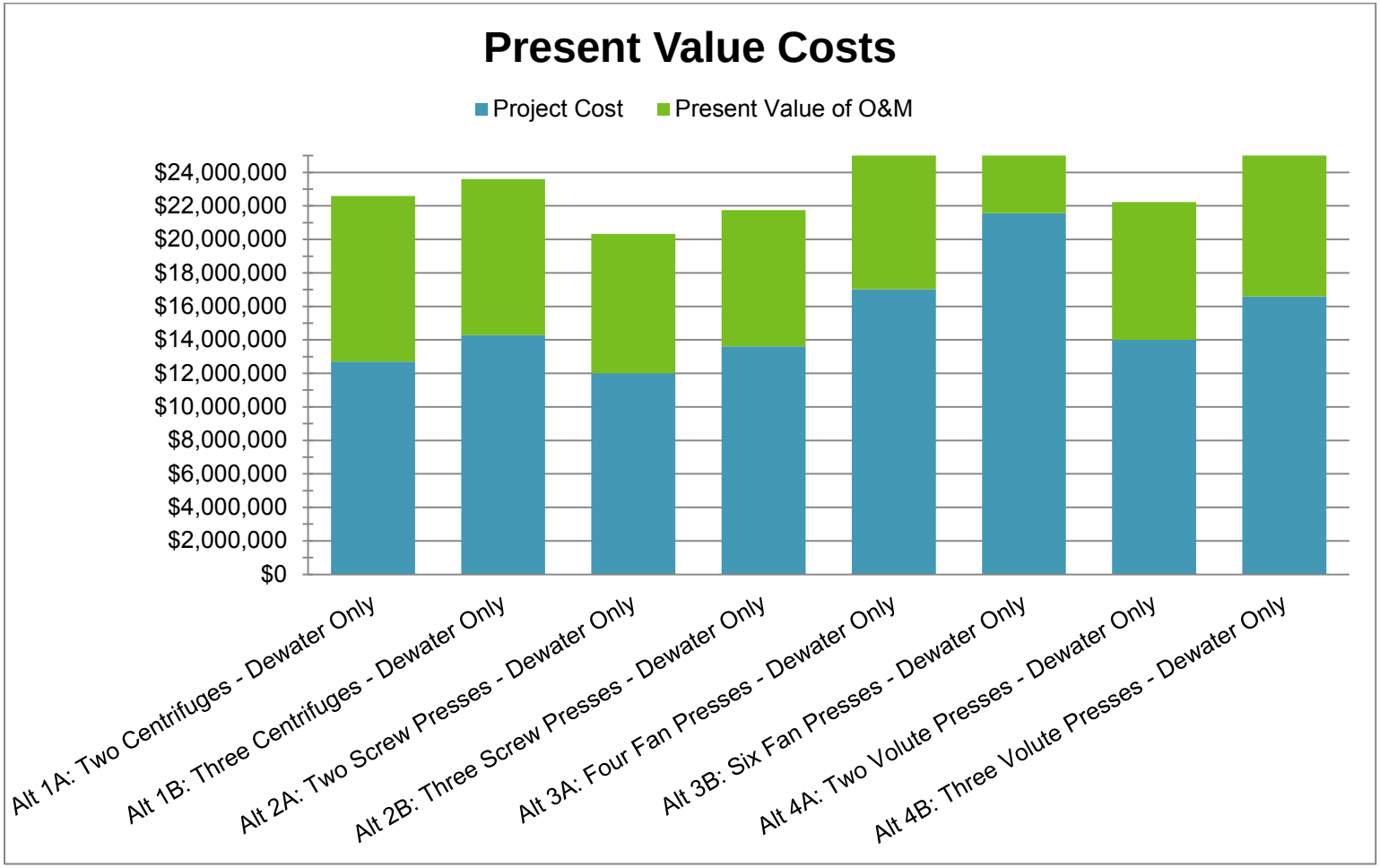


Figure 4.2.21. Present Value Life Cycle Cost Estimates for Dewatering Alternatives

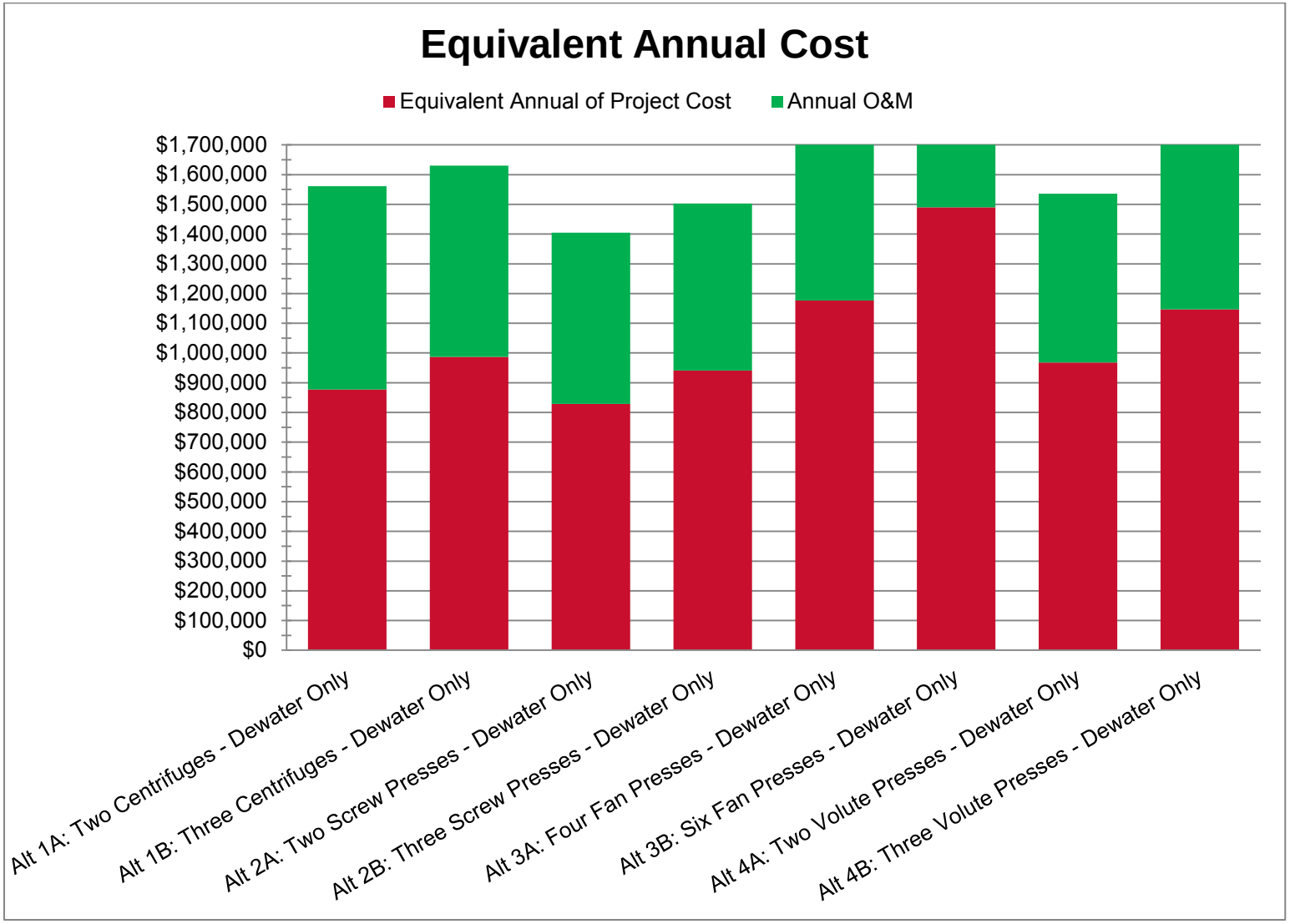


Figure 4.2.22. Equivalent Annual Life Cycle Cost Estimates for Dewatering Alternatives

Table 4.2.9. Solids Dewatering Design Basis and Comparative Cost Evaluation Summary

Number of Units	Alt 1A: Centrifuge Two Units/One Operating and One Standby		Alt 1B: Centrifuge Three Units/Two Operating and One Standby		Alt 2A: Screw Press Two Units/One Operating and One Standby		Alt 2B: Screw Press Three Units/Two Operating and One Standby		Alt 3A: Fan Press Four Units/Three Operating and One Standby		Alt 3B: Fan Press Six Units/Five Operating and One Standby		Alt 4A: Volute Press Two Units/One Operating and One Standby		Alt 4B: Volute Press Three Units/Two Operating and One Standby	
Estimated Current Conditions																
Current Sludge to Holding Pond (Max Month)	490,096	Gals/WK	490,096	Gals/WK	490,096	Gals/WK	490,096	Gals/WK	490,096	Gals/WK	490,096	Gals/WK	490,096	Gals/WK	490,096	Gals/WK
	33	DT/WK	33	DT/WK	33	DT/WK	33	DT/WK	33	DT/WK	33	DT/WK	33	DT/WK	33	DT/WK
Operating Flow/Unit	200	gpm	400	gpm	125	gpm	250	gpm	201	gpm	335	gpm	200	gpm	400	gpm
	3.33	gphr	6.67	gphr	2.08	gphr	4.17	gphr	3.35	gphr	5.58	gphr	3.33	gphr	6.67	gphr
Hours of Operation	41	Hrs/WK	20	Hrs/WK	65	Hrs/WK	33	Hrs/WK	41	Hrs/WK	24	Hrs/WK	41	Hrs/WK	20	Hrs/WK
	12	Hrs/Day	12	Hrs/Day	12	Hrs/Day	12	Hrs/Day	12	Hrs/Day	12	Hrs/Day	12	Hrs/Day	12	Hrs/Day
	3.4	Days/WK	1.7	Days/WK	5.4	Days/WK	2.7	Days/WK	3.4	Days/WK	2.0	Days/WK	3.4	Days/WK	1.7	Days/WK
Cake Solids Processing and Hauling	131	WT/WK @ 25% Solids	131	WT/WK @ 25% Solids	163	WT/WK @ 20% Solids	163	WT/WK @ 20% Solids	163	WT/WK @ 20% Solids	163	WT/WK @ 20% Solids	163	WT/WK @ 20% Solids	163	WT/WK @ 20% Solids
	144	CY/WK @ 25% Solids	144	CY/WK @ 25% Solids	181	CY/WK @ 20% Solids	181	CY/WK @ 20% Solids	181	CY/WK @ 20% Solids	181	CY/WK @ 20% Solids	181	CY/WK @ 20% Solids	181	CY/WK @ 20% Solids
	38	WT/Day @ 25% Solids	77	WT/Day @ 25% Solids	30	WT/Day @ 20% Solids	60	WT/Day @ 20% Solids	48	WT/Day @ 20% Solids	80	WT/Day @ 20% Solids	48	WT/Day @ 20% Solids	96	WT/Day @ 20% Solids
	3.2	WT/HR	6.4	WT/HR	2.5	WT/HR	5.0	WT/HR	4.0	WT/HR	6.7	WT/HR	4.0	WT/HR	8.0	WT/HR
	3.5	CY/HR	7.1	CY/HR	2.8	CY/HR	5.5	CY/HR	4.4	CY/HR	7.4	CY/HR	4.4	CY/HR	8.8	CY/HR
	1.9	Truck Loads/Day	3.8	Truck Loads/Day	1.5	Truck Loads/Day	3.0	Truck Loads/Day	2.4	Truck Loads/Day	4.0	Truck Loads/Day	2.4	Truck Loads/Day	4.8	Truck Loads/Day
	7.2	Truck Loads/WK	7	Truck Loads/WK	9	Truck Loads/WK	9	Truck Loads/WK	9	Truck Loads/WK	9	Truck Loads/WK	9.0	Truck Loads/WK	9.0	Truck Loads/WK
Projected Future (2035) Conditions for Equipment Sizing																
Future (2035) Sludge to Holding Pond (Max Month)	988,960	Gals/WK Design	988,960	Gals/WK Design	988,960	Gals/WK	988,960	Gals/WK	988,960	Gals/WK	988,960	Gals/WK	988,960	Gals/WK Design	988,960	Gals/WK Design
	68	DT/WK Design	68	DT/WK Design	68	DT/WK	68	DT/WK	68	DT/WK	68	DT/WK	68	DT/WK Design	68	DT/WK Design
Operating Flow/Unit	200	gpm	400	gpm	125	gpm	250	gpm	201	gpm	335	gpm	200	gpm	400	gpm
	3.33	gphr	6.67	gphr	2.08	gphr	4.17	gphr	3.35	gphr	5.58	gphr	3.33	gphr	6.67	gphr
Days and Hours of Operation	82	Hrs/WK	41	Hrs/WK	132	Hrs/WK	66	Hrs/WK	82	Hrs/WK	49	Hrs/WK	82	Hrs/WK	41	Hrs/WK
	12	Hrs/Day (Staffed 12 hrs/day)	12	Hrs/Day (Staffed 12 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)
	6.9	Days/WK	3.4	Days/WK	5.5	Days/WK	2.7	Days/WK	3.4	Days/WK	2.1	Days/WK	3.4	Days/WK	1.7	Days/WK
Cake Solids Processing and	274	WT/WK @ 25% Solids	274	WT/WK @ 25% Solids	342	WT/WK @ 20% Solids	342	WT/WK @ 20% Solids	342	WT/WK @ 20% Solids	342	WT/WK @ 20% Solids	342	WT/WK @ 20% Solids	342	WT/WK @ 20% Solids

Number of Units	Alt 1A: Centrifuge Two Units/One Operating and One Standby		Alt 1B: Centrifuge Three Units/Two Operating and One Standby		Alt 2A: Screw Press Two Units/One Operating and One Standby		Alt 2B: Screw Press Three Units/Two Operating and One Standby		Alt 3A: Fan Press Four Units/Three Operating and One Standby		Alt 3B: Fan Press Six Units/Five Operating and One Standby		Alt 4A: Volute Press Two Units/One Operating and One Standby		Alt 4B: Volute Press Three Units/Two Operating and One Standby	
Hauling	302	CY/WK @ 25% Solids	302	CY/WK @ 25% Solids	383	CY/WK @ 20% Solids	383	CY/WK @ 20% Solids	383	CY/WK @ 20% Solids	383	CY/WK @ 20% Solids	383	CY/WK @ 20% Solids	383	CY/WK @ 20% Solids
	40	WT/Day @ 25% Solids	80	WT/Day @ 25% Solids	62	WT/Day @ 20% Solids	125	WT/Day @ 20% Solids	100	WT/Day @ 20% Solids	167	WT/Day @ 20% Solids	100	WT/Day @ 20% Solids	199	WT/Day @ 20% Solids
	3.3	WT/HR	6.6	WT/HR	2.6	WT/HR	5.2	WT/HR	4.2	WT/HR	7.0	WT/HR	4.2	WT/HR	8.3	WT/HR
	3.7	CY/HR	7.3	CY/HR	2.9	CY/HR	5.8	CY/HR	4.7	CY/HR	7.8	CY/HR	4.7	CY/HR	9.3	CY/HR
	2.0	Truck Loads/Day	4.0	Truck Loads/Day	3.1	Truck Loads/Day	6.2	Truck Loads/Day	5.0	Truck Loads/Day	8.3	Truck Loads/Day	5.0	Truck Loads/Day	10.0	Truck Loads/Day
	15.1	Truck Loads/WK	15.1	Truck Loads/WK	19.2	Truck Loads/WK	19.2	Truck Loads/WK	19.2	Truck Loads/WK	19.2	Truck Loads/WK	19.2	Truck Loads/WK	19.2	Truck Loads/WK
Dewatered Sludge Storage Required	None		None		255.6	CY	255.6	CY	255.6	CY	255.6	CY	255.6	CY	255.6	CY
					Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building	
Projected Future (2025) Conditions for Operation and Maintenance Evaluation																
Future (2025) Sludge to Holding Pond For O&M Costs (Average Annual)	758,730	Gals/WK Design	758,730	Gals/WK Design	758,730	Gals/WK	758,730	Gals/WK	758,730	Gals/WK	758,730	Gals/WK	758,730	Gals/WK Design	758,730	Gals/WK Design
	53	DT/WK Design	53	DT/WK Design	53	DT/WK	53	DT/WK	53	DT/WK	53	DT/WK	53	DT/WK Design	53	DT/WK Design
Operating Flow/Unit	200	gpm	400	gpm	125	gpm	250	gpm	201	gpm	335	gpm	200	gpm	400	gpm
	3.33	gphr	6.67	gphr	2.08	gphr	4.17	gphr	3.35	gphr	5.58	gphr	3.33	gphr	6.67	gphr
Days and Hours of Operation	63	Hrs/WK	32	Hrs/WK	101	Hrs/WK	51	Hrs/WK	63	Hrs/WK	38	Hrs/WK	63	Hrs/WK	32	Hrs/WK
	12	Hrs/Day (Staffed 12 hrs/day)	12	Hrs/Day (Staffed 12 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)	24	Hrs/Day (Staffed 8 hrs/day)
	5.3	Days/WK	2.6	Days/WK	4.2	Days/WK	2.1	Days/WK	2.6	Days/WK	1.6	Days/WK	2.6	Days/WK	1.3	Days/WK
Cake Solids Processing and Hauling	210	WT/WK @ 25% Solids	210	WT/WK @ 25% Solids	263	WT/WK @ 20% Solids	263	WT/WK @ 20% Solids	263	WT/WK @ 20% Solids	263	WT/WK @ 20% Solids	263	WT/WK @ 20% Solids	263	WT/WK @ 20% Solids
	232	CY/WK @ 25% Solids	232	CY/WK @ 25% Solids	294	CY/WK @ 20% Solids	294	CY/WK @ 20% Solids	294	CY/WK @ 20% Solids	294	CY/WK @ 20% Solids	294	CY/WK @ 20% Solids	294	CY/WK @ 20% Solids
	40	WT/Day @ 25% Solids	80	WT/Day @ 25% Solids	62	WT/Day @ 20% Solids	125	WT/Day @ 20% Solids	100	WT/Day @ 20% Solids	167	WT/Day @ 20% Solids	100	WT/Day @ 20% Solids	199	WT/Day @ 20% Solids
	3.3	WT/HR	6.6	WT/HR	2.6	WT/HR	5.2	WT/HR	4.2	WT/HR	7.0	WT/HR	4.2	WT/HR	8.3	WT/HR
	3.7	CY/HR	7.3	CY/HR	2.9	CY/HR	5.8	CY/HR	4.7	CY/HR	7.8	CY/HR	4.7	CY/HR	9.3	CY/HR
	2.0	Truck Loads/Day	4.0	Truck Loads/Day	3.1	Truck Loads/Day	6.2	Truck Loads/Day	5.0	Truck Loads/Day	8.3	Truck Loads/Day	5.0	Truck Loads/Day	10.0	Truck Loads/Day

