2024 TECHNICAL REPORT

Case Studies of Power Plants Using Municipal Effluent as an Alternative Water Source

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3002029983

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ABSTRACT

Current operations at electric power plants are forced to handle fluctuating water availability from shifting climate conditions, erratic precipitation patterns, prolonged drought, as well as deteriorating water quality from algae blooms, higher water temperatures, and eutrophication. Simultaneously, the power industry is moving toward decarbonization, where water-intensive technologies such as carbon capture and electrolyzers are expected to be deployed. With these challenges in mind, along with a growing population and related industrial demands, alternative water sources outside of traditionally used freshwater ground- or surface water should be considered as a way to enhance resiliency and mitigate climate impacts.

This report is intended to initiate conversations regarding the use of treated municipal wastewater (MWW) as an alternative water source within power generation, focusing on six case studies. These case studies are located across the United States and highlight various treatment systems and uses of treated MWW throughout the plant.

Keywords

Alternative water sources
Municipal effluent
Treated municipal wastewater (MMW)

EXECUTIVE SUMMARY

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Product Title: Case Studies of Power Plants Using Municipal Effluent as an Alternative Water Source

Primary Audience: Power generation station personnel; water resources planners; staff working with treated municipal wastewater (MMW) or alternative water sources.

KEY RESEARCH QUESTION

Several research questions are addressed in this report:

- What type of treatment(s) is required to use MWW at a site?
- What issues arise while using MWW, and how are they addressed?
- What are the relationships between the generation station and the municipality?
- What changes would on-site personnel make to the treatment system design, if possible?
- What advice would on-site personnel give to those considering the use of MWW at their site?

RESEARCH OVERVIEW

This report is intended to initiate conversations on the use of treated municipal wastewater within power generation, focusing on six case studies. These case studies are located across the United States and highlight various treatment systems and uses of treated MWW throughout the plant. Information was gathered through multiple site visits and interviews with plant personnel.

KEY FINDINGS

Although each case study has its own unique experiences, common themes emerged across most or all:

Drivers:

- Most case studies were initially driven by limited water accessibility, with secondary drivers including regulations, reputation, and environmental concerns.
- Alternative water sources such as groundwater were frequently ruled out because of poor quality.
- Water quantity or quality are frequently both drivers and challenges for sites.

System information:

- All case studies use either zero liquid discharge systems or send their wastewater back to the municipality instead of discharging through a National Pollutant Discharge Elimination System permit.
- Most sites rely on their municipality for water and were not designed to include a backup source.
- Water treatment systems vary based on the intended use of MWW (cooling, service, demineralization) and incoming water quality. Several case studies were willing to share information regarding the water quality of their influent MWW stream.

Relationship to municipality:

- Having close working relationships with the municipality is crucial for timely excursion notifications and coordinating any planned work or operational issues.
- Most sites reported the timeliness of excursion notices as the most significant issue.
- Most case studies do not have regular access to wastewater treatment plant (WWTP) effluent water quality data. Several use on-site monitoring for key parameters because of limited accessibility from the WWTP side as well as a difference in measured parameters for WWTPs versus power plants.
- Financially, case studies that are not ZLD generally pay to receive the treated MWW and send it back.

Benefits and challenges:

- The main benefit of using treated MWW is the ability to site a power plant in otherwise unsuitable locations.
- The most common challenge that case studies experienced was total suspended solids (TSS) slugs from WWTP excursions, which can increase chemical treatment costs and potentially damage water treatment equipment further upstream.
- Sites without influent water holding systems (reservoirs or raw water tanks) struggle with residence time as a common challenge.
- Another common challenge is the ability to reroute influent MWW that is out-of-specification. Several case studies reported not being able to shut off their pipeline as well as a lack of accountability on the WWTP to ensure that required influent water quality standards are met.

Lessons learned:

- WWTPs that handle larger populations will most likely also experience higher rates of excursions.
- Sites that route influent MWW directly to a treatment system often struggle with fluctuating influent water quantity and quality. Sites with a front-end reservoir or storage

tank can use them as an equalization tank and have more residence time if the WWTP shuts down unexpectedly.

WHY THIS MATTERS

Electric power plants are experiencing unpredictable changes in water quantity and quality because of factors including shifting weather patterns, increased algae blooms, and higher surface water temperatures. These changes to water supply, coupled with rapidly growing power demands, require the consideration of alternative water sources outside of traditionally used freshwater ground- or surface water.