Number of Units	Alt 1A: Centrifuge Two Units/One Operating and One Standby		Alt 1B: Centrifuge Three Units/Two Operating and One Standby		Alt 2A: Screw Press Two Units/One Operating and One Standby		Alt 2B: Screw Press Three Units/Two Operating and One Standby		Alt 3A: Fan Press Four Units/Three Operating and One Standby		Alt 3B: Fan Press Six Units/Five Operating and One Standby		Alt 4A: Volute Press Two Units/One Operating and One Standby		Alt 4B: Volute Press Three Units/Two Operating and One Standby	
	11.6	Truck Loads/WK	11.6	Truck Loads/WK	14.7	Truck Loads/WK	14.7	Truck Loads/WK	14.7	Truck Loads/WK	14.7	Truck Loads/WK	14.7	Truck Loads/WK	14.7	Truck Loads/WK
Dewatered Sludge Storage Required	None		None		196.1	CY	196.1	CY	196.1	CY	196.1	CY	196.1	CY	196.1	CY
					Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)		Dewatered Sludge Storage 40 ft x 50 ft building (Salt/Sand Style Storage Building)	

4.2.9 Non-Economic Considerations

In addition to economic evaluation, consideration of non-economic criteria is important because the alternatives have different risks, benefits, and drawbacks that should be compared and considered before a recommendation is made.

Non-Economic Criteria for evaluation were developed in an attempt to address the range of non-economic issues that are important in this decision-making process. Criteria are as follows:

- Constructability and Construction Disruption – This criterion considers whether there are quantifiable differences in equipment layout and interfaces with existing facilities that increase disturbances or potential operational risks during construction. New dewatering and thickening technology will likely have more disruption to the solids handling processes and require additional coordination and temporary equipment to continue solids dewatering and thickening operations during construction.
- Space Constraints – This criterion considers space constraints and the ability of the equipment to fit within the existing facilities, while allowing satisfactory space for O&M of the equipment. The screw press is larger than an existing centrifuge and will use more space in the existing facility.
- Storage Space – The existing centrifuge room and solids handling facility currently house chemicals, maintenance tools, and other equipment that would be impacted by retrofit alternatives.
- Reliability (Bullet Proof) – Overall robustness of the dewatering process to outages and unplanned down time.
- Operational Requirements – O&M costs include operational labor. This criterion considers whether there are qualitative differences in sophistication or complexity of processes or equipment, or both, that make an alternative more operator friendly.
- Maintenance Requirements – O&M costs include maintenance labor. This criterion considers whether there are qualitative differences in sophistication or complexity of processes or equipment, or both, that are maintenance friendly including factors such as limited or no need for special equipment, or limited or no requirement on external service from manufacturer.
- Consistency with Current Operation – This criterion considers whether there are qualitative differences with respect to the extent that current operations familiarity is sufficient and/or additional operations training will be required.
- Noise – Although equipment will have noise enclosures, typically centrifuges produce more noise at least in the area where they are operating. This criterion considers the noise levels that operations staff will be exposed to during operation of the equipment.
- Odor Potential – Centrifuges have in some cases produced enough shearing during dewatering to create more odorous biosolids. This criterion considers the odors that operations staff will be exposed to during O&M of the equipment.

Table 4.2.10 represents an initial non-economic evaluation of the alternatives. Input from the Rapid City WRF operations and management staff has not yet been included in this non-

economic evaluation. Additional investigation and pilot testing are recommended before a final non-economic evaluation is completed with Rapid City WRF staff input.

Table 4.2.10. Non-Economic Criteria Evaluation of Dewatering Alternatives

Non Monetary Criteria	Alt 1A: Two Centrifuges-Dewater Only	Alt 1B: Three Centrifuges-Dewater Only	Alt 2A: Two Screw Presses-Dewater Only	Alt 2B: Three Screw Presses-Dewater Only	Alt 3A: Four Fan Presses-Dewater Only	Alt 3B: Six Fan Presses-Dewater Only	Alt 4A: Two Volute Presses-Dewater Only	Alt 4B: Three Volute Presses-Dewater Only
Constructability and Construction Disruption	8	6	5	3	5	3	5	3
Space Constraints	10	8	7	4	7	2	8	6
Storage Space	8	7	6	5	3	1	7	6
Reliable (Bullet Proof)	5	7	8	9	4	5	8	9
Operational Requirements	5	5	7	7	7	7	7	7
Maintenance Requirements	5	5	7	7	6	6	7	7
Consistency with Current Operation	10	10	6	6	4	4	8	8
Noise	5	5	10	10	10	10	10	10
Odor Potential	5	5	8	8	8	8	8	8
Total	**61**	**58**	**64**	**59**	**54**	**46**	**68**	**64**

Note: 1 = worst; 10 = best

4.2.10 Recommendation

Additional investigation and pilot testing is recommended before a final decision is made on a solids dewatering alternative. Investigation and pilot testing would provide the following:

- Potential for site visits to observe the alternatives evaluation in a full scale operation at other facilities.
- Reliability of the alternatives to consistently meet the sludge dewatering performance goals.
- Determine the ability to operate the alternatives continuously on a 24-hour basis with minimal adjustments of the polymer and operator attention.

For capital improvements planning it is recommended that the total project cost for Alternative 4B: Three Volute Presses, is included in the Rapid City WRF Capital Improvements Plan. Alternative 3B: Six Rotary Fan Presses, has a higher total project cost, but does not appear to be practical in this application, because of the number of units required. Rotary fan presses are more suitable to smaller applications.

4.2.11 Phasing Options

Table 4.2.11 shows three options for phasing implementation of the volute press alternative of dewatering. Under Option 1 three dewatering units and all the improvements required for the 20 year planning period would be implemented in a single phase by 2020 at an estimated total project cost of $16.6 million. Under Option 2, two dewatering units would be installed and additional liquid sludge storage constructed initially to meet immediate needs. Drying cake sludge storage would not be constructed as part of the immediate needs. The remaining improvements including liquid sludge storage, a third dewatering unit, and dry cake storage would be constructed in two phases based on capacity and operational requirements. Phasing Option 3 would be similar to Option 2 in that two dewatering units would be installed and additional liquid sludge storage constructed initially to meet immediate needs. However, under Option 3 dry cake storage would also be constructed as part of the initial project. Option 3 differs from Option 2, in that it would be assumed the two dewatering units would be operated continuously and therefore a third unit would not be planned for a future phase.

Table 4.2.11.Solids Handling Facilities Improvements – Volute Presses – Phasing Option

Phasing Options	Immediate Needs	Phase I	Phase II
1	**By 2020 (No Phasing)** Install all three dewatering units. Construct 1.5 MG of additional liquid sludge storage. Construct dry cake storage building. Complete all age & conditions improvements. Project Cost: **$16.6 million.**		
2	**By 2020 (Phasing)** Install two dewatering units – Two units operated 40 hours per week will provide dewatering capacity to 2033 or equivalent population 102,388. Constructed 1.2 MG of additional liquid sludge storage. No dry cake storage building. Implement age & condition improvements scheduled for 1- 5 years. Project Cost: **$11.95 million**.	**By 2025** Construct 300,000 gallons of additional liquid sludge storage. Implement scheduled age & condition improvements. Project Cost: **$1.22 million.**	**By 2033** Install third dewatering unit- Three units operated at 28 hours per week, will provide dewatering capacity beyond 2035. Construct dry cake storage building. Implement scheduled age & condition improvements Project Cost**:** **$3.46 million.**
3	**By 2020 (Phasing)** Install two dewatering units – One unit operated continuously for up to 85 hours per week will provide dewatering capacity beyond 2035 or equivalent population 105,184. Construct dry cake storage building. Construct 1.2 MG of additional liquid sludge storage. Implement age & condition improvements scheduled for 1–5 years Project Cost: **$12.92 million**.	**By 2025** Construct 300,000 gallons of additional liquid sludge storage. Implement scheduled age & condition improvements. Project Cost: **$0.93 million.**	Assume volute press operation is 24/7, 5 days per week.

Phasing Option 2 is recommended for implementation of the solids handling improvements. A detailed breakdown in the estimated costs for Phasing Option 2 is shown in Table 4.2.12.

Table 4.2.12.Solids Handling Facilities Improvements– Recommended Phasing Option Costs

Item Description	Immediate Needs	Phase I	Phase II
Division 1 - General Requirements (Included in contingencies)			
Division 2 - Site work			
2.1. New Building Site and Piping Work	$202,000		
2.2. Driven Piles	$70,000		
2.3. Additional liquid sludge storage	$402,000	$70,000	
Division 3 - Concrete			
3.1. Grade Beams/Footings/Base Slab	$435,500		
3.2. Precast Roof Panels	$25,000		
3.3. Intermediate Floor Slab	$89,000		
Division 4 - Masonry			
4.1. New Building Exterior Masonry Walls	$86,500		
4.2. New Building Interior Masonry Walls	$23,000		
Division 5 - Metals	$33,333		$16,667
Division 7 - Thermal & Moisture Protection			
7.1. New Building Roof System	$75,600		
Division 8 - Doors & Windows	$20,000		
Division 9 - Finishes	$21,000.00		$11,000.00
Division 11 - Equipment			
11.1. Three Volute Presses	$1,477,000		$738,500
11.2. Mixing equipment for new liquid sludge storage	$204,000		$36,000
11.3. New Sludge feed pump and grinder for third volute press			$91,000
11.4. Replace mixing/aeration system & add decant pumps in existing west sludge holding pond	$405,440		
11.5. Sludge feed pumps and grinders	$182,000		
11.6. Polymer feed system	$140,420	$24,780	
11.7. Replace compressor valves		$123,000	
11.8. Polymer feed system for third volute press		$82,600	
Division 13 - Special Construction			
13.1. Controls for new equipment	$252,229	$8,590	$85,840

Item Description	Immediate Needs	Phase I	Phase II
13.2. Automate controls for centrate flow	$5,000		
13.3. Add centrate flow metering from sludge storage ponds	$10,000		
13.4. Replace failing ultrasonic level sensor in centrate tank	$3,000		
13.5. Dry cake sludge storage building			$267,000
Division 14 - Conveyance Systems			
14.1. Conveyors from volute presses to sludge load out	$135,000		$67,501
14.2. Solids load out crossover hopper and conveyor	$609,000		
14.3. Conveyor to dry cake storage building			$140,000
14.4. New Building Monorail & Hoist	$100,000		
Division 15 - Mechanical			
15.1. New Building HVAC and Plumbing	$125,000		
15.2. Sludge feed pump piping	$175,000		$87,500
Division 16 - Electrical			
16.1. New Building Electrical and Equipment MCC	$335,286	$10,738	$107,300
16.2. Replace sludge holding pond control panel	$35,000		
16.3. Replace the solids handling building standby generator and ATS		$250,000	
Subtotal - Direct Costs	**$5,680,000**	**$570,000**	**$1,670,000**
Undeveloped Design Details (25%)	$1,420,000	$140,000	$420,000
Cons. Subtotal w/Cont.	**$7,100,000**	**$710,000**	**$2,090,000**
General Conditions, Mobilization (5%)	$360,000	$40,000	$100,000
Sales Tax (Allowance) (5%)	$370,000	$40,000	$110,000
Overhead & Profit (15%)	$1,170,000	$120,000	$350,000
Bonds & Insurance (2%)	$180,000	$20,000	$50,000
Construction Subtotal	**$9,180,000**	**$930,000**	**$2,700,000**
Construction Contingency (5%)	$460,000	$50,000	$140,000
Total Construction Cost	**$9,640,000**	**$980,000**	**$2,840,000**
Engineering, Admin, Legal, Permitting (24%)	$2,310,000	$240,000	$680,000
Total Project Cost	**$11,950,000**	**$1,220,000**	**$3,460,000**

Chapter 5.1 Recommended Plan

This Chapter presents the recommended improvements along with a preliminary capital improvements plan that reflects the age and condition, hydraulic and organic capacity, operational and regulatory related needs. It includes planning level costs and anticipated timing for each item.

The recommended plan provides a long-term master plan for ultimate expansion of the plant, while identifying a phased construction program to meet capacity and treatment requirements for the next 20 years. The implementation programming is designed to provide timely construction of the necessary improvements at the plant without creating an overly complex construction management program. The plan will likely be refined as part of the City's rate study.

Age and condition related needs were determined by onsite condition assessment and are reflected in Chapter 1.1 Operations and Physical Condition Assessments. Operational improvements were discussed both in terms of physical operation of the plant in Chapter 1.1 and in terms of energy consumption in Chapter 1.2 Energy Assessment. Capacity related needs were determined and are reflected in Chapter 3.1 Plant Hydraulic Capacity and 3.2 Plant Organic Capacity. Finally, regulatory related capacity needs were considered and projects were identified for secondary treatment and solids handling in Chapters 4.1 and 4.2, respectively. All have been compiled and presented herein in the form of a preliminary capital improvements plan included as Table 5.1.1. A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility cost is contained in Appendix 5.1.A.

The long term recommended improvements and ultimately the capital improvements plan envisions the following:

1. No change in regulatory standards for ammonia or nutrients thru Permit #2 (2025); the existing North Plant would be maintained in service with relatively major provisional improvements to trickling filter pumping and RBC aeration.
2. More stringent permit in 2025 in response to Permit #2 ammonia criteria with no change in nutrient regulatory standards. At this point, the North plant would no longer be part of the treatment process. The South Plant would need to be constructed by 2025 and will treat the entire flow to comply with promulgated ammonia standards. The North plant structures would be re-purposed as part of the predesign process to the extent possible.
3. More stringent nutrient control standards are expected for Permit #3 (2030) and nutrient removal improvements including the anoxic basins and anoxic recycle would need to be constructed by 2030 to meet promulgated nutrient control standards.
4. Solids handling improvements are recommended as an immediate need. Alternative 4B: Three Volute Presses constructed in a new building, is included in the Rapid City WRF

Capital Improvements Plan. A phased approach is provided to add additional units concurrent with Permit #2 (2025) liquid process train improvements.

5. The trickling filter pump station will be improved to provide service through Permit #2 issuance.

Improvements identified from the plant review were ranked with a priority system based on the following rankings. Refer to Figure 5.1.1.

The summary of recommendation has been separated into the following categories:

- **Short-Term Capital Improvements**
  These are improvements required to reliably continue to treat the flow to meet the current permit. Short-term improvements are anticipated to be implemented within the next five years. These improvements address items such as treatment and hydraulic capacity items, reliability, operations and energy minimization. Priority 1 items are recommended to be completed in 2016 – 2018, and Priority 2 items completed by 2020.

- **Plant Modifications to meet 2025 Permit #2**
  These are improvements that will be necessary to meet the federally adopted ammonia criteria. These ammonia limits will be included in a future permit anticipated by 2025. These improvements primarily address treatment capacity upgrades.