HOW TO APPLY RESULTS

Current operations are forced to handle fluctuating water availability from shifting climate conditions, erratic precipitation patterns, and prolonged drought as well as deteriorating water quality from algae blooms, higher water temperatures, and eutrophication. Simultaneously, the power industry is moving toward decarbonization, where water-intensive technologies such as carbon capture and electrolyzers are expected to be deployed. With these challenges in mind, along with a growing population and industrial demands, alternative water provides a way to enhance resiliency and mitigate impacts. Considerations for use are relevant for sites dealing with current water quantity or quality issues, sites considering the implementation of water-intensive post-combustion carbon capture or electrolyzers, sites that plan to expand their capacity but may not be able to expand their water withdrawal permits, and future planned sites that have not yet sourced their water and may struggle to do so because of quality, quantity, or regulatory issues.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- *Can Alternative Water Supplies Effectively Support Power Generation?* EPRI, Palo Alto, CA: 2017. 3002012044.
- *Water Supplies for Power Generation*. EPRI, Palo Alto, CA: 2017. 3002012045.

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PROGRAM: Water Treatment Technologies, P238

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1 INTRODUCTION

Electric power plants are experiencing unpredictable changes in water quantity and quality due to factors including shifting weather patterns, increased algae blooms, and higher surface water temperatures. These changes to existing water supply, coupled with rapidly growing power demands, requires the consideration of alternative water sources outside of traditionally used freshwater ground- or surface water.

Current operations are forced to handle fluctuating water availability from shifting climate conditions, erratic precipitation patterns, prolonged drought, as well as deteriorating water quality from algae blooms, higher water temperatures, and eutrophication. Simultaneously, the power industry is moving towards decarbonization, where water-intensive technologies such as carbon capture and electrolyzers are expected to be deployed ([1], [2]). With these challenges in mind, along with a growing population and industrial demands, alternative water provides a way to enhance resiliency and mitigate impacts. Considerations for use are relevant for existing sites dealing with high influent water temperature and algae blooms, existing sites considering the implementation of post-combustion carbon capture (PCC) or electrolyzers, and planned sites that have not yet sourced their water and may struggle to do so due to quality, quantity, or regulatory issues.

Alternative water sources, such as brackish groundwater, reverse osmosis (RO) reject, municipal and industrial effluent, and stormwater can contribute to the development of a more resilient power industry. Treated municipal wastewater (MWW), or municipal effluent, is the most commonly used alternative water at power generation stations. Many sites using MWW today were designed this way due to drivers like limited freshwater access. While multiple plants across the United States currently use MWW, there is a lack of conversation between them, including discussion over best practices and lessons learned when using this specific type of alternative water.

This document aims to initiate conversations regarding the use of treated municipal wastewater (MWW) within power generation, focusing on six different case studies. These case studies are located across the United States and highlight different treatment systems and uses of treated MWW throughout the plant. Information was gathered through multiple site visits and interviews with plant personnel. Questions addressed within this paper include the following:

- What type of treatment(s) is required to use MWW at the site?
- What issues arise while using MWW and how are they addressed?
- What are the relationships between the generation station and the municipality?
- What changes would the onsite personnel make to the treatment system design, if possible?
- What advice would onsite personnel give to those considering the use of MWW at their site?

The goal of this paper is to compile learnings from power plants currently using MWW to support and enable future use of alternative water sources[1]. Table 1 summarizes basic information for each case study, with detailed discussions on drivers for use, system information, municipality relations, benefits, challenges, and lessons learned included in individual case study sections. All case studies were verified with plant personnel.

[1] While this deliverable focuses specifically on municipal wastewater, EPRI is researching other alternative water sources and has an active Alternative Water User Group. Please contact a member of Program 238, Water Treatment Technologies, if interested in joining.

2 CASE STUDIES

Table 1. Overall summary table of different case studies

Case Study	State	Fuel Type(s)	Plant capacity (~MW)	MWW use(s)	MWW used (~MGD)	Years used	Initially used MWW?
A	Mississippi	NGCC	735	Cooling, Fire, Demin, Evap cooler	0 – 5.5	10	Yes
B	Mississippi	NGCC	765	Cooling, Service, Demin	4	21	Yes
C	Florida	Coal, NGCC	1,883	Cooling, Service, Fire	10	37	Yes
D	Nebraska	NGCC	164	Cooling, Service, Demin	0.2	21	Yes
E	Georgia	NGCC	1,250	Cooling	10 – 12	22	Yes
F	Arizona	Nuclear	4,238	Cooling	65 – 85	38	Yes

Case Study A

Overview

Case Study A is a 582-MW nameplate capacity, 735-MW maximum capacity NGCC plant in Mississippi. "A" utilizes 0 – 5.5 MGD of treated municipal wastewater from a nearby municipality as a supply for cooling water, fire water, demin water, and evaporative coolers. The supply can also be used for service water if needed. This site originally planned to use MWW and has been doing so for the past 10 years.

Drivers

"A" is located further inland than many of Mississippi's other power plants to provide better protection from severe weather events, i.e. hurricanes. The plant's location was chosen due to this sheltering effect as well as the site being near a deposit of coal that could be mined for fuel supply. The site has no surface water available nearby. Drilling was done to locate potential deep-well water source(s), but the salinity of the water found would have necessitated a desalination plant for treatment. Treated MWW was the next water source for consideration, and was the source ultimately decided upon.

Table 2. Key drivers of MWW use and reasoning for Case Study A

	Driver	Benefit	Challenge
Quantity	X	X	
Quality			X
Reputation			
Regulatory			X
Cost	X		

System Information

Treated municipal wastewater is supplied from a nearby city. Incoming water is transported from the city's two WWTP pumping stations through a 32-mile pipeline and into a reservoir located onsite at "A". The site takes the majority of the main WWTP's effluent and all the eastern WWTP's effluent due to the eastern site having no NPDES discharge permit. Water use is variable and dependent on season and local rainfall amounts. The site can take up to 6,000 – 8,000 GPM, down to 400 GPM, and sometimes down to 0. This is generally experienced in the wintertime when rainfall is high and supplies the reservoir with water. If the pipeline is not used for an extended period and the MWW effluent stagnates in the pipeline, the site can experience a slug of TSS once the pipeline begins to flow again. This is avoided by "A" whenever possible. Average incoming water quality parameters are included below in Table 3.

Table 3. Characteristics of incoming treated MWW for Case Study A

Constituent	Units	Average Influent
Conductivity	µmhos/cm	367
Dissolved Oxygen	mg/L	8
Oxidation Reduction Potential	mV	113
pH	-	8.6
Temperature	Deg. C.	23
Turbidity	NTU	2
Alkalinity	mg/L $CaCO_3$	51
TSS	mg/L	1.4
Nitrogen, Ammonia by Gas Diffusion	mg/L as N	0.18
Nitrogen, Nitrate/Nitrite	mg/L as N	11.4
Nitrogen, Total, Calculation	mg/L	11.3
Ortho Phosphate	mg/L as P	0.50
Phosphorus, Total	mg/L	0.50
Sulfate	mg/L	27
Dissolved Organic Carbon	mg/L	5.0
Total Organic Carbon	mg/L	4.5

After the treated MWW enters the reservoir, it is filtered using a mix of 55 µm and 100 µm Amiad disc filters, then acid and bleach are dosed, and the water passes through four 200 µm UF filters. After filtration, the water is sent to a flocking tank, where the site used to add ferric chloride but no longer does, and then to two 0.04 µm UF units. After UF, the water is sent to the site's filter water tank. From this tank, water can either be used as fire water, cooling for the system, as a source for service water, or sent for further treatment to create demin water. To create demin, the filter water is first passed through 5 µm cartridge filters (to remove any particulates that may have accumulated in the filter tank), then a 2-stage, 2-pass RO system. After the RO system, the water is stored in a permeate tank, where water is pulled from and then sent through a de-gasifier and 2 mixed beds to create the final demin water. The demin water is then stored in the site's condensate tank. A summarized flow of the process is included in Figure 1.