- **Plant Modifications to meet 2030 Permit #3**
  These are improvements that will be necessary to meet future nutrient criteria limit of 10 mg/l TN and 1 mg/L phosphorus. These limits are planned for 2030; however, these limits are the most uncertain with respect to schedule and numeric criteria. These improvements primarily focus on an expanded activated sludge system.

- **Plant Modifications to meet Other Needs**
  These are improvements that are necessary to continue to meet the needs for the City of Rapid City to operate effectively and meet the effluent permit limits. These items have been given Priority 3, 4 or 5 designations. Priority 3 items are planned to be completed in 2020 – 2025 and Priority 4 and 5 items are planned for completion in 2025 – 2035.

The costs are incorporated into Table 5.1.1 and footnoted accordingly. Table 5.5.1 includes the recommended projects for Secondary Treatment and Solids Handling Improvements, which include elements that are age and condition, operational and energy, and capacity related.

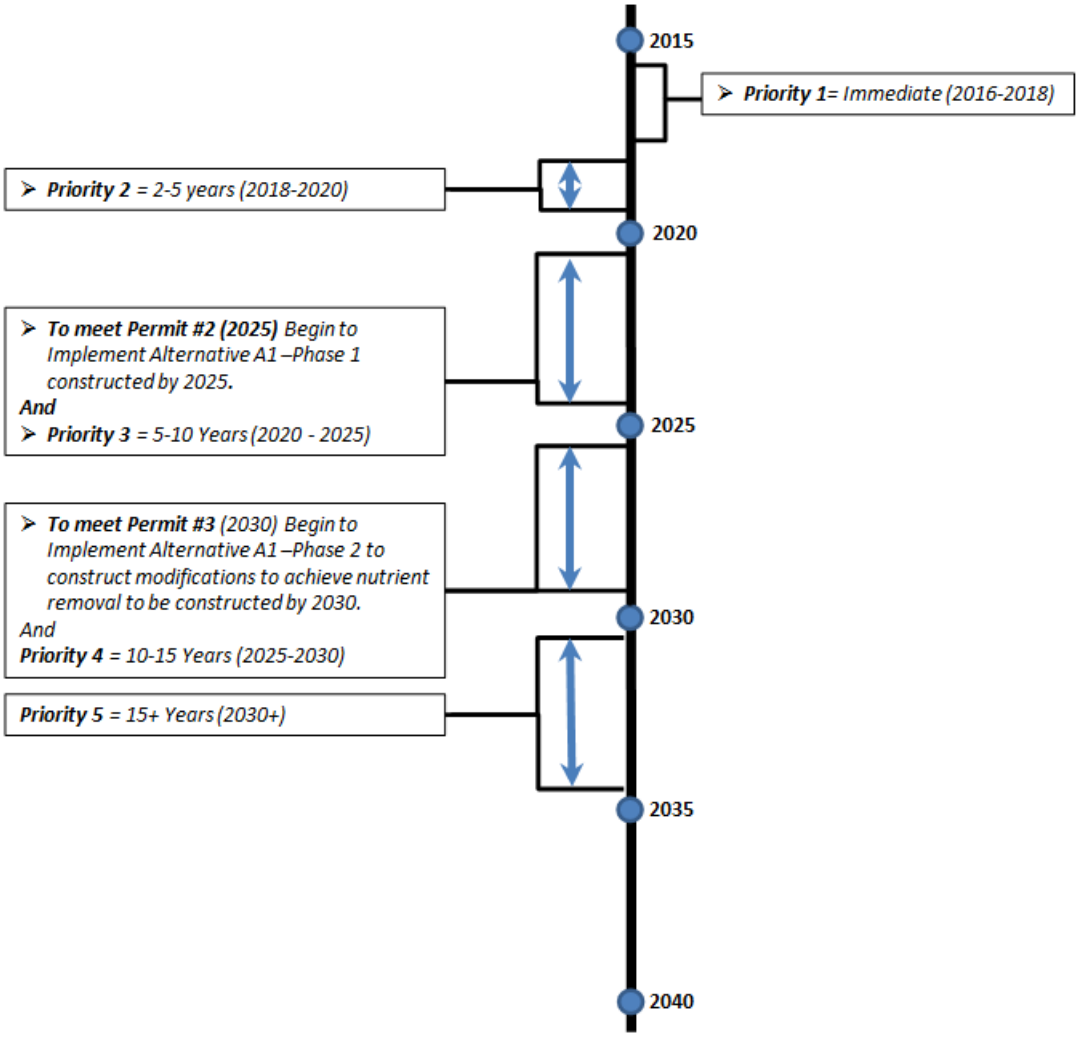


Figure 5.1.1. Rapid City WRF Recommended Improvements

Table 5.1.1. Preliminary Capital Improvements Plan

Driving Force		Fiscal Years							Total
		FY 2016-2020		FY 2021-2025		FY 2026-2030		FY 2031+	
		Priority 1	Priority 2	Required to meet Permit No. 2	Priority 3	Required to meet Permit No. 3	Priority 4	Priority 5	
Capacity, Age & Condition	Activated Sludge Improvements	$4,014,000							$4,014,000
	Trickling Filter Pump Sta. Improvements	$2,410,000							$2,410,000
	Sludge Handling Improvements	$11,950,000			$1,220,000		$3,460,000		$16,630,000
	Misc. Improvements	$256,000	$3,790,000		$1,860,000		$400,000	$2,290,000	$8,596,000
	Age & Condition Total	$18,630,000	$3,790,000		$3,080,000		$3,860,000	$2,290,000	$31,650,000
Operation & Energy	Operation	$120,000	$300,000		$290,000				$710,000
	Energy	$470,000							$470,000
	Operation & Energy Total	$590,000	$300,000		$290,000				$1,180,000
Regulatory				$20,570,000		$7,800,000		$800,000	$29,170,000
Period Totals		$19,220,000	$4,090,000	$20,570,000	$3,370,000	$7,800,000	$3,860,000	$3,090,000	$62,000,000

Notes: All costs are reported in 2015 Dollars and include construction and engineering.
1. Priority 1 Age and Condition includes Sludge Handling Project, which is also driven by capacity
3. Priority 1 Operation and Energy includes energy conservation measures #s 4, 5, and 11.
4. Priority 1 Capacity limitation includes AB Curtain Wall (Anoxic Basin).
5. Capacity limitations are included in Regulatory project costs.
6. Odor Control is included in Regulatory project costs for FY 2031+ at $800,000.

5.1.1 Age and Condition Driven Needs

A condition assessment of the WRF was conducted to determine the estimated remaining useful life of the facilities' components and was documented in Chapter 1.1 - Physical Condition and Operational Assessment. The condition assessment included review of the following areas:

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

Based on the assessment, the WRF is in generally good condition; however, the WRF has facilities that are up to 50 years old and have significant signs of age related deterioration. As part of the condition assessment, a schedule for replacement and/or renovation was developed. The drivers for the schedule are the estimated remaining useful life, reliability, and risk of failure for each item and coordination with future improvements.

It is prudent to continue to maintain and replace equipment as required rather than schedule complete replacement if that equipment is going to be obsolete in the future plans for the facility. For example, it would not be prudent to invest in a completely new trickling filter pump station if future nutrient standards will drive replacement of the trickling filters with activated sludge as currently envisioned.

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

Table 5.1.2 identifies age and condition driven needs determined by onsite condition assessment and are reflected in Chapter 1.1 Physical Condition and Operational Assessment. Within the guidelines presented in that chapter, it also presents the timeline and incorporates an order of magnitude budget cost for each.

Table 5.1.2. Age and Condition Related Capital Improvements

Component	Recommended Improvements	Implementation Date
Short-Term Capital Improvements		
Priority 1		
Activated Sludge Improvements	One new clariflocculator, curtain wall, drain pump	Priority 1 - 2016-2018
Trickling Filter Pump Sta. Improvements	New pumps with VFDs to handle flow range, and repair and recoat pump discharge piping.	Priority 1 - 2016-2018
Sludge Handling Improvements	Provide new dewatered sludge conveyance and storage equipment.	Priority 1 - 2016-2018
Misc. Preliminary Treatment Improvements	Screening bypass, septage safety and volume, misc.	Priority 1 - 2016-2019
Misc. Digester Improvements	Roof access, chemical feed and waste gas improvements.	Priority 1 - 2016-2018
Priority 2		
Site work	Roadways, plant access, Gaging Station, water well abandon	Priority 2 - 2018-2020
Primary Treatment	Scum pumps & piping, skimmers and gearboxes, sludge level sensors, pumping room HVAC, railing, and misc. tuck-pointing.	Priority 2 - 2018-2020
Secondary Clarification	Humus pumps, gear boxes, and clarifier railing	Priority 2 - 2018-2020
RBCs and Generator	Repair RBC in-tank air piping, replace generator, HVAC	Priority 2 - 2018-2020
Tertiary Clarifiers and Pumping	Costs to Maintain existing pumps, drives and HVAC	Priority 2 - 2018-2020
Activated Sludge Improvements	Splitter box gate actuators, Blower intakes/HVAC, generator controls and misc. architectural	Priority 2 - 2018-2020
UV Disinfection/Post Aeration Improvements	Generator controls and misc. architectural	Priority 2 - 2018-2020
Digestion Area Improvements	Replace steel gas lines, boiler controls, electric modifications and misc. vac and architectural	Priority 2 - 2018-2020
HVAC Improvements	Upgrade Secondary Building, Water Building, Maintenance Shop, and Metals Shop HVAC.	Priority 2 - 2018-2020
Instrumentation, Electrical and Misc. Improvements	Maintenance Shop MCC, Integration of PLCs, and Samplers	Priority 2 - 2018-2020
Cold Storage Building and Misc. Architectural	Construct new cold storage building.	Priority 2 - 2018-2020
Plant Modifications - Other Needs		
Priority 3		
Sludge Handling Project	Provide Phased sludge conveyance and storage.	Priority 3
Process	Includes equipment replacement, including paddles and drives, and coating of the tanks.	Priority 3
Architectural	Administration Facilities Expansion -Building addition & site improvements	Priority 3
Structural		

Component	Recommended Improvements	Implementation Date
HVAC Improvements	AB Pump Room, UV Building, Secondary standby generator	Priority 3
Electrical, Instrumentation, and Misc. Improvements	Remote monitoring capabilities, CMMS replacement, on-line metering capabilities	Priority 3
Operation & Energy Total	SCADA/Remote Operations & Computerized Maintenance Management Software (CMMS) & On-line Monitoring	Priority 3
Priority 4		
Sludge Handling Improvement	Phase 2 Sludge Handling Improvements	Priority 4
Process	Miscellaneous process equipment replacement	Priority 4
Priority 5		
Process Upgrades	Screen gear boxes, replace MCCs, grit classifier, gas flare and misc.	Priority 5
HVAC Improvements	Replace digester boilers	Priority 5
Electrical, Instrumentation, and Misc. Improvements		Priority 5
Odor Control	Construct odor control facilities for odor-related areas. Tie to existing odor sources.	Priority 5
Priority 5 Subtotal		**Priority 5 Subtotal**

5.1.2 Operational and Energy Driven Needs

Table 5.1.3 identifies operational improvements reflected in Chapter 1.1 Operations and Physical Condition Assessments. Table 5.1.4 identifies recommended Energy Conservation Measures (ECMs) detailed in Chapter 1.2 Energy Assessment. Tables 5.1.3 and 5.1.4 incorporate an order of magnitude budget cost for each need.

As indicated in Chapters 1.1 and 1.2, there are several short-term capital recommendations for maximizing operations and energy efficiency at the WRF.

5.1.3 Capacity Driven Needs

Table 5.1.5 identifies hydraulic and organic capacity driven needs. The associated timeline reflects current and projected flows and loads presented in Chapter 2.1 Flows and Loads and implementation of the recommended alternatives. Table 5.1.5 identifies where the hydraulic and organic capacity driven costs are included i.e. Regulatory or Age and Condition.

A few peak hour capacity limited processes have not been included in the capital improvement plan. The reasoning is that the trend for flows has been to decrease due to high efficiency fixtures and increased water costs. If peak hour flows track with the Chapter 2.1 projections, these processes will reach capacity at the projected peak hour between 2030 and 2035.

- Influent screens: The screens have a combined rated capacity of 37 MGD. However, assuming 20 percent screen blockage, the flow through the screens may be increased to 45 MGD with the upstream channel freeboard at approximately 0.75 foot. This means that the cleaning mechanisms may have to operate continuously during the peak to keep the screen clean.
- Grit units: The current treatment capacity is 40 MGD while the hydraulic capacity can be increased by simply raising the channel wall. The efficiency may be decreased at flows exceeding 40 MGD.
- UV Disinfection system (current rated capacity is 40 MGD): The actual capacity of the UV unit is dependent on a number of factors including UV transmittance. The activated sludge system is expected to exhibit an improved UV transmittance and will likely increase the process efficiency.

Peak flows should continue to be monitored to determine if improvements to these processes need to be budgeted for in long-term planning.

Table 5.1.3. Operations Improvements Summary – Monetary

Priority	Type	Assessment Category	Opportunity	Opportunity Description	Years of Implementation (Immediate, 1–5 years, 5–10 years, 10–20 years)	Cost
1	Monetary	Vulnerability	Emergency Operating Plan	Increase fuel storage complete with containment to up to 3 days. Station fuel tanker on-site prior to anticipate blizzard/flood events.	Immediate	$18,000
1	Monetary	Vulnerability	SCADA	Address high-risk areas for instruments via SCADA only and provide hard-wired alarms for influent screening, trickling filter pumping, aeration blowers, and UV.	Immediate	$102,000
2	Monetary	Operational Capabilities and Procedures	Operations Manuals	Development of a facility level O&M Manual is recommended. A digital intranet based manual should be considered to facilitate continuous update and central access to SOP's and equipment manuals.	2–5	$200,000
2	Monetary	Operational Capabilities and Procedures	SCADA	Update the SCADA / Information Technology Master Plan to improve control capabilities of existing processes and meet future demands of new treatment technologies. An important part of the SCADA Master plan should be a well-defined controls philosophy based on a Failure Mode Effects Analysis of each unit process. Currently only monitoring failures. Facility has Siemen's smart MCC(s) but not using to diagnose problems.	2–5	$50,000
2	Monetary	Maintenance Procedures	Equipment Asset Management Software Updates (EAM)	Consider developing an EAMs system to better manage renewal decisions. There are several short term alternatives to implement this initiative either by; enhancing the current CMMS system to include EAM features described earlier or implementing a separate EAMs system such as AWWA's Plant Infrastructure Manager or HDR's AM Tools that are based on an MS Access database.	2–5	$50,000
	1-5 year Total					***$420,000***
3	Monetary	Operational Capabilities and Procedures	SCADA/ Remote Operations	Include remote capabilities via SCADA to ensure process function and limit trips to the plant. Cost will be dependent on amount of control required.	5–10	$125,000
3	Monetary	Operational Capabilities and Procedures	SCADA/ Remote Operations	Provide a reliable and sufficient internet connection for the WRF. (I.e. Fiber optic cable). This will be required to implement remote system monitoring and/or control.	5–10	$10,000
3	Monetary	Maintenance Procedures	Computerized Maintenance Management Software (CMMS)	Consider the eventual replacement of the existing CMMS with a commercial version. Based on a cursory review of the current CMMS architecture the migration of the asset registry and historical data should be straightforward. Implementation is estimated to be $50,000 subject to final negotiations and changes to the scope of work. The licensing for a model includes an annual cost of $15-30K assuming 20 individual users.	5–10	$50,000
3	Monetary	Operational Capabilities and Procedures	On-line Monitoring	Implement additional on-line metering possibilities i.e. sludge blanket, ammonia, TSS.	5–10	$100,000
	5-10 year Total					***$285,000***

Table 5.1.4. Recommended Energy Conservation Measures – Monetary Summary

ECM #	Description	Savings kW	Savings kWh/yr	Savings $/yr	Cost	Simple Payback (yrs)	Recommended For Evaluation	Trigger Point	Comments
4	Install VFDs on the lift pumps to complement the recently retrofitted trickling filter distributor arms with pneumantically controlled distributor arms.	84	803,800	$67,500	$239,000	3.5	Yes	Rotary distributor arms have already been replaced. VFDs should be included on new trickling filter pump station.	The combination of VFD's on the trickling filter pumps and the pneumatically operated distributor arms would improve operation of the trickling filters. In addition, the pumps and lift station configuration need to be addressed for future operations. Improvements to the Trickling Filter Pump Station pumps and trickling filter recirculation system in general are currently being evaluated to address both long- and short-term goals. Operational flexibility and energy efficiency should be included in any proposed improvements, including consideration of replacing all starters with VFDs.
5	Convert from propane to natural gas as a pretreatment building and shop building heat source.	NA	NA	$40,800	$25,000	0.6	Yes	As soon as NG service is extended to the WRF	Natural gas is significantly less expensive than propane and electric heat.
9	Increase size of centrate discharge lines from the centrifuges in the biosolids handling building.	NA	42,000	$3,900	$46,000	12	Yes	Within the next year or as funds are available.	This payback period for implementation of this ECM is more than 10 years. However, it is still recommended for further evaluation as it would also reduce the total annual labor hours required to operate the centrifuges by 25%.
10	Replace the Centrifuges with an alternate dewatering system that uses less energy, such as fan presses.	93	118,000	$9,922,	$963,000 (Cost difference)	97	Yes	When centrifuges require overhaul (3 - 5 Years)	ECM assumes the existing centrifuges will need to be overhauled or replaced within the next 3 to 5 years. The cost is the difference between replacing the centrifuges with three screw presses verses replacement in-kind with new centrifuges. With other factors considered such as biosolids hauling, labor, maintenance costs, polymer usage, and equipment replacement costs, the payback period would be less than 6 years. Pilot testing and futher investigation is recommend before making a final selection of dewatering technologies.
11	Maximize the use of digester gas by using excess biogas to heat buildings at the WRF, such as the Pretreatment Building and the Shop Building.	NA	NA	$68,300	$210,000	3.1	Yes		The waste gas burner piping needs to be repaired to eliminate the wasting of excess biogas through the digester covers. The use of excess digester gas to heat one or more of the buildings, such as the pretreatment building and shop building would help in maximizing the use of biogas and reduce the amount of propane required for heating purposes.
	Total for Recommended ECMs	**177**	**963,800**	**$190,422**	**$1,483,000**	**7.8**			

Notes:
*Kw – Kilowatts: Instantaneous power usage.
** Kw-hr – Kilowatt-hours: Power consumption equivalent to 1,000 watts for 1 hour.