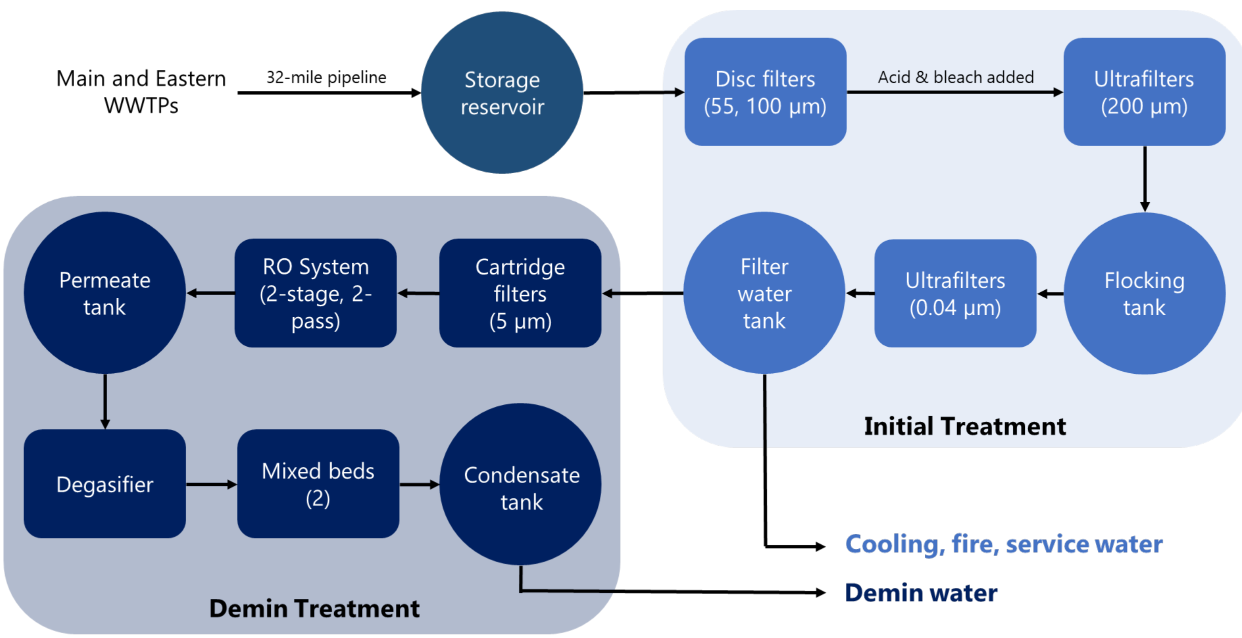

Figure 1. Process flow for Case Study A

The site is considered zero liquid discharge. Wastewater is processed on-site using thermal evaporators. Produced solid waste is disposed of using a landfill and distillate from the thermal evaporators (~200 gpm) is used to feed the cooling towers. While technically a ZLD site, "A" does have an NPDES permit for their incoming MWW reservoir in case of extreme weather events and overflow conditions. An overflow event has not occurred at the site.

Relationship to Municipality

Case Study A reported that involvement with the municipality has diminished throughout the years due to high turnover rates. At one point, "A" received a bi-weekly spreadsheet of water quality data, but is currently receiving data monthly. The municipality has never provided any real-time data on their effluent. "A" has several meters located at the reservoir itself and incoming to the filtration system, but no direct monitoring is located on the MWW influent point coming into the site's reservoir. "A" reports that reservoir conductivity drops in the winter and increases in the summer, presumably due to increased rain during the wintertime. Increased rain in the reservoir also means that "A" does not require as much treated MWW, and that the treated MWW already present in the reservoir is diluted.

If there is a municipality upset, Case Study A is aware of it roughly 8-24 hours later when the MWW effluent travels through the 32-mile pipeline and enters the reservoir. "A" cannot reject water from the municipality due to having an open-ended pipeline at the end (no gate valve available). Excursions must be handled reactively by the site. The most common excursion from the municipality is slugs of high TSS. However, it was noted that this could be caused by WWTP operations or by water in the pipeline becoming stagnant for a period of time. "A" reported that the reservoir chemistry remains consistent and that WWTP excursions are not a large issue at the site.

Regarding the legal contract between Case Study A and the nearby WWTPs, the contract is written favorably for the municipality, because "A" cannot reject the water and is solely dependent on it as a source for the site. The power plant pays to purchase the water from the municipality, and pays an administration fee monthly, regardless of whether they receive water or not. The administration fee is used to cover an extra step of chlorination when sending through the 32-mile pipeline; however, the municipality does not currently do this. In terms of system ownership, the 32-mile pipeline is owned by the power plant company, and the main and eastern pumping stations are partially owned. The power plant company does not own any part of the two WWTPs.

Benefits and Challenges

The site has experienced several O&M difficulties from the use of treated MWW effluent.

- IUF (Inlet Ultra Filtration) Strainers: The site originally took influent water directly from the reservoir into the IUF system, which required them to backflush these strainers every 4 minutes. They modified the system by adding piping to flow the reservoir water through the Amiad disc pond water filters (PWF) before sending it to the IUF system, which extends the time to 220 minutes between backflushes.
- Pond water filters (PWF): The disc filters directly after the reservoir struggled with algae build-up and could only run ~45 minutes between backwashes. In the wintertime when algae growth is lower, this increases to 24 hours between backwashes. Backwashes for the PWF system were originally from the Ultra Filtration tank and could use as much as 240,000 gallons of filtered water per day. Case Study A made logic changes and now uses the PWF outlet water to backwash themselves, and no longer uses any filtered water for the PWF backwashing.
- Algae: The primary issue reported by Case Study A is the algae growth that they experience within their reservoir. It has been an iterative process at the site to fix issues within the system caused by increased biological growth. Lowering the micron size of the initial pond water filters (listed above) helped.

- Pipeline maintenance: "A" typically does not take flow through the pipeline in the winter, and restarts flow through the pipeline around February. Although the pipeline drops over the 32 miles and drains into the reservoir, left-over residuals can continue to develop over the months that the pipeline is not used. When it's opened in February, "A" has no choice but to handle whatever is washed out into the reservoir.

Currently, the site is utilizing low-dosage copper to control algae growth within the reservoir. Higher doses, or alternative algaecides, are not allowed due to the site's NPDES permit for their emergency discharge point on the water storage reservoir.

Regarding severe weather events, if the site's reservoir reaches maximum level and threatens to discharge, there is an actuator that can be closed from the main WWTP's pumping station to shut off this flow. This requires the city to then handle the effluent flow. The pipeline connecting the main and eastern pumping stations that then flow to the plant can be bypassed, and the effluent redirected from the east pump to the main pump. This scenario is avoided whenever possible, and only done if the reservoir level is leading to imminent discharge, or if there's an outage and the plant does not require any water.

Advice for Future Users/Lessons Learned

When asked what Case Study A would change about their system if they could re-design it, the site had several requests as well as recommendations for future users.

Municipality Contract

- Make sure that the Terms & Conditions and Liquidated Damages are satisfactory for the power plant.
- Include parameters for the required quality of incoming MWW effluent to get consistency.
  - Include mechanisms so that if influent MWW doesn't meet the parameters set in the contract, then it automatically recycles or shuts down the pipeline in some way.
- Make sure that the water is chlorinated when it comes to the power plant, especially if it's being transported through a longer pipeline.

System Design

- Include a clarifier or raw water tank after the reservoir, before entering the pond water filtration system.
  - Provide a starting point where the quality of water can be measured before being sent to filters.
  - Allows for the pre-treatment of water if needed (chlorination, flocculation) and acts as a buffer before the treatment system
- Include a way to close off the influent pipeline when needed
  - Consider designing an automatic shut-off system according to incoming water quality
  - "A" reported that TSS, pH, and conductivity would be the best parameters to measure

- Include a turbidity curtain (also called a boom/floating boom) in front of the inlet to help settle any TSS plugs that come through the pipeline
  - "A" reported that turbidity issues from the WWTPs relate to stormwater run-off events from the city
  - When construction occurs (trees planted, gravel graded) and then rain, the plant can see turbidity of the influent increase

Verification

Verification for Case Study A was completed by multiple onsite chemistry technicians, the site Compliance and Support Manager, and several members of the utility Environmental Compliance group.

Case Study B

Overview

Case Study B is a 765-MW (nameplate capacity) NGCC plant in Mississippi. "B" utilizes roughly 4 MGD of treated municipal wastewater from a nearby municipality to supply their cooling, service, and demin water. This site originally planned to use MWW and has been doing so for the past 21 years.

Drivers

The location of Case Study B is not near any surface water, and a test well dug on-site showed high iron levels. Therefore, treated MWW was chosen as the water source, and the plant was initially designed to take this effluent from a nearby municipality.

Table 4. Key drivers of MWW use and reasoning for Case Study B

	Driver	Benefit	Challenge
Quantity	X	X	
Quality			X
Reputation			
Regulatory			
Cost			X

System Information

Treated municipal wastewater is supplied from a nearby municipality. Incoming water to the plant is pumped from the city's treated wastewater lagoon through a 17-mile pipeline and into the site. With all three units running onsite, water use averages 4 MGD, but can vary depending on the seasons.

After the treated MWW leaves the pipeline, it routes into a surge tank. The water from the surge tank is pumped through automatic in-line strainers to a clarifier, where bleach is added (~35 ppm).

The original site design included the clarifier, flocculation and blowdown system, and a filter press, but this was difficult to maintain as there was less influent TDS than expected. The original flocculation and blowdown systems were decommissioned in 2006, and automatic inline strainers were added before the clarifier. The addition of the automatic strainers was an improvement for the site both operationally and safety-wise. The strainers blow down automatically; “B” reported experiencing high ΔP issues generally less than once a year. The clarifier currently acts as a holding tank for the system.