Table 5.1.5. Hydraulic Capacity Improvements Summary – Monetary

Year	Priority	Hydraulic Limitation	Addressed
2015	Peak Hour Flow is 30.2 MGD		
	1	Replace the aeration basin selector curtain with a concrete wall.	Included in Age and Condition
	2	Add one clariflocculator.	Included in Age and Condition (Reliability)
	5	Modify the tertiary clarifier effluent launders to accommodate more flow (double the capacity of the launders). Add a second 48-inch pipe from the Tertiary Clarifiers to UV. (Option is allow to submerge)	Not included due to limited treatment impact during peak event.
2025	Peak Hour Flow is 37.7 MGD		
	To Meet Permit #2	Add a 10 MGD in-plant peak flow pump station to pump from grit basin effluent to the aeration basin splitter box.	Included in Regulatory -Secondary Project Costs
	To Meet Permit #2	Add two additional clariflocculators.	Included in Regulatory -Secondary Project Costs
	To Meet Permit #2	New effluent piping to UV Disinfection.	Included in Regulatory -Secondary Project Costs
	To Meet Permit #3	Increase the size of the wall openings in the aeration basin to accommodate anoxic recycle flows.	Included in Regulatory -Secondary Project Costs
	To Meet Permit #2	Remove the aeration basin weir plates on the effluent launder.	Included in Regulatory -Secondary Project Costs
	5	Increase the capacity of the influent screens (currently rated at 37 MGD total combined flow).	Not Included at this time as screens will run continuously during the peak hour.
2030-2035	Peak Hour Flow is 40.6 - 43.5 MGD		
	5	Increase capacity of grit units (current capacity is 40 MGD).	Included $100,000 in Capacity category. Increase upstream channel wall height. Third grit unit not Included at this time. Efficiency will be reduced but can pass hydraulically.
	5	Upgrade UV Disinfection system and effluent flow measurement (current capacity is 40 MGD).	Not Included at this time.

5.1.4 Regulatory Driven Needs

Table 5.1.6 identifies the recommended regulatory activity, which were considered and identified in Chapter 2.2 Regulatory Planning. The timeline reflects the anticipated schedule for approval and implementation of nutrient standards as follows.

Table 5.1.6. Projected Limitation with Corresponding Permit Recommended Activity Timing

Permit Cycle (Year)	Projected Limitations	Recommended Activity
Current Permit 2016	New Ammonia Standards based on updated Rapid Creek water quality	Identify how to achieve reliable ammonia removals and improve plant serviceability and reliability. Establish schedule for construction – assume major projects are 5 years from study completion unless other justification (i.e. Trickling Filter Pump Station type trigger).
Permit #1 2020	Compliance Schedule for New Ammonia Standards based on 2013 EPA Ammonia Criteria	Begin design to construct modifications to achieve ammonia removals. Project to be constructed by 2025. Ammonia standards will become part of the SD Water Quality Standards After 2017 and new treatment process is required to meet proposed Ammonia limits.
Permit #2 2025	New Ammonia Standards	Assuming required improvements for ammonia removals complete. Begin design to construct modifications to achieve nutrient removal (TN 10 / TP 1) to be constructed by 2030.
Permit #3 2030	New Nutrient Standards : Total Nitrogen and Total Phosphorus Limits @ 8-10 mg/l TN and 0.5-1.0 mg/l P	Assuming modifications to achieve nutrient removal (TN 10 / TP 1) complete. Nutrient discharge limits have medium level of uncertainty. Track potential for more stringent nutrient standards.
Permit #4 2035	Potentially more Stringent TN and TP	Track potential for more stringent nutrient standards.

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

As outlined in Chapter 4.1 Secondary Treatment Alternative Evaluation, an Activated Sludge System is recommended to meet the requirements of Permit #1 and #2 consists of the following major components:

- New alum storage and feed facility
- New anoxic and activated sludge basins,
- New blowers
- New clariflocculators
- Expand existing RAS/WAS pumping in AB Blower Pump Building
- New activated sludge basin influent splitter from primary effluent,
- Modification of aeration basins and existing splitter structures to handle peak and anoxic recycle flow.
- Associated piping, electrical, and controls

Odor control facilities have been included for the preliminary treatment building and solids handling facilities in the 2031-2035 fiscal year range.

Practical Implementation of Regulatory Improvements

Table 5.1.7. Regulatory Related Capital Needs

Driving Force	Fiscal Years FY 2016-2020	To Meet Permit #2 FY 2021-2025	To Meet Permit #3 FY 2026-2030	FY 2031+	Total	Triggers
Regulatory (Alternative A1 Activated Sludge System)		$20,570,000	$7,800,000	$800,000	$28,370,000	Needed to meet expected discharge permit for Permit #2 (2025) Ammonia and Permit #3 (2030) Nutrient Reduction Standards

5.1.5 Recommended Facilities

5.1.5.1 Overview

The recommended plan includes a long-term plan of expanding the South Plant treatment technology to treat all of the flow. The most notable technology-based change was the evaluation of options for dewatering to improve operability and reduce cost of the sludge handling operation. All of the recommended improvements involve conventional, commonly used wastewater treatment technologies. The recommended Alternate A1 is consistent with the 2000 Facility Plan as this plan recommended expanding the activated sludge treatment for additional capacity with provisions for denitrification and phosphorus removal.

Anticipating that regulatory requirements will change in the future, the plan provides flexibility to incorporate future process changes such as effluent filtration or alternative methods for Class A sludge production. However, no costs are allocated in the long-term improvement program for these potential future needs.

Figure 5.1.2 presents a simplified site plan for the proposed system improvements and Figure 5.1.3 represents the recommended facility flow schematic.

The following sections describe recommended facilities for each unit process. In each case, the long-term recommendation is presented, followed by a listing of improvements needed to address age and condition, current capacity deficiencies as well as effluent quality requirements dictated in the plant's current NPDES permit. Refer to Table 5.1.2 Age and Condition for the detailed planned repair and associated sequencing.

The specific improvements are designed to provide adequate capacity for the projected 20-year nominal planning year flow of 13 mgd (peak flow of 43.5 mgd).

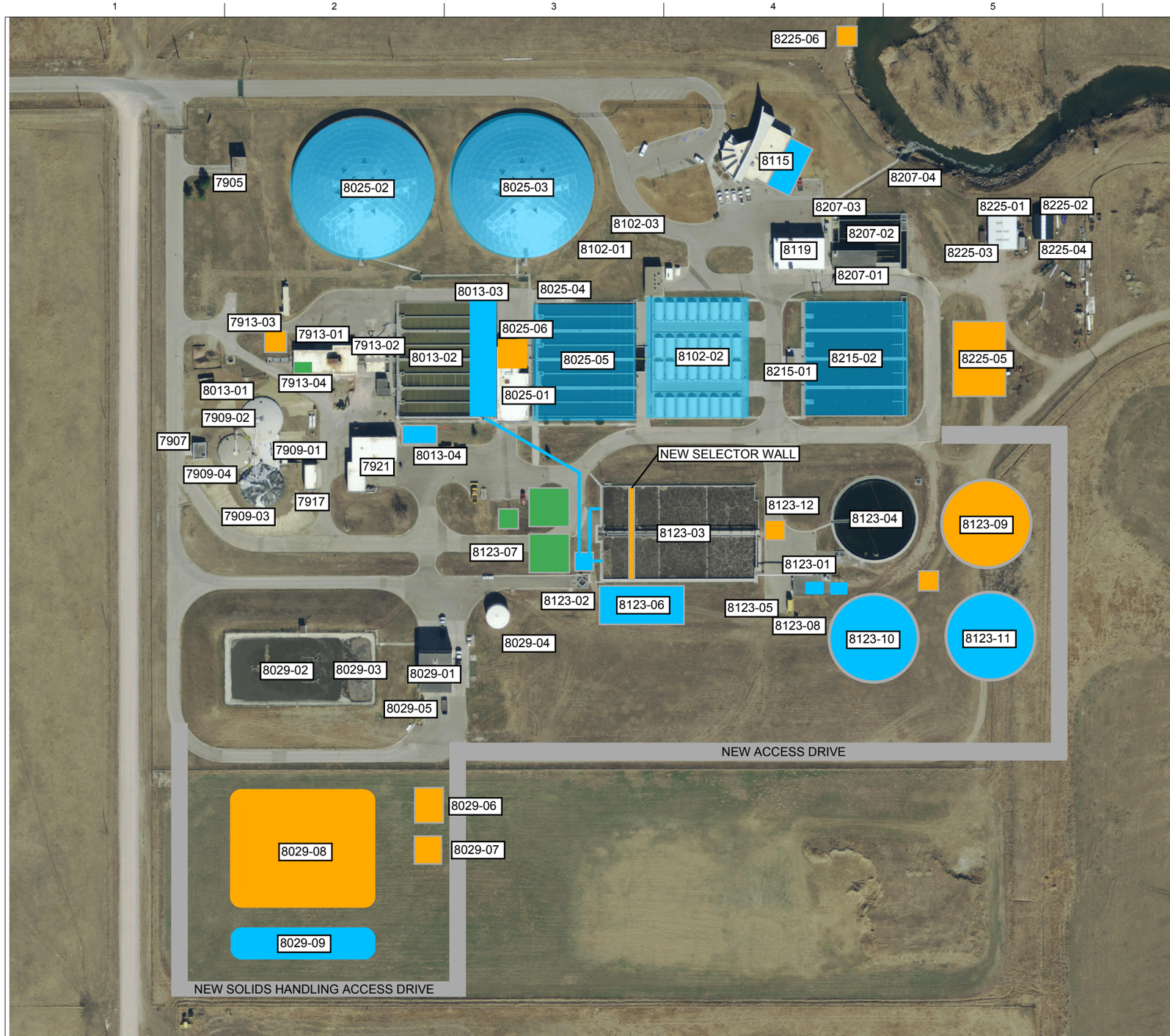
5.1.5.2 General Civil/Site

Civil and site improvements include the following:

- Update main gate to provide for a remote-access security style gate.
- Mill and resurface plant access drives.
- Properly abandon water well.
- Provide Odor Control (described in more detail in later section).
- Add an USGS flow gaging station upstream of WRF for Rapid Creek.

5.1.5.3 Influent Sampling

Influent sampling will be modified to be flow proportional and will be removed and replaced as part of normal maintenance.



KEY PLAN: WATER RECLAMATION FACILITY

Pretreatment
7913-01 PRETREATMENT BUILDING
7913-02 SEPTAGE RECEIVING
7913-03 VACTOR RECEIVING STATION
7913-04 POTENTIAL NEW SCREEN

North Fixed Film Plant
8013-01 PRIMARY SLUDGE PUMP BUILDING
8013-02 PRIMARY CLARIFIERS
8013-03 PRIMARY CLARIFIER EFFLUENT IMPROVEMENTS
8013-04 IN-PLANT PEAK FLOW PUMP STATION
8025-01 SECONDARY BUILDING
8025-02 WEST TRICKLING FILTER - REPURPOSE
8025-03 EAST TRICKLING FILTER - REPURPOSE
8025-04 GENERATOR -SECONDARY
8025-05 SECONDARY CLARIFIERS - REPURPOSE
8025-06 IMPROVEMENTS TO TRICKLING FILTER PUMP STATION
8102-01 RBC BLOWER BUILDING
8102-02 RBC's - REPURPOSE, POTENTIAL SLUDGE STORAGE
8102-03 GENERATOR - RBC's
8215-01 TERTIARY PUMP PIT
8215-02 TERTIARY CLARIFIERS - REPURPOSE, POTENTIAL SLUDGE STORAGE

South Activated Sludge Plant
8123-01 AB BLOWER / PUMP BUILDING
8123-02 ACTIVATED SLUDGE - DISTRIBUTION BOX
8123-03 ACTIVATED SLUDGE - AERATION BASINS
8123-04 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-05 GENERATOR -SOUTH PLANT ACTIVATED SLUDGE
8123-06 ACTIVATED SLUDGE - AERATION BASIN WITH SPLITTER BOX
8123-07 ANOXIC BASINS WITH SPLITTER BOX
8123-08 RAS PUMPS AND AERATION BLOWERS
8123-09 ACTIVATED SLUDGE - CLARIFFLOCULATOR WITH SPLITTER BOX
8123-10 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-11 ACTIVATED SLUDGE - CLARIFLOCCULATOR
8123-12 ACTIVATED SLUDGE - EFFLUENT BOX

Disinfection
8207-01 UV DISINFECTION BUILDING
8207-02 RE-AERATION BASIN
8207-03 GENERATOR UV/ADMIN
8207-04 Outfall

Digestion
7907 GAS BLOWER BLDG
7909-01 PUMP/BOILER BLDG
7909-02 NORTH DIGESTER
7909-03 SOUTH DIGESTER
7909-04 WEST DIGESTER

Solids Handling
8029-01 SOLIDS HANDLING BUILDING
8029-02 750K WEST SLUDGE HOLDING POND
8029-03 50K EAST SLUDGE HOLDING POND
8029-04 CENTRATE STORAGE TANK
8029-05 GENERATOR SOLIDS HANDLING
8029-06 SOLIDS HANDLING BUILDING
8029-07 DEWATERD SLUDGE STORAGE
8029-08 SOLIDS HOLDING POND
8029-09 SOLIDS HOLDING POND

Other
8115 ADMINISTRATION BUILDING WITH EXPANSION
7905 WATER PLANT BUILDING
7917 OIL STORAGE
7921 WASTEWATER MAINTENANCE SHOP
8119 METAL FABRICATION SHOP
8225-01 COLD STORAGE NO. 1
8225-02 SOFT SIDED COLD STORAGE NO. 2
8225-03 WEST WOODEN STORAGE SHED
8225-04 EAST WOODEN STORAGE SHED
8225-05 COLD STORAGE
8225-06 RIVER GAUGING STATION (LOCATED UPSTREAM)

NOTE: UNITS SHOWN IN BOLD ARE PROPOSED OR MODIFIED.