From the clarifier, the water is sent to a clearwell, a raw water forwarding pump, and then two 50,000-gallon service water tanks. From the service water tanks, the water can be sent to the cooling tower, used in the service water system for fire water, or sent for further treatment to the demin plant. Local potable water can be used to supply the demin plant, but this is very uncommon. The demin plant consists of two multimedia tanks, UF treatment, carbon filters, RO prefilters, a 2-pass, single-stage RO system, and EDI / Mixed beds. The final demin water is stored in a demin tank. The plant reports using an average of 45 GPM of demin water. The process flow is included below in Figure 2.

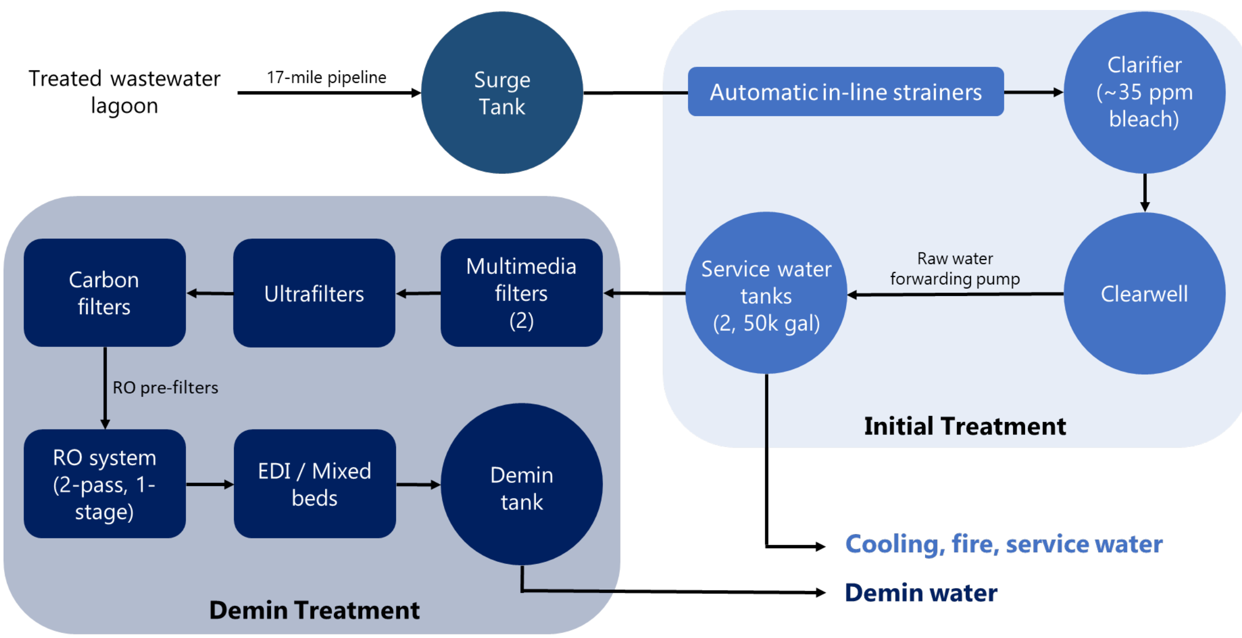

Figure 2. Process flow for Case Study B

The site does not discharge any wastewater. All water on the site, such as cooling tower blowdown, inline strainer backwash, and stormwater, routes to the site outfall which is sent back to the WWTP. Case Study B reports that the water that they send back to the municipality is cleaner than the water they receive from the pipeline.

Relationship to Municipality

Case Study B reports that there are times when the municipality gives them advanced warnings about process upsets and times when they do not. If “B” is not warned ahead of time about excursions, they will see its impact in the clarifier, i.e. typically high TSS. “B” does have a modem that allows them to turn the WWTP lagoon pumps on or off based on the site’s tank levels. This allows the plant to shut off the pipeline if it experiences an excursion from the municipality. However, due to low volume of the service water tanks (100,000 gallons combined), the plant can only run 8-12 hours at base load before the pipeline has to be re-opened. Case Study B has not yet had to shut down due to lack of water, but they reported there being close calls in the past when the municipality was shut down for maintenance. “B” is currently working with the municipality to schedule tours between the two entities to foster closer connections and better communication.

Regarding the legal contract between Case Study B and the municipality, “B” pays the municipality to both receive the treated MWW and send it back after use. If the WWTP cannot provide enough MWW for “B”, the municipality cuts in potable water, and “B” is charged the additional price of potable water. The municipality does have limitations for water conductivity and pH sent to “B”, but these are not always met. There is also a minimum chlorine residual requirement of 0.2. Additionally, “B” has water quality limitations (ex. pH range) that they must meet before sending their outfall water back to the municipality. These limitations are included in their discharge agreement. In terms of system ownership, the 17-mile pipelines that transports water to and from the site and the influent pump station are the responsibility of the WWTP. Anything within the property lines of Case Study B, such as the remaining pipeline portions and the effluent pump station, are the responsibility of the site.

Benefits and Challenges

Case Study B reports that the main water-related issue that they have is corrosion within their fire protection system and on their service water valves. “B” reports that excursions from the municipality are rare, but when they do occur, can cause many issues within the water treatment system. The only excursions that the site has experienced are plugs of extremely high TSS water.

The plant no longer has a flocculant/blowdown system that can be used to settle out solids within the clarifier. Instead, solids are typically caught in the multi-media filters (MMFs). If the TSS is high enough that the MMFs do not catch all solids, the plug can continue through the system and damage the RO membranes and EDI system. Case Study B reported previously experiencing a 36-hour high TSS slug that killed both the RO and EDI systems and required system replacement. “B” had to bring a demin trailer on-site while they cleaned and replaced the systems. High solids can also clog lines, which requires the site to undo valves and wire the system out to unclog it. Typically, the site sees solid levels rise in the summertime, or when there’s a drought, due to the lagoon water level decreasing and solids concentration increasing.

Case Study B reports experiencing no biological growth or algae issues due to bleach usage. “B” states that, while not flawless, the system makes good water and rarely experiences issues.

Advice for Future Users/Lessons Learned

When asked what Case Study B would change about their system if they could re-design it, the site had several requests. "B" reported that their recommendations for future users would depend on the water that the site is receiving. "B" is supplied by a smaller municipality, so the site does not experience as many excursions as one might receive when using wastewater from a larger city.

Lessons Learned

- Case Study B switched cooling tower chemicals to a GenGuard© product, which helped them raise their cooling tower cycles of concentration (CoCs) and reduce water usage
  - Reported increasing conductivity ~40% and reducing chemical usage (anti-scalant, caustic, bleach) due to the reduction in water being brought in.
  - Before switching to GenGuard©, the total residence time of the system with the pipeline closed was 5 – 6 hours when relying solely on service water tanks.

System Design

- Consider designing a site to have a backup source of water (i.e. well water).
  - "B" is solely dependent on wastewater.
  - If the WWTP goes down, the powerplant goes down.
- Include a service water pond or influent pond to provide more residence time for the site in case the MWW provider experiences system upsets.
- Include a reclaim tank to allow for re-use of HRSG blowdown.
  - Clean HRSG blowdown is currently sent directly to the site outfall.
  - Reuse of HRSG blowdown to cooling towers or water inlet could extend how much time the plant would have using their on-site water supplies.

Verification

Verification for Case Study B was completed by the Plant Manager, Program Manager, Maintenance Manager, Operations Manager, and onsite Chemist/Technical Service Analyst.

Case Study C

Overview

Case Study C is a 1,883-MW nameplate capacity power plant (936-MW Coal, 933-MW NGCC, 14-MW Solar) located in Florida. "C" utilizes approximately 10 MGD of treated municipal wastewater from a nearby municipality as a supply for their cooling, service, and fire protection water. This site originally planned to use MWW and has been doing so for the past 37 years.

Drivers

The location of Case Study C is not in proximity to any surface water. Well water was not chosen as a water source due to the volume required by the site to run. Additionally, the site is within proximity to a river basin that could have been negatively impacted had the site chosen to discharge its wastewater. Therefore, Case Study C decided to use treated MWW as their water source, and the plant was designed initially to take this effluent from a nearby municipality. “C” also takes a smaller stream of the county’s landfill leachate alongside the reclaimed MWW stream. Well water is utilized for the site’s potable water and demin water sources.