KEY PLAN: FACILITY IMPROVEMENT PHASING

- IMMEDIATE NEED
- PHASE 1 IMPROVEMENTS - 2025
- PHASE 2 IMPROVEMENTS - 2035

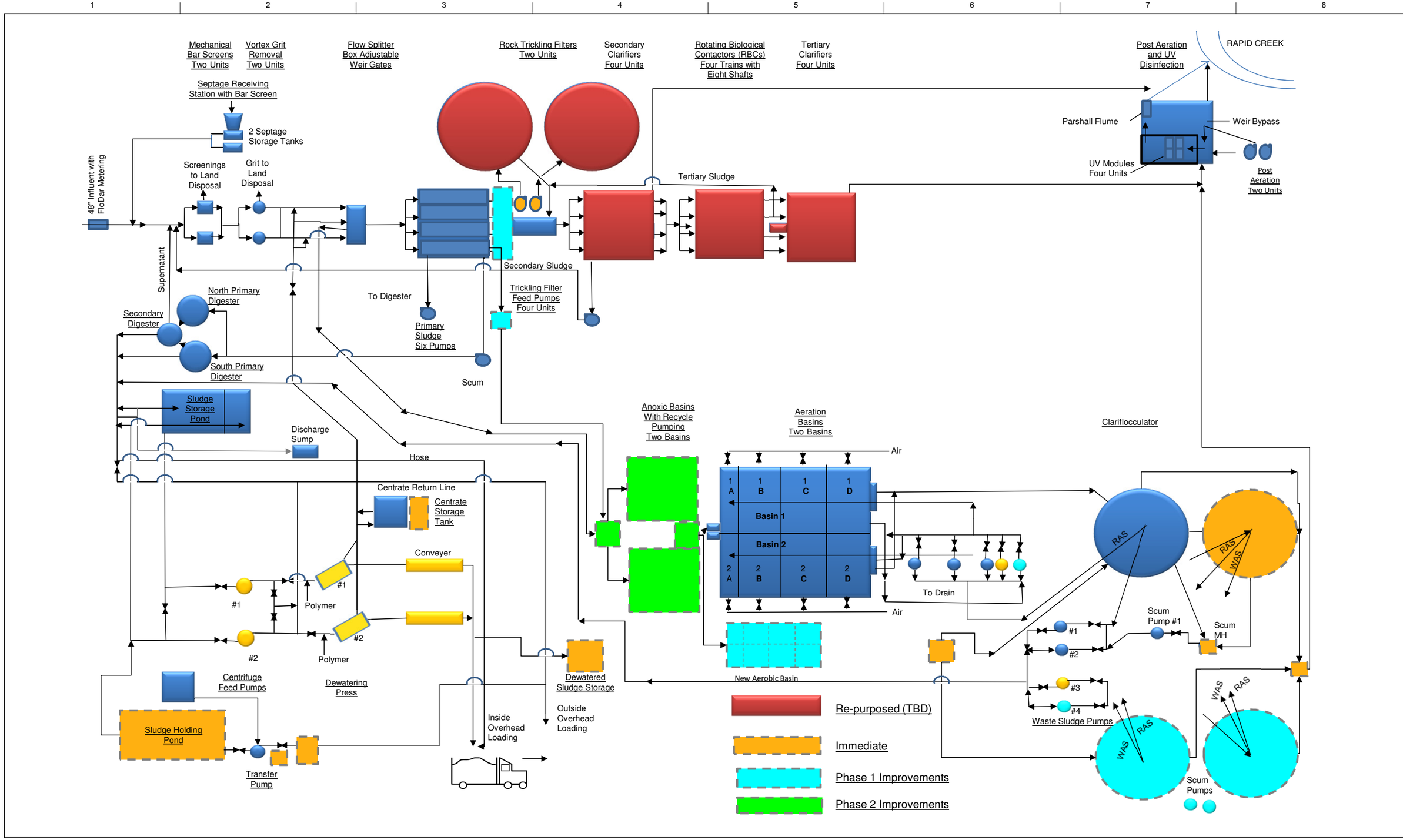
80 0 80 160
SCALE IN FEET

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

RECOMMENDED ALTERNATIVE A1
MAJOR IMPROVEMENTS

0 1" 2"
FILENAME ALT A1 IMPROVEMENTS.DWG
SCALE
FIGURE 5.1.2



ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER	-
CIVIL	-
STRUCTURAL	-
ARCHITECTURAL	-
FIRE PROTECTION	-
MECHANICAL	-
ELECTRICAL	-
PROJECT NUMBER	255661

WATER RECLAMATION FACILITY
FACILITY PLAN
RAPID CITY, SOUTH DAKOTA

2015

RECOMMENDED FACILITY FLOW SCHEMATIC

FILENAME
SCALE

FIGURE 5.1.3

5.1.5.4 Influent Flow Metering

For influent flow metering, the long-term plan is to continue use of the current FloDar system.

5.1.5.5 Vactor Receiving Station

The City Vactor trucks are used to clean out rocks and sediment from storm sewers and remove accumulated solids from sewage manholes and lift stations in the City's collection system.

The trucks used for cleaning lift stations often have concentrated loads of fats, oil, and grease (FOG). FOG can coat analytical probes, plug process equipment, and generally increase the maintenance requirements at treatment plants. Large rocks and debris removed from storm drainage systems can have devastating effects on pumps and screens and increase the maintenance frequency needed for downstream equipment. To avoid damaging equipment and minimize excess maintenance demands, it is recommended to separate the handling of this material from the main treatment processes. A simple and inexpensive removal system consists of a concrete drying bed, sloped to open mesh grating that drains into a shallow sand bed. Vactor trucks can dump debris directly into the drying beds. The rocks, sediment, and scum are retained on the drying bed and the liquid passes through the sand filter and then to the treatment plant processes. The sediment and scum are allowed to dry and then disposed of in a sanitary landfill. A new Vactor receiving station is recommended with the following design criteria:

- Type: Sloped Concrete Slab with sand drying bed
- Vactor Load Receiving Capacity: One
- Size (L x W x H): 20' x 20' x 5'

5.1.5.6 Septage Receiving Station

The existing septage receiving station was originally constructed by retrofitting an existing pre-aeration basin. The problems with the current system identified by haulers and WRF staff are primarily associated with the limited hours of operation, inconvenient access for large vehicles and general housekeeping issues with the open gravity dump basin and screen. Smaller rocks and gravel are not effectively removed by the current screening system thus Street Department wastes and others with gravel components can result in unpumpable build up in storage tanks. A significant amount of operator time is needed for waste sampling, record keeping and overall monitoring, supervision, and clean-up activities.

A technical memorandum detailing septage receiving concerns, objectives, and proposed schematic layouts along with preliminary facility cost is contained in Appendix 5.1.A.

The long-term plan is to conduct informational meeting(s) with the local septage haulers and determine if there is a need for an improved Septage Receiving Station that can be addressed in a feasible and cost effective manner.

In the meantime, the following improvements are recommended:

- Repair immediate safety concerns including access hatch covers and fall protection.
- Include level sensor via SCADA with volume calculation to determine the amount of septage received.

5.1.5.7 Fat, Oil, and Grease (FOG) Receiving

The amount of biogas produced could be increased by feeding FOG to the anaerobic digesters. The excess biogas could then be used for cogeneration, which would reduce the electrical costs at the WRF. At an assumed typical 30% increase in biogas production from feeding FOG, an annual savings of over $80,000 in power costs could be realized. This would increase to over $293,000 in annual savings at future loading conditions. However, the cost of FOG receiving and cogeneration facilities would be approximately $6.8 million. The payback period would be over 23 years and therefore FOG receiving and cogeneration facilities are not recommended from an economic standpoint. The decision to construct FOG receiving and cogeneration facilities would be based on the City's need to provide a place for customers do dispose of FOG waste.

5.1.5.8 Pretreatment Building

INFLUENT SCREENING AND DISPOSAL

The recommendation for influent screening is to:

- Renovate the bypass to include an option unscreened bypass complete with alarming to SCADA. This is a critical reliability issue.
- Long-term plan includes connection to the plant-wide odor control system.

The existing influent mechanically cleaned screens and compactors will continue to be serviced for long-term use.

GRIT REMOVAL

For grit removal, the long-term plan is to continue use of the current vortex grit removal system. Efficiency will be reduced at 40 mgd, but units can pass flow up to the projected 2035 peak hour. The following improvements are planned:

- Vortex grit removal equipment replacement, including paddles and drives, and coating of the tanks should be included in the 10-15 year plan.
- Raise upstream channel walls.

5.1.5.9 Primary Treatment

The existing, conventional, rectangular clarifiers will continue to be used to provide primary treatment. The primary method of phosphorus removal will be chemical precipitation, with alum fed to the wastewater flow upstream of the primary clarifiers. However, flexibility will be provided to allow future conversion to biological phosphorus removal should that become desired or cost effective. Primary sludge will continue to be withdrawn from the clarifiers in

dilute form and discharged directly to anaerobic digestion. At some point, the existing clarifiers may also need to be covered, although this is not included as a near-term activity.

Required improvements for the projected 20-year nominal planning year are as follows:

- Sludge Pumping improvements
  - Replace sludge pump air compressors.
  - Replace isolation valves.
- Primary Clarifiers
  - Replace sludge collector gearboxes.
  - Replace skimmers and gearboxes.
  - Provide safe access on existing tanks -replace metal railing and walkways.
  - Repair concrete walkway damage.
  - Replace effluent trough bypass gate.
  - Replace Sludge Blanket Level Detectors in Primary Clarifiers.
- Items included as part of secondary treatment alternative.
  - Build a primary effluent junction structure with pipeline from the primary effluent to discharge to an aeration basin influent splitter structure.

5.1.5.10 North Plant – Secondary Building

Improvements are planned for the following processes as follows:

- Scum Pumping
  - Install primary scum pump & repair piping to digester.
- The trickling filters and trickling filter pump station are not part of the long-term recommended improvements for the Rapid City WRF. The trickling filter process is expected to be eliminated at Permit #2 which is estimated to by year 2025. As part of provisional improvements to maintain the process for another 10+ years before the north plant is phased out of the process scheme, trickling filter pumping recommended improvements include:
  - New pumps with VFDs to handle flow range. The investment in the VFDs is paid back in less than 8 years.
  - Repair and recoat pump discharge piping.
  - No repairs are recommended to the wetwell at this time.
  - Tuck point exterior.
  - HVAC
- Replace secondary clarifier humus pumping and valves.
  - Process Water System
  - Replace pumps and discharge check valves.
- Trickling Filters
  - Tie VFD controls to pneumatically driven arms and as noted above, this is expected to pay for itself in energy savings.

5.1.5.11 North Plant – Secondary Clarifiers

The sludge collector gearbox for unit Nos. 1, 3, and 4 are planned for replacement.

5.1.5.12 Rotating Biological Contactor (RBC)

The RBCs are expected to be phased out within approximately 10 years and firm capacity is available; therefore, wholesale replacement is not recommended. The blowers, motors, and variable speed drives should continue to be maintained and replaced as required. The air piping in the basins is in poor shape and planned to be repaired as required.

5.1.5.13 Tertiary Clarifiers and Pumping

The tertiary clarifiers are expected to be phased out within approximately 10 years; therefore, wholesale replacement is not recommended. The pumps and clarifier drives should continue to be maintained and replaced as required.

5.1.5.14 South Plant – Secondary Treatment

The process recommendation for secondary treatment is to operate new activated sludge facilities and phase out the trickling filter and RBC facilities, Alternative A1. This configuration provides the lowest-cost approach to reliably meet the pending ammonia-nitrogen and nutrient discharge limits. The approach also provides the best flexibility for future process modifications to achieve total nitrogen removal (denitrification), biological phosphorus removal, or both, while maintaining reliable ammonia removal.

The aeration basin curtain is planned to be refurbished as soon as possible. The existing diffusers and drain pumping will also be replaced in the near term.

The activated sludge process will be implemented in two modular expansions. However, at the completion of Phase 1, 100 percent of the flow will be treated through the activated sludge process.

Priority 1 required facilities prior to Phase 1:

- New clariflocculator – one new, two total.

Required facilities for Phase 1, Permit #2:

- New primary effluent junction box and flow control structure.
- New flow metering
- New aeration basin - additional 0.9 million gallons.
- New clariflocculator influent junction box and flow control structure.
- New clariflocculators – two new, four total.
- New aeration blowers.
- New secondary effluent piping to disinfection facilities.
- RAS/WAS pumping improvements to serve four clarifiers.

- WAS piping from RAS/WAS pumping station extended to new WAS storage pond.
- Refurbish existing clariflocculator drive unit.

Required additional facilities for Phase 2, Permit #3:

- New anoxic basin splitter box and flow control structure.
- New anoxic basins complete with mixing at 0.9 million gallons.
- New recycle pumping and associated piping.

For Phase 2, the option will be available to explore Biological Nutrient Removal for phosphorus, which is Alternative A2.

5.1.5.15 Tertiary Treatment

Tertiary treatment facilities other than disinfection are not required to meet permit conditions for conventional pollutants and nutrients. In the future, effluent limits for phosphorus may become more stringent and additional polishing steps such as effluent filtration or ballasted flocculation will be needed if the required effluent concentration drops to 0.7 mg/L or lower.

Given these potential requirements, it is recommended that the WRF treatment process be designed to allow future incorporation of a tertiary process and that adequate space be preserved for such a process in the preliminary design site planning. The appropriate type of tertiary process (if needed at all) must be determined once the specific treatment objectives have been defined.

5.1.5.16 UV Disinfection

Based on flow projections, the hydraulic capacity of the current UV disinfection is reached in year 2030. Beyond 40 mgd, it is recommended that the City revisit the peak flow, bulb technology, and actual system performance. Actual system performance may improve with the selected activated sludge alternative as the existing UV system was sized for a trickling filter effluent, which has a lower transmissivity. In addition, the trend has been that flows are decreasing on a per capita basis. The potential for decreased peak flows along with the continuing UV technology advancements lead to a recommendation of continued use of UV thru 2035.

Replacement of the UV effluent control gate actuators is planned with in the next 5-10 years.

On-line instrumentation including the Isco sampler, Hach pH meter, and dissolved oxygen sensors are planned for replacement as part of the normal maintenance program.

5.1.5.17 Effluent Pumping and Outfall

The plant currently discharges by gravity to Rapid Creek with no means to isolate or pump effluent. Effluent pumping capacity may be necessary to protect against flooding at the treatment plant as the 500-year flood elevation encroaches on the hydraulic profile. There is no recorded event in the past 30-years, which has impacted the ability to discharge.

Approaches to convey peak flows associated with the 2035, 43.5 mgd peak hour design condition are to 1) build a new effluent pump station 2) re-purpose the trickling filter pump station 3) equalize flows during the 500-year event.

In any case, an embankment would need to be extended to protect the facility to the 500-year event. Refer to Figure 5.1.4. With the new pump station approach, the firm capacity of the effluent pumping station will be 43.5 mgd.

A number of factors will influence the design of future facilities including regulatory requirements guiding the definition of critical facilities. **Given the uncertainty regarding these factors, determination of long-term effluent discharge facilities should be deferred and the City should continue to monitor for final Executive Order requirements.**

Required improvements for the design condition, illustrated in Figure 5.1.4, include:

- Outfall isolation.
- New pump station with provision for standby power.
- Isolation berm.

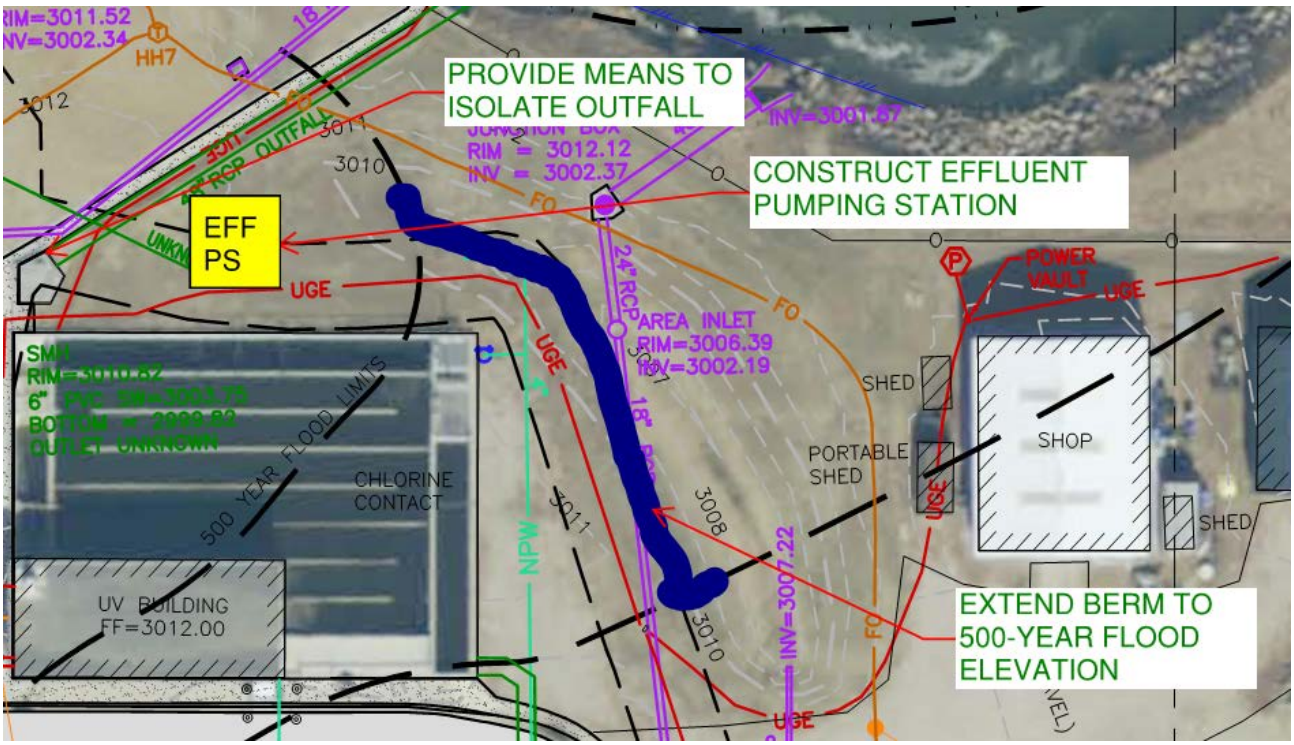


Figure 5.1.4. 500-year Flood Protection

5.1.5.18 Sludge Digestion

For sludge stabilization, the plant should continue to use single-stage mesophilic digestion on a long-term basis, while using the subsequent composting operation to produce a Class A biosolids. Compared to other in-plant stabilization processes, this approach provides the lowest cost, least complex, easiest to operate solution.