Table 5. Key drivers of MWW use and reasoning for Case Study C

	Driver	Benefit	Challenge
Quantity	X	X	X
Quality			
Reputation	X		
Regulatory	X		
Cost		X	
Other: Environmental	X		

System Information

Treated municipal wastewater and municipal landfill leachate/run-off blend are supplied from a nearby municipality and landfill. The WWTP supplying the MWW is a tertiary-treated facility. The Class III section of the landfill discharges wastewater consisting of landfill leachate diluted with groundwater and stormwater, to its on-site wetlands treatment system. This landfill leachate/run-off blend is then pumped to Case Study C’s reservoir. The landfill leachate/run-off blend comes in separately from the MWW, which is pumped through a 4-mile pipeline from the WWTP and into the site’s 500-million-gallon reservoir. “C” reports that they do not experience any issues using untreated landfill leachate/run-off blend because it gets diluted since most of the reservoir volume is MWW and rainwater. Averaged influent water quality data for the MWW is included below in Table 6. “C” reports an average water use of 10 MGD, which can vary depending on how many units are running, how full the reservoir is, and how much rainfall there is.

Table 6. Characteristics of incoming treated MWW for Case Study C

Constituent	Units	Influent Measure
TSS	mg/L	<5
TDS	mg/L	~360
pH	-	7.5
pAlk	mg/L $CaCO_3$	14.5
mAlk	meq/L HCO_3^-	270
Total Hardness	mg/L	145
Ca	mg/L	110
SiO2	mg/L	14
Specific Conductivity	µS/cm	770
Cl-	mg/L	90
PO_4	mg/L	15

After the treated MWW leaves the pipeline, it goes into the reservoir. From the reservoir, cooling tower make-up is pulled directly and dosed with sodium hypochlorite or chlorine dioxide and sulfuric acid when it comes into the cooling towers. Service water is pulled from the reservoir and treated via a dual media filter (quartz sand, anthracite) to remove solids, and then chlorinated. This is demonstrated below in
Figure 3.

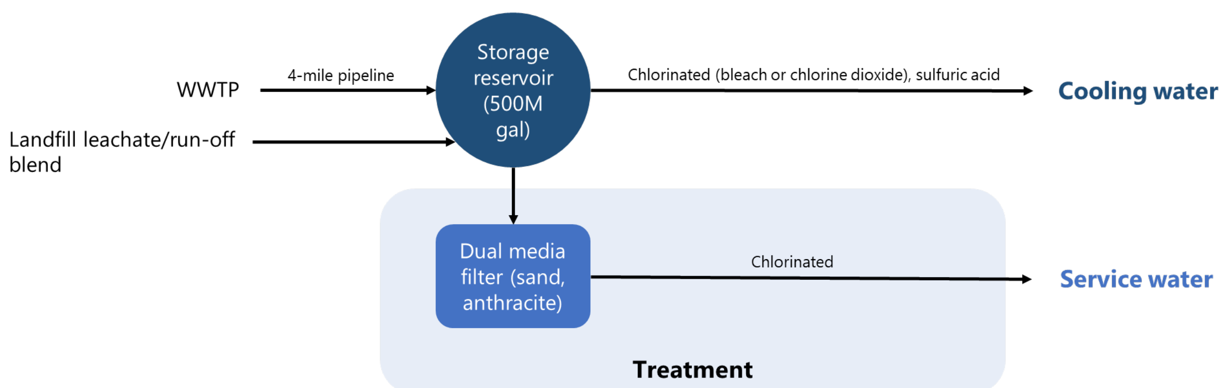

Figure 3. Process flow for Case Study C

The site is considered zero liquid discharge and sends its cooling tower blowdown to a brine concentrator (installed capacity of 1700 GPM) and then a crystallizer. Crystallized solids get sent to an onsite landfill after blending with ash and scrubber solids. Brine concentrator (BC) distillate (~600 GPM) gets rerouted back to the cooling towers. FGD water is currently evaporated from the stacks. However, "C" reported that this year the site broke ground on a new lime-soda softening facility that will be used as pretreatment for the site's recycle basin (made up of onsite water sources including the FGD wastewater, neutralization basin, coal ponds, and oil-water separator) before sending it to the brine plant (CT blowdown treatment facility).

Relationship to Municipality

Case Study C analyzes for basic constituents such as NH_3, pH, conductivity, chlorides, alkalinity, TSS, and TDS, using grab samples taken 5 days a week from the influent water supplied to the reservoir. "C" mentioned that their site is in constant contact with the municipality to arrange how much MWW should be sent to the reservoir depending on the weather.

The WWTP holds an operating permit to send MWW to "C", which includes testing requirements. These can be found below:

			Reclaimed Water Limitations		Monitoring Requirements		
Parameter	Units	Max./ Min	Limit	Statistical Basis	Frequency of Analysis	Sample Type	Monitoring Site Number
Flow	MGD	Max Max	13.0 Report	Annual Average Monthly Average	Continuous