Some near term repairs and replacements include:

- Digester roof access needs to be provided to address health and safety.
- Reinstall the waste gas flare feed piping to slope to drain.
- Remove and replace the steel portion of the boiler gas feed lines with stainless steel inside the building as they are corroded and pitted.

Additional planned replacements include:

- The sludge recirculation pumps have been recently overhauled but the expected service life is 5-10 years and should be scheduled for replacement at that time.
- The digested sludge chemical feed needs to be relocated complete with containment due to the corrosive nature of ferric chloride and the safety risks of sodium hydroxide.

5.1.5.19 Sludge Handling Facilities

The existing sludge dewatering system is failing and in need of replacement. In addition, it is recommended that additional liquid sludge storage ponds(s) be built to provide fifteen days of storage at maximum month loading between the continuously operated digestion process and the intermittently operated dewatering process. These ponds also will be equipped with new mixing.

Required improvements for the design condition include:

- New two-level solids dewatering building for housing the dewatering devices.
- New conveyors to transfer cake from the dewatering unit to the sludge load-out area, plus additional conveyors as needed for additional dewatering unit. The assumption is that each dewatering unit will have a dedicated conveyor for transfer of cake to the sludge load-out area.
- Sludge load-out conveyor to even distribution of dewatered sludge in the roll-off containers.
- New liquid polymer feed and storage system, plus additional liquid polymer feed and storage system for additional dewatering units. The assumption is that each dewatering unit would have a dedicated polymer feed system.
- New dewatering unit feed pumps, plus additional feed pumps for additional dewatering units. The assumption is that each dewatering unit would have a dedicated sludge feed pump.
- 1.5 million gallons of additional liquid sludge storage are included assuming the construction of two new lined earthen basins with new mixing and aeration equipment.

- Electrical and instrumentation costs for new equipment are estimated as a percentage of other construction costs.
- Replacement of the existing mixing/aeration equipment in the west cell of the existing sludge storage basin.
- Automation of the controls for the centrate flow; addition of a centrate flow meter; and replacement of the ultrasonic level sensor in the centrate storage tank.
- Replacement of the sludge holding pond control panel.
- Replacement of the solids handling building standby generator and automatic transfer switch (ATS).
- Dry cake storage with conveyance is included with alternatives 2A, 2B, 3A, 3B, 4A, and 4B.

The recommendation for sludge dewatering is to replace the centrifuges due to reliability and age and condition. Alternative 4B -Three Volute Presses is recommended for improvements to the solids handling facilities.

Additional investigation and pilot testing is recommended before a final decision is made on a solids dewatering alternative. Investigation and pilot testing would provide the following:

- Potential for site visits to observe the alternatives evaluation in a full-scale operation at other facilities.
- Reliability of the alternatives to consistently meet the sludge dewatering performance goals.
- Determine the ability to operate the alternatives continuously on a 24-hour basis with minimal adjustments of the polymer and operator attention.

5.1.5.20 Centrate/Supernatant Recycle Management

Compliance with the effluent limit for ammonia-nitrogen will be enhanced by improving storage for recycle flows from the sludge dewatering process and returning these flows to the liquid treatment stream during periods of low influent ammonia loading. An existing tank will continue to be used for this purpose with the following planned improvements:

Upgraded controls and metered pumping for the recycle return system.

- Provision for additional centrate tankage to allow for returning flow during the low-flow periods.

5.1.5.21 Materials Recycling Facility (MRF)/Composting

The MRF facility equipment review was not included in the scope of this facility plan, however, improvements were reviewed that would improve both WRF and MRF operations. The WRF delivers dewatered sludge and 12,000 to 15,000 gallons per day of unthickened sludge and or centrate to the MRF facility.

Operational improvements include:

Approximately 50,000 gallons of liquid storage as it would be extremely beneficial to operations to provide scheduling relief for the WRF and an as-needed liquid supply for the landfill. The new tankage would allow WRF to deliver in one day and have this task complete for the week.

Costs for these improvements have not been included in the facility plan at this time.

5.1.5.22 Standby Power

The standby power planning includes provision for phased replacement of the units based on reliability, age, and condition.

5.1.5.23 Automation and Controls

The expansion alternatives include integrating the process into a uniform, plant-wide solution for automation and controls.

5.1.5.24 Administrative, Maintenance, and Laboratory Facilities

Long-term requirements were reviewed for administration, laboratory, and maintenance facilities. Based on both the projected staffing and limited heated garage space the following improved support facilities are recommended:

Administration Building Addition: New 1,800 square foot expansion of both the upper and lower level, paralleling the east side of the administration building.

- The upper level includes offices;
- The lower level includes garage and storage space.

The pumps and control panel in the pumps station serving the building are planned for replacement.

The current operation facilities and the maintenance shop are projected to remain, as is, however a new cold storage steel building is planned for as follows:

- 100-foot by 60-foot steel building

5.1.5.25 Chemical Feed Facilities

The plan includes modification of the existing Oil Storage Building in the near term for feeding storing corrosive chemicals utilized for digester pH control.

5.1.5.26 Mechanical Facilities Improvements

Planned mechanical, HVAC, and plumbing, improvements are as follows:

- Replace Maintenance Shop boiler and pump with new N+1 boiler system
- Provide ventilation system for compressor room in Primary Sludge Pump Building

- Repair/Replace roof drain piping in Digester Building
- Install permanent heater in Secondary Building restroom
- Replace unit heater in Tertiary Pump Pit
- Full renovation of Solids Handling Building Ventilation
- Replace Water Plant Building unit heater, exhaust fan and controls
- Trickling Filter Pump Room HVAC upgrade
- Replace RBC Blower Building Exhaust fans and unit heater
- Upgrade AB Blower Room Ventilation system/blower intakes
- Add PPU and mechanical cooling to AB Blower/Pump Building Electrical Room
- Replace Tertiary Pump Pit ventilation system, add dehumidifier
- Replace Primary Sludge Pump Building Ventilation System
- Replace corroded door louvers on Digester Building
- Replace old Maintenance Shop unit heaters
- Replace Maintenance Shop water heater
- Renovation of Metal Shop HVAC system
- Wall off Solids Handling electrical equipment and install PPU and mechanical cooling
- Replace AB Pump Room ventilation system
- Replace UV Building air handling unit
- Campus Wide Odor Control System
- Replace Digester boilers
- Replace Gas Blower Bldg. HVAC

5.1.5.27 Odor Control/Site Buffer

The City should develop long-term plans for the WRF site and should begin implementation of the plans as soon as possible. As surrounding properties become further developed, it will become increasingly important that the City provide an attractive visual buffer between wastewater operations and surrounding uses. The closest development will likely be to the west and potentially north. As properties become available, it may be prudent to purchase adjacent properties to buffer the site. Costs have been included as a capacity related item at 15+ years.

As growth occurs, odor control facilities should be provided for the following facilities:

- Septage/Vactor Receiving Facilities
- Pretreatment Building
- Primary Clarifiers (optional)
- Solids Handling Facilities including:
  - Sludge Storage Ponds
  - Dewatering area
  - Dewatered Storage and Loading

A plant-wide odor control system at the treatment plant would collect foul air from these process areas. The odorous air will be routed through a bio-filter bed for odor scrubbing or alternatively

utilize a pre-engineered and customized packed bed odor control scrubbers and systems which utilizes hypochlorite with pH control to oxidize odorous compounds.

Planning costs have been included in Regulatory project costs for FY 2031+ totaling $800,000.

5.1.5.28 Electrical

Recommended electrical improvements include the following:

- Replace MCC-3 and any additional power panels (Maintenance Shop) along with the wooden cable pulling hut by the Maintenance Shop, possible combining into one new pre-fabricated fiberglass or concrete enclosure.
- Replace MCC-4 (located building in front of Digester Pump/Boiler Building), enlarge the building to provide adequate clearance in front of MCC-4 or possibly relocate it to the Oil Storage Building.
- Work included in Sludge Handling Project:
  - Electrical and Instrumentation complete.
  - Replace the Sludge Holding Pond Mixer Control Panel that is failing and add VFDs with turndown capability for all mixers. Possibly relocate the mixer control panel and the centrifuge control panels into their own separate, controlled space (possibly the upper level Blower Room).
    - Replace Failing Ultrasonic Level Sensor in Centrate Tank.
    - Automate controls for Centrate Flow
- Clean and inspect the three Caterpillar Standby Generation Systems (Sludge Handling, AB Blower/Pump Building and UV/Administration Building and upgrade the controls and wiring with systems enhanced for extreme use and corrosive areas (marine package), especially the generator system and near the Sludge Handling Facility and its associated ATS.
- Add air conditioning to the AB Blower/Pump Building Electrical Room to elongate the life of the ATS, VFD, and MCC and control panel equipment.
- Replace the 400kW ONAN Standby Generator System that presently feeds the RBC Blower Building, Metal Fabrication Shop, and Tertiary Pump Pit.
- Replace MCC-2 in the Metal Fabrication Shop.
- Replace the Solids Handling Building Standby Generation System and ATS.
- Replace the Blower/Pump Building MCC-AB, dependent on how well the existing MCC holds up when air conditioning is installed to the MCC Room space. It is highly likely that this may be able to be pushed out past 15 years.
- Replace the Solids Handling Building Standby Generation System and ATS.
- Replace the 500kW Kohler Standby Generation System near the Secondary Building. This generator is critical as it powers the entire North side of the WRF.
- Replace Utility Company primary service cables and transformers, depending on testing and future corrosion caused by exposure.
- Replace the Secondary Building, Pretreatment Building, and UV Building MCCs.

- Replace the Caterpillar Standby generation systems installed at the AB Blower/Pump Building and the UV Building.

5.1.5.29 Instrumentation

Recommended instrumentation improvements include the following:

- Tie in site access control, Intercom and CCTV (Admin/Driveway)
- Add Septage Receiving Station volume metering
- Access Control, Intercom, CCTV and Billing Recording (New Septage Receiving Station
- Add decant Flow metering from Sludge Storage Ponds
- Replace Sludge Blanket Level Detectors in Primary Clarifier
- Upgrade Splitter Box Flow metering inefficiencies
- Upgrade AB SLC5 PLC Processors.

5.1.5.30 Staffing Requirements

A preliminary analysis was conducted to estimate the number of additional staff that will be required to operate and maintain the expanded plant. The first step of this analysis was to benchmark the City's current staffing for treatment functions against other publicly and privately operated wastewater utilities across the country utilizing the EPA Staffing Model. The staffing review in Chapter 1.1 provides an indication that the City is currently providing the proper number of employees as the City's staffing level matches the EPA Staffing Model.

About 45 percent (9 of 19) of WRF staff are eligible for retirement over the next 8 years.

A plan needs to be in-place to maintain trained and skilled personnel to reliably operate the WRF. Limitations in the labor force will require an on-going employee search to find and hire qualified employees in advance.

To determine future treatment staff needs, the EPA Staffing Model was used to project requirements for the projected planning year WRF employing the selected activated sludge process, and using both anaerobic digestion and dewatering. Note that the EPA Staffing Model gives a general measure of nation-wide staffing levels and the detailed breakdown of employee classifications will differ. Refer to Table 5.1.8.

Table 5.1.8. Rapid City WRF EPA Staffing Estimate Worksheet

Projected 2035 Nominal Daily Average Flow = 13 MGD

Unit Process	Operation (Hours/Yr.)	Maintenance (Hours/Yr.)	Supervisory & Admin. (Hours/Yr.)	Clerical (Hours/Yr.)	Laboratory (Hours/Yr.)	Yard work and Misc. (Hours/Yr.)
Screening	1416	43				
Grit Removal	803	67				
Primary Clarification	2822	553				
Activated Sludge w/ Nitrification	12,932	3,312				
Secondary Clarification	2,648	439				
Anaerobic Digestion	1056	267				
Sludge Lagoons	174	104				
Dewatering	2,000	1,175				
Disinfection	380	437				
Subtotal Hours	24231	6,397	2,728	1,169	3,587	2,621
Technology Adjustment	2,423	-640	-218	23	72	262
Total Hours / Year / Category	26,654	5,757	2,510	1,192	3,659	2,883
Workers Required / Category	14.8	3.2	1.4	0.7	2.0	1.6
Total Number of Workers Required	23.7					
Current Staffing	19					
Total Additional Workers	5					

Note: 1 worker = 1,800 hours / year

This analysis projected 24 people for a typical publicly owned utility of this size. Based on the City's current level of staffing, a staff level of 24 people would seem appropriate at year 2035. This staffing level should be built up gradually, with one additional employee added in the next couple of years and two more staff added for each -Phase 1 and 2.

It is recommended that the City budget for a pretreatment employee to handle the additional workload requirements for monitoring mercury best practices at dental offices. The proposed pretreatment standards apply to wastewater discharges to the WRF from offices where dentistry is performed, including institutions, permanent or temporary offices, clinics, mobile units, home offices, and facilities, including dental facilities owned and operated by federal, state, or local governments. The proposed changes to 40 CFR 403 reflect EPA's recognition that the current regulatory framework needs to be adjusted for the effective implementation and enforcement of these pretreatment requirements on the dental industry. Therefore, EPA is proposing a new classification of CIU, specifically the tailored to the proposed rule -Dental Industrial User (DIU). The extent of the impact to the WRF workload is not final and the rulemaking should continue to be monitored.

5.1.6 Summary

Table 5.1.9 provides a summary of the preliminary recommendations to upgrade the Rapid City WRF to reliably treat the 2035 projected flows and loads. This table provides an overview of facility requirements, driving forces, urgency/timing considerations, site planning impacts and order of magnitude costs.

Table 5.1.9. Summary of Recommendations

Priority	Treatment Component	Recommended Improvements for the Design Year	Driving Force for Improvement						Urgency/Timing	Impact on Site Planning	Cost Impact[1]
			Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	Good Neighbor			
2	Site	Repair Roads				✓			Needed within 1-5 years.		Moderate
1	Influent Screening	Renovate the bypass to include an option unscreened bypass complete with alarming to SCADA.		✓			✓		High priority – This is a critical reliability issue. Need as soon as implementable.	None	Low to Moderate
3	Grit Removal	Major facilities are adequate for 13-mgd flow. Includes equipment replacement, including paddles and drives, and coating of the tanks.				✓			Continue to monitor condition.	None	Moderate
2	Primary Clarification	Major facilities are adequate. Replace aged equipment and improve walkways and handrails.	✓	✓					Much equipment has reached service life & failure will impact capacity. Access items are health & safety item. Scum pumping is currently not operational.	None	Low
3	Primary Effluent Flow Control	Construct new flow control structures to split flow between activated sludge basins.	✓	✓	✓		✓		Component of activated sludge system construction to meet permit limits.	Near new activated sludge basins. Coordinate with Phase 2.	Moderate
2	Clariflocculator	Build one new clariflocculator complete with appurtenant splitter box, pumps and piping.		✓		✓	✓		Needed for reliability.	Major new facilities, but located within currently developed treatment plant area. Need to keep other clariflocculator operational.	
To meet Permit #2 and #3	Activated Sludge System (Phase 1 and 2 Improvements)	Construct new aeration basin, blowers, and clarifiers and return sludge pumping station.	✓		✓				Driven by ammonia limit. Need Phase on-line in 2025 and Phase 2 on-line in 2030 as permit schedule dictates.	New facilities would be constructed adjacent to South Plant. Major site layout impact.	High
1	Existing Activated Sludge/Trickling Filter/RBC System	Implement provisional repair of Trickling Filter Lift Station, Sec. Clarifier Gear boxes, humus pumping, aeration basin curtain, & RBC airlines.				✓	✓		High priority – This is a critical reliability issue. Need as soon as implementable.	Retrofit within existing building. No site impact.	Moderately High
3	UV Disinfection	Replace UV effluent control gate actuators			✓	✓			Needed within 5-10 years.	Retrofit within existing structures. No site impact.	Low
5	Effluent Pumping & Outfall	Add new effluent pumps to protect the facility to the 500-year event.		✓	✓				Defer and monitor for final Executive Order.	Site impact – Provide placeholder adjacent to post aeration basin.	Moderately High - TBD
n/a	Primary Sludge Thickening	None required.									
n/a	Secondary Sludge Thickening	None required.									
1	Sludge Digestion	Digester roof access. Reinstall the waste gas flare feed piping to slope to drain. .Remove and replace the steel portion of the boiler gas feed lines.				✓	✓		Roof access needs to be provided to address health and safety.	None	Moderate
1	Sludge Storage Pond	Build one new sludge storage pond complete with new mixing for new and existing.		✓		✓	✓		Included as part of the sludge dewatering improvements.	Major new facilities, but located within currently developed treatment plant area to south of existing Sludge Holding Pond. Need to keep other pond operational.	Moderate

Priority	Treatment Component	Recommended Improvements for the Design Year	Driving Force for Improvement						Urgency/Timing	Impact on Site Planning	Cost Impact[1]
			Organic Capacity	Hydraulic Capacity	Regulatory	Age & Condition	Improve Operations	Good Neighbor			
1	Sludge Dewatering	Install dewatering handling equipment in new building. Include new feed equipment; discharge piing and polymer feed system. Provide new dewatered sludge conveyance and storage equipment as required for the selected operating schedule.		✓		✓	✓		High priority – This is a critical hydraulic and condition reliability issue. Need as soon as implementable.	Site impact for new two-level building and dewatered sludge storage to south of existing Sludge Dewatering Building.	High
1	Centrate Storage	Improve usability of existing tankage.	✓		✓		✓		Included as part of the sludge dewatering improvements.	Continued use of existing tankage. No site impact.	-
5	Odor Control	Construct odor control facilities for odor-related areas. Tie in existing odor sources.						✓	No timetable set – driven by neighboring growth.	Depends on technology selected.	Moderate
To meet Permit #2	Administration Facilities	New facilities needed for recommended staffing requirements. Heated garage are required due to lack of useable space on-site.	✓	✓			✓		Implement Phase 1 expansion.	New facilities will be located east of the existing Administration Building.	Moderate
To meet Permit #2	Maintenance Facilities	New cold storage facility recommended. Heated garage included in Administration Building Addition.					✓		No timetable set. Currently majority of service equipment remains outside.	New facilities will be located south of the existing cold storage building.	Moderate
n/a	Laboratory	No new facilities needed –space is adequate.							No timetable set.	No impact.	None
3,4	Treatment Plant Landscaping & Buffer	Establish landscape buffers and berms at perimeter of property.						✓	No timetable set. Desirable to establish perimeter landscaping as part of early projects.	Need to landscape interim and final property boundaries to create buffers.	Moderate
2	Compost Facility	Provide liquid sludge storage, which is used for blending.					✓		As soon as possible -extremely beneficial to operations' for both WRF and MRF	Not reviewed.	Low
2	HVAC Improvements	Replace bulk of HVAC equipment.							Much equipment has reached service life & failure will impact processes.	No impact.	Moderate

Cost Impact Legend
High: Over $3 million
Moderately High: $1 to $3 million
Moderate: $0.1 to $1 million
Low: Less than $0.1 million
None: No cost anticipated for planning year

5.1.7 Summary of Recommendations

Table S.23 provides a summary of the preliminary recommendations to upgrade the Rapid City WRF to reliably meet the new permit conditions. This table provides an overview of facility requirements, driving forces, urgency/timing considerations, and order of magnitude costs.

The summary of recommendation has been separated into the following categories:

5.1.7.1 Short-Term Capital Improvements

These are improvements required to reliably continue to treat the flow to meet the current permit. Short-term improvements are anticipated to be implemented within the next five years. These improvements address items such as treatment and hydraulic capacity items, reliability, operations and energy minimization. Priority 1 items are recommended to be completed in 2016 – 2018, and Priority 2 items completed by 2020.

5.1.7.2 Plant Modifications to meet 2025 Permit #2

These are improvements that will be necessary to meet the federally adopted ammonia criteria. These ammonia limits will be included in a future permit anticipated by 2025. These improvements primarily address treatment capacity upgrades.

5.1.7.3 Plant Modifications to meet 2030 Permit #3

These are improvements that will be necessary to meet future nutrient criteria limit of 10 mg/l TN and 1 mg/L phosphorus. These limits are planned for 2030; however, these limits are the most uncertain with respect to schedule and numeric criteria. These improvements primarily focus on an expanded activated sludge system.

5.1.7.4 Plant Modifications to meet Other Needs

These improvements are necessary to continue to meet the needs for the City of Rapid City to operate effectively and meet the effluent permit limits. These items have been given Priority 3 or 4 designations. Priority 3 items are planned to be completed in 2020 – 2025 and Priority 4 and items are planned for completion in 2025 – 2035.

Table 5.1.10. Summary of Recommendations

Component	Recommended Improvements	Implementation Date	Project Cost
Short-Term Capital Improvements			
Priority 1			
Activated Sludge Improvements	One new clariflocculator, curtain wall, drain pump	Priority 1 - 2016-2018	$4,014,000
Trickling Filter Pump Sta. Improvements	New pumps with VFDs to handle flow range, and repair and recoat pump discharge piping.	Priority 1 - 2016-2018	$2,410,000
Sludge Handling Project	Provide new dewatered sludge conveyance and storage equipment.	Priority 1 - 2016-2018	$11,950,000
Misc. Preliminary Treatment Improvements	Screening bypass, septage safety and volume, misc.	Priority 1 - 2016-2019	$150,000
Misc. Digester Improvements	Roof access, chemical feed, and waste gas improvements.	Priority 1 - 2016-2018	$106,000
Operations and Energy Improvement	Emergency operating plan, risk based SCADA and alarms and energy conservation measures	Priority 1 - 2016-2018	$590,000
	Priority 1 Subtotal		**$19,180,000**
Priority 2			
Site work	Roadways, plant access, Gaging Station, water well abandon	Priority 2 - 2018-2020	$434,000
Primary Treatment	Scum pumps & piping, skimmers and gearboxes, sludge level sensors, pumping room HVAC, railing, and misc. tuck-pointing.	Priority 2 - 2018-2020	$696,000
Secondary Clarification	Humus pumps, gear boxes, and clarifier railing	Priority 2 - 2018-2020	$264,000
RBCs and Generator	Repair RBC in-tank air piping, replace generator, HVAC	Priority 2 - 2018-2020	$311,000
Tertiary Clarifiers and Pumping	Costs to Maintain existing pumps, drives and HVAC	Priority 2 - 2018-2020	$60,000
Activated Sludge Improvements	Splitter box gate actuators, Blower intakes/HVAC, generator controls and misc. architectural	Priority 2 - 2018-2020	$156,000
UV Disinfection/Post Aeration Improvements	Generator controls and misc. architectural	Priority 2 - 2018-2020	$31,000
Digestion Area Improvements	Replace steel gas lines, boiler controls, electric modifications and misc. vac and architectural	Priority 2 - 2018-2020	$178,000
HVAC Improvements	Upgrade Secondary Building, Water Building, Maintenance Shop, and Metals Shop HVAC.	Priority 2 - 2018-2020	$624,000
Instrumentation, Electrical and Misc. Improvements	Maintenance Shop MCC, Integration of PLCs, and Samplers	Priority 2 - 2018-2020	$321,000

Component	Recommended Improvements	Implementation Date	Project Cost
Cold Storage Building and Misc. Architectural	Construct new cold storage building.	Priority 2 - 2018-2020	$715,000
Operations and Energy Improvement	Equipment Asset Management Software Updates (EAM), O&M Manual, SCADA Integration Plan i.e. smart drive monitoring.	Priority 1 - 2016-2018	$300,000
		Priority 2 Subtotal	**$4,092,000**
Plant Modifications - 2025 Permit			
Activated Sludge System (Phase 1 Improvements)	Construct new aeration basin, blowers (2), and secondary clariflocculators and return sludge pumping station.	2025	**$20,570,000**
Plant Modifications - 2030 Permit			
Activated Sludge System (Phase 2 Improvements)	Anoxic basins, recycle pumping	2035	**$7,800,000**
Plant Modifications - Other Needs			
Priority 3			
Sludge Handling Project	Provide Phased sludge conveyance and storage.	Priority 3	$1,220,000
Process	Includes equipment replacement, including paddles and drives, and coating of the tanks.	Priority 3	$647,000
Architectural	Administration Facilities Expansion - Building addition & site improvements	Priority 3	$990,000
Structural			$5,000
HVAC Improvements	AB Pump Room, UV Building, Secondary standby generator	Priority 3	$37,500
Electrical, Instrumentation, and Misc. Improvements	Remote monitoring capabilities, CMMS replacement, on-line metering capabilities	Priority 3	$185,000
Operation & Energy Total	SCADA/Remote Operations & Computerized Maintenance Management Software (CMMS) & On-line Monitoring	Priority 3	$290,000
	Priority 3 Subtotal		**$3,370,000**
Priority 4			
Sludge Handling Improvement	Phase 2 Sludge Handling Improvements	Priority 4	$3,460,000
Process	Miscellaneous process equipment replacement	Priority 4	$400,000
	Priority 4 Subtotal		**$3,860,000**
Priority 5			
Process Upgrades	Screen gear boxes, replace MCCs, grit classifier, gas flare and misc.	Priority 5	$657,000
HVAC Improvements	Replace digester boilers	Priority 5	$435,000

Component	Recommended Improvements	Implementation Date	Project Cost
Electrical, Instrumentation, and Misc. Improvements		Priority 5	$1,202,000
Odor Control	Construct odor control facilities for odor-related areas. Tie to odor existing sources.	Priority 5	$800,000
Priority 5 Subtotal			**$3,090,000**
Total			**$62,000,000**

5.1.8 Consequences of Inaction

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

- Non-compliance with discharge permit requirements
- Raw sewage spills, and associated public health impacts
- Water quality impairment of Rapid Creek
- Inability to handle wastewater generated by the community

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

Glossary[1]

10th Percentile	A low end statistic based on ranking a data set from the minimum to the maximum value. The 10th percentile defines the value for which 10% of the ranked data set is less than the statistic and 90% of the data set is greater than the statistic. Used in this study to define "worst-case" conditions for evaluation of "before and after" trends of dissolved oxygen.
90th Percentile	A high end statistic based on ranking a data set from the minimum to the maximum value. The 90th percentile defines the value for which 90% of the ranked data set is less the statistic and 10% of the data set is greater than the statistic. Used in this study to define "worst-case" conditions for evaluation of "before and after" trends of BOD5.
Activated sludge	A secondary wastewater treatment process that removes organic matter by mixing air and recycled sludge bacteria with sewage to promote decomposition.
Advanced primary treatment	Waste treatment process that incorporates primary sedimentation of suspended solids with chemical addition and flocculation to increase the overall removal of organic solids. Advanced primary treatment typically achieves about 50% removal of suspended solids and BOD.
Advanced secondary treatment	Biological or chemical treatment processes added to a secondary treatment plant including a conventional activated sludge to increase the removal of solids and BOD. Typical removal rates for advanced secondary plants are on the order of 90% removal of solids and BOD.
Advanced wastewater treatment (AWT)	Wastewater treatment process that includes combinations of physical and chemical operation units designed to remove nutrients, toxic substances, or other pollutants. Advanced, or tertiary, treatment processes treat effluent from secondary treatment facilities using processes such as nutrient removal (nitrification, denitrification), filtration, or carbon adsorption. Tertiary treatment plants typically achieve about 95% removal of solids and BOD in addition to removal of nutrients or other materials.
Aerobic	Environmental conditions characterized by the presence of dissolved oxygen; used to describe biological or chemical processes that occur in the presence of oxygen.
Algae	Any organisms of a group of chiefly aquatic microscopic nonvascular plants; most algae have chlorophyll as the primary pigment for carbon fixation. As primary producers, algae serve as the base of the aquatic food web, providing food for zooplankton and fish resources. An overabundance of algae in natural waters is known as eutrophication.

[1] This glossary is from the United States Environmental Protection Agency's *Progress In Water Quality: An Evaluation of the National Investment in Municipal Wastewater Treatment*, available online at http://water.epa.gov/polwaste/wastewater/treatment/benefits.cfm.

Algal bloom	Rapidly occurring growth and accumulation of algae within a body of water. It usually results from excessive nutrient loading and/or sluggish circulation regime with a long residence time. Persistent and frequent bloom can result in low oxygen conditions.
Ammonia	Inorganic form of nitrogen; product of hydrolysis of organic nitrogen and denitrification. Ammonia is preferentially used by phytoplankton over nitrate for uptake of inorganic nitrogen.
Anaerobic	Environmental condition characterized by zero oxygen levels. De scribes biological and chemical processes that occur in the absence of oxygen.
Anoxic	Aquatic environmental conditions containing zero or little dissolved oxygen. See also anaerobic.
Base flow	Sustained, low flow discharge rate in a stream derived from ground water discharge into the stream channel. During extended periods of low precipitation, baseflow may account for most, or all, of the streamflow.
Biochemical oxygen demand (BOD)	The amount of oxygen per unit volume of water required to bacterially or chemically oxidize (stabilize) the oxidizable matter in water. Biochemical oxygen demand measurements are usually conducted over specific time intervals (5, 10, 20, 30 days). The term BOD_5 generally refers to standard 5-day BOD test.
Carbonaceous	Pertaining to or containing organic carbon derived from plant and animal residues.
Carbonaceous BOD	Biochemical oxygen demand accounted for by decomposition of organic carbon derived from plant and animal residues.
Coliform bacteria	A group of bacteria that normally live within the intestines of mammals, including humans. Coliform bacteria are used as an indicator of the presence of sewage in natural waters.
Concentration	Mass amount of a substance or material in a given unit volume of solution. Usually measured in milligrams per liter (mg/l) or parts per million (ppm).
Constituent	A chemical or biological substance in water, sediments, or biota that can be measured by an analytical method (e.g., nitrate-N, organic carbon, or chlorophyll).
Consumptive use	That part of water withdrawn that is evaporated, transpired, or incorporated into a manufactured product, or consumed by humans or animals, or otherwise removed from the immediate waterbody environment.
Conventional pollutants	As specified under the Clean Water Act, conventional contaminants include suspended solids, coliform bacteria, biochemical oxygen demand, pH, and oil and grease.

Denitrification	Describes the decomposition of ammonia compounds, nitrites, and nitrates (by bacteria) that results in the eventual release of nitrogen gas into the atmosphere.
Discharge	The volume of water that passes a given point within a given period of time. It is an all-inclusive outflow term, describing a variety of flows such as from a pipe.
Discharge permits (NPDES)	A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. It is called the NPDES because the permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act. In South Dakota NPDES permits are referred to as Surface Water Discharge (SWD) Permits.
Dissolved oxygen (DO)	The amount of oxygen gas that is dissolved in water. It also refers to a measure of the amount of oxygen available for biochemical activity in water body, and as indicator of the quality of that water.
Diurnal	Actions or processes having a period or a cycle of approximately one tidal-day or are completed within a 24-hour period and which recur every 24 hours.
Domestic wastewater	Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.
Dynamic model	A mathematical formulation describing the physical behavior of a system or a process and its temporal variability.
Dynamic simulation	Modeling of the behavior of physical, chemical, and/or biological phenomena and their variation over time.
Effluent	Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.
Eutrophication	Enrichment of an aquatic ecosystem with nutrients (nitrogen, phosphorus nitrates, phosphates) that accelerate biological productivity (growth of algae, periphyton and macrophytes/weeds) and an undesirable accumulation of plant algal biomass.
Factor of Safety	Coefficient used to account for uncertainties in representing, simulating, or designing a system.
Fecal coliform bacteria	Coliform bacteria that are present in the intestines or feces of warm blooded animals including humans. They are often used as indicators of the sanitary quality of water. See Coliform bacteria.
Flocculation	The process by which suspended colloidal or very fine particles are assembled into larger masses or flocules that eventually settle out of suspension.

Frequency analysis	A numerical determination of the distribution of values for a parameter within a data set. See 10th percentile, median and 90th percentile.
Gaging station	A specific location on a stream, river, canal, lake or reservoir where systematic measurements of hydrologic data such as stage height and streamflow are collected. The USGS maintains and operates a network of stream gaging stations to collect hydrologic data for many streams and rivers. Historical streamflow and stage height data is available from the USGS streamflow database - (www.waterdata.usgs.gov/nwis-w). Earliest records are available from the late 19th century for some rivers.
In situ	Latin word for "in place"; in situ measurements consist of measurement of component or processes in a full-scale system or a field rather than in a laboratory.
Influent	Water volume flow rate or mass loading of a pollutant or other constituent into a water body or wastewater treatment plant.
Inorganic	Pertaining to matter that is neither living nor immediately derived from living matter.
Loading, Load, Loading rate	The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight (mass) per unit time.
Low-flow (7Q25)	Low-flow (7Q25) is the 7-day average low flow occurring once in 25 years; this probability-based statistic is used in determining stream design flow conditions and for evaluating the water quality impact of effluent discharge limits.
Mass balance	An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving the defined area. The flux in must equal the flux out to achieve a mass balance.
Mathematical model	A system of mathematical expressions that describe the spatial and temporal distribution of water quality constituents resulting from fluid transport and the one, or more, individual processes and interactions within some prototype aquatic ecosystem. A mathematical water quality model is used as the basis for waste load allocation evaluations.
Mean	The numerical average of a set of observations; computed as the sum of the observations divided by the number of observations in the data set.
Median (50th Percentile)	A middle statistic based on ranking a data set from the minimum to the maximum value. The median value divides the data set into so that one-half of the values are lower than the median and one-half of the values are greater than the median. The median is also defined as the 50th percentile value.
Milligrams per liter (mg/L)	A unit of measurement expressing the concentration of a constituent in solution as the weight (mass) of solute (1 milligram) per unit volume (1 liter) of water; equivalent to 1 part per million (ppm) for a water density ~1 g cm-3. 1 mg/L = 1000 ug/L; 1 g/L = 1000 mg/L.

Million gallons per day (mgd)	Rate of water volume discharge representing a volume of 1 million gallons of water passing across a given location in a time interval of 1 day. A flow rate of 1 mgd = 1.54723 cubic feet per second (cfs) = 0.04381 cubic meters per second (cms).
Mixing characteristics	Refers to the tendency for natural waters to blend; i.e. for dissolved and particulate substances to disperse into adjacent waters.
Mussels (Freshwater)	Freshwater mussels are mollusks and are similar to their marine clam and oyster cousins. They have two shells connected by a hinge-like ligament. Around the world, mussels live in a variety of freshwater habitats but are most prevalent in stream and rivers. They vary in their adult sizes from those as small as a thumbnail to others as big as a pie plate. The wide variety of shapes and colors are reflected in species like purple wartyback, pink heelsplitter, and threeridge. On the stream bottom, mussels are sometimes only noticeable by two small siphons, which are used to draw and expel water.
N/P ratio	The ratio of nitrogen to phosphorus in an aquatic system. The ratio is used as an indicator of the nutrient limiting conditions for algal growth; also used as indicator for the analysis of trophic levels of receiving waters.
Nitrate (NO_3) and Nitrite (NO_2)	Oxidized nitrogen species. Nitrate is the form of nitrogen used by aquatic plants for photosynthesis.
Nitrification	Biologically mediated process of the oxidation of ammonium salts to nitrites (via Nitrosomonas bacteria) and the further oxidation of nitrite to nitrate via Nitrobacter bacteria.
Nitrifier organisms	Bacterial organisms that mediate the biochemical oxidative processes of nitrification.
Nitrobacter	Type of bacteria responsible for the conversion of nitrite to nitrate.
Nitrogenous BOD (NBOD)	Refers to the biochemical oxygen demand associated with the oxidation of ammonia to nitrite and nitrate.
Nitrosomonas	Type of bacteria responsible for the oxidation of ammonia to the intermediate product nitrite.
Nutrient	A primary element necessary for the growth of living organisms. Carbon dioxide, nitrogen, and phosphorus, for example, are required nutrients for phytoplankton (algae) growth.
Organic matter	The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.
Organic nitrogen	Organic form of nitrogen bound to organic matter.
Outfall	Location point where wastewater or stormwater flows from a conduit, stream, or drainage ditch into natural waters.
Oxidation	The chemical union of oxygen with metals or organic compounds accompanied by a removal of hydrogen or another atom. It is an important factor for soil formation and permits the release of energy

	from cellular fuels.
Oxygen demand	Measure of the dissolved oxygen used by a system (microorganisms) and or chemical compounds in the oxidation of organic matter. See also biochemical oxygen demand.
Oxygen depletion	Deficit of dissolved oxygen in a natural waters system due to oxidation of natural and anthropogenic organic matter.
Oxygen sag	Description of characteristic spatial trend of the concentration of dissolved oxygen in a stream or river downstream of high loading rate of oxygen-demanding materials from tributaries, municipal or industrial wastewater dischargers, or urban stormwater and combined sewer overflow systems.
Oxygen saturation	The maximum amount of oxygen gas that can be dissolved in natural waters by transfer of oxygen from the atmosphere across the air water interface. The concentration of oxygen saturation is greatly influenced by water temperature, salinity or chlorides concentration and elevation above mean sea level, and other water characteristics.
Parameters	Constituents measured in water quality monitoring programs. Examples: dissolved oxygen, BOD_5, TSS, water temperature.
Parts per million (ppm)	Measure of concentration of 1 part solute to 1 million parts water (by weight). *See milligrams per liter*.
Per-capita use	The quantity of water used per person per day averaged over a time interval of 1 day; expressed as gallons per capita per day (gpcd).
pH	A measure of acidity indicated by the logarithm of the reciprocal of the hydrogen ion concentration (activity) of a solution. pH values less than 7 are acidic; values greater than 7 are basic; pH of 7 is neutral. pH of natural waters typically ranges from ~6-8.
Phosphorus	A nutrient essential for plant growth that can play a key role in stimulating the growth of aquatic plants in streams, rivers and lakes.
Pollutant	A contaminant in a concentration or amount that adversely alters the physical, chemical, or biological properties of a natural environment. The term includes pathogens, toxic metals, carcinogens, oxygen demanding substances, or other harmful substances.
Pretreatment	The treatment of wastewater to remove or reduce contaminants prior to discharge into another municipal treatment system or a receiving water.
Primary treatment	Wastewater treatment process where solids are removed from raw sewage primarily by physical settling. The process typically removes about 25-35% of solids and related organic matter (BOD5).
Publicly Owned Treatment Works (POTW)	Municipal wastewater treatment plant owned and operated by a public governmental entity such as a town or city.
Range	Statistical measure expressing the difference between the minimum and maximum values recorded for a given constituent in time and space.

Raw sewage	Untreated municipal sewage.
Reach (of a river)	A linear or longitudinal section of a stream or river defined by the upstream and downstream locations of lower stream order tributaries flowing into a higher stream.
Reaction rate coefficient	Coefficient describing the rate of transformation of a substance in an environmental medium characterized by a set of physical, chemical, and biological conditions such as temperature and dissolved oxygen level.
Reaeration	The net flux of oxygen transferred occurring from the atmosphere to a body of water with a free surface.
Removal efficiency	A measure of how much of a pollutant is removed from raw sewage prior to discharge into a receiving water after completion of waste water treatment processes. Expressed as percentage calculated as Removal % = [(influent - effluent)/(influent)] x 100.
Receiving waters	Creeks, streams, rivers, lakes, estuaries, groundwater formations, or other bodies of water into which surface water and/or treated or untreated wastewater are discharged, either naturally or in man-made systems.
Rotating biological contactors (RBCs)	A wastewater treatment process consisting of a series of closely spaced rotating circular disks of polystyrene or polyvinyl chloride. Attached biological growth is promoted on the surface of the disks. The rotation of the disks allows contact with the wastewater and the atmosphere to enhance oxygenation.
Secondary treatment	Waste treatment process where oxygen-demanding organic materials (BOD) are removed by bacterial oxidation of the waste to carbon dioxide and water. Bacterial synthesis of wastewater is enhanced by injection of oxygen.
Significance level	A statistical measure of the certainty that can be associated with the results of a statistical analysis.
State Revolving Fund (SRF)	Passed under the Amendments to the Clean Water Act (CWA) in 1987, the Clean Water State Revolving Fund (CWSRF) program replaced the long-running federal Construction Grants program. Under the CWSRF program, each state and Puerto Rico created revolving loan funds to provide independent and permanent sources of low-cost financing for a range of environmental water quality projects. As payments are made on loans, funds are recycled to fund additional water protection projects. While traditionally used to build or improve wastewater treatment plants, loans are used increasingly for agricultural, rural, and urban runoff control; wet weather flow control, including storm water and sewer overflows; alternative treatment technologies; small decentralized systems; brownfields remediation; and estuary improvements projects. Funds to establish SRF programs are provided through federal government grants (83 percent of total capitalization) and state matching funds (17 percent of total capitalization). To augment the federal and state capitalization, states may use the assets of the fund

	to support the issuance of bonds. At their option some states choose to transfer some Construction Grant funds into their CWSRF. From the beginning of capitalization in 1988 through 1999, federal contributions to the CWSRF program grew to $16.1 billion. Additional state match, state leveraged bonds, loan repayments and fund earnings increased CWSRF assets to over $30 billion since 1988.
Station (monitoring)	Specific location in a waterbody chosen to collect water samples for the measurement of water quality constituents. Stations are identified by an alphanumeric code identifying the agency source responsible for the collection of the data and a unique identifier code designating the location. Station measurements can be recorded from either discrete grab samples or continuous automated data acquisition systems. Station locations are typically sampled by state, federal or local agencies at periodic intervals (e.g., weekly, monthly, annual etc.) as part of a routine water quality monitoring program to track trends. Station locations can also be sampled only for a period of time needed to collect data for an intensive survey or a special monitoring program.
Stoichiometric ratio	Mass-balance based ratio for nutrients, organic carbon, dry weight and algae (e.g., nitrogen-to-carbon ratio).
Streamflow	Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term streamflow is more general than "runoff" as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.
Surface waters	Water that is present above the substrate or soil surface. Usually refers to natural water bodies such as streams, rivers, lakes and impoundments, and estuaries and coastal ocean.
Surface Water Discharge Permit	In South Dakota NPDES permits are referred to as Surface Water Discharge (SWD) Permits.
Suspended solids or load	Organic and inorganic particles (solids/sediment) suspended in and carried by a fluid (water). The suspension is governed by the upward components of turbulence, currents, or colloidal suspension.
Tertiary treatment	Waste treatment processes designed to remove or alter the forms of nitrogen or phosphorus compounds contained in domestic sewage.
Total Kjeldahl Nitrogen (TKN)	The sum total of organic and ammonia nitrogen in a sample, determined by the Kjeldahl method.
Total Maximum Daily Load (TMDL)	The sum of the individual wasteload allocations and load allocations. A margin of safety is included with the two types of allocations so that any additional loading, regardless of source, would not produce a violation of water quality standards.
Total coliform bacteria	A particular group of bacteria that are used as indicators of possible sewage pollution.

Trickling filter	A wastewater treatment process consisting of a bed of highly permeable medium (e.g., gravel or stones) to which microorganisms are attached and through which wastewater is percolated or trickled over the biofilm that forms on the media.
Wastewater	Usually refers to effluent from an industrial or municipal sewage treatment plant. See also domestic wastewater.
Wastewater treatment	Chemical, biological, and mechanical processes applied to an industrial or municipal discharge or to any other sources of contaminated water in order to remove, reduce, or neutralize contaminants prior to discharge to a receiving water.
Water quality	Numerical description of the biological, chemical, and physical conditions of a water body. It is a measure of a water body to support beneficial uses.
Water quality criteria (WQC)	Water quality criteria include both numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or States for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.
Water quality standard (WQS)	A water quality standard is a law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

UNIT PROCESS	NUMBER OF UNITS	DIMENSIONS AND/OR CAPACITY	HYDRAULIC DETENTION TIME (HOURS)			LOADING RATE		
			Ave. Day 11.3 MGD	Max. Day 22.2 MGD	Peak Hour 37.7 MGD	Ave. Day 11.3 MGD	Max. Day 22.2 MGD	Peak Hour 37.7 MGD
Mechanically Cleaned Screen	2	1/4" Passage @ 4.5' wide @ 18.5 MGD Each	-	-	-	-	-	-
Vortex Grit Removal	2	16 ft Dia. @ 20 MGD Each	-	-	-	-	-	-
Primary Clarifiers	4	40' x 142' x 7' SWD	2.5 hr	1.3 hr	0.8 hr	500 gpd/ft^2	980 gpd/ft^2	1,660 gpd/ft^2
Peak Flow Pump Station	-	10 MGD Capacity	-	-	-	-	-	-
Aeration Basins	12 Day SRT @ 2,200 mg/L MLSS							
L1 & R1	2	69.5' x 82' x 16' SWD	1.4 hr	0.7 hr	0.4 hr	-	-	-
L2 & R2	2	68.7' x 82' x 16' SWD	1.4 hr	0.7 hr	0.4 hr	-	-	-
L3 & R3	2	69.3' x 82' x 16' SWD	1.4 hr	0.7 hr	0.4 hr	-	-	-
L4 & R4	2	60' x 41' x 16' SWD	0.6 hr	0.3 hr	0.2 hr	-	-	-
Aeration Basin Totals:	-	-	9.9 hr	5.0 hr	3.0 hr	-	-	-
Clariflocculators	2	110 ft Dia. x 16' SWD	4.8 hr	2.5 hr	1.4 hr	600 gpd/ft^2	1,170 gpd/ft^2	1,980 gpd/ft^2
Solids Loading on Clariflocculator at 2,200 mg/L MLSS	-	-	-	-	-	7.3 lb/ft^2/day		
UV System	2	20 MGD each	-	-	-	-	-	-
Effluent Parshall Flume	1	5 ft throat width	-	-	-	-	-	-
Primary Anaerobic Digesters	2	60 ft Dia. x 25 ft SWD	23.2 days	21.5 days	-	80 lb-VSS/ (1,000 ft^3-day)	-	-
Secondary Anaerobic Digester	1	50 ft Dia. x 24 ft SWD	7.7 days	7.1 days	-			
Liquid Sludge Storage	2	1.9 MG Total Volume	-	-	-	-	-	-
Volute Press	2	6.7 gal/hr	-	-	-	-	-	-
Dewatered Sludge Storage	-	257 cu. Yd	-	-	-	-	-	-

UNIT PROCESS	NUMBER OF UNITS	DIMENSIONS AND/OR CAPACITY	HYDRAULIC DETENTION TIME (HOURS)			LOADING RATE		
			Ave. Day 13.0 MGD	Max. Day 25.5 MGD	Peak Hour 43.5 MGD	Ave. Day 11.3 MGD	Max. Day 25.5 MGD	Peak Hour 43.5 MGD
Mechanically Cleaned Screen	2	1/4" Passage @ 4.5' wide @ 18.5 MGD Each	-	-	-	-	-	-
Vortex Grit Removal	2	16 ft Dia. @ 20 MGD Each	-	-	-	-	-	-
Primary Clarifiers	4	40' x 142' x 7' SWD	2.2 hr	1.1 hr	0.7 hr	570 gpd/ft^2	1,120 gpd/ft^2	1,920 gpd/ft^2
Peak Flow Pump Station	-	10 MGD Capacity	-	-	-	-	-	-
Anoxic Basins								
L1 & R1	2	450,000 gallons Each	1.7 hr	0.9 hr	0.5 hr	-	-	-
Anoxic Pumps	3	1-4 Q	-	-	-	-	-	-
Aeration Basins	12 Day SRT @ 2,200 mg/L MLSS							
L1 & R1	2	69.5' x 82' x 16' SWD	1.3 hr	0.6 hr	0.4 hr	-	-	-
L2 & R2	2	68.7' x 82' x 16' SWD	1.2 hr	0.6 hr	0.4 hr	-	-	-
L3 & R3	2	69.3' x 82' x 16' SWD	1.3 hr	0.6 hr	0.4 hr	-	-	-
L4 & R4	2	60' x 41' x 16' SWD	1.5 hr	0.3 hr	0.2 hr	-	-	-
Aeration Basin Totals:	-	-	8.6 hr	4.4 hr	2.6 hr	-	-	-
Clariflocculators	4	110 ft Dia. x 16' SWD	8.4 hr	4.3 hr	2.5 hr	340 gpd/ft^2	670 gpd/ft^2	1,140 gpd/ft^2
Solids Loading on Clariflocculator at 2,200 mg/L MLSS	-	-	-	-	-	7.3 lb/ft^2/day		
UV System	2	20 MGD each	-	-	-	-	-	-
Effluent Parshall Flume	1	5 ft throat width	-	-	-	-	-	-
Primary Anaerobic Digesters	2	60 ft Dia. x 25 ft SWD	20.4 days	18.9 days	-	80 lb-VSS/(1,000 ft^3-day)	-	-
Secondary Anaerobic Digester	1	50 ft Dia. x 24 ft SWD	6.8 days	6.3 days	-			
Liquid Sludge Storage	3	2.2 MG Total Volume	-	-	-	-	-	-
Volute Press	3	6.7 gal/hr	-	-	-	-	-	-
Dewatered Sludge Storage	-	196 cu. Yd	-	-	-	-	-	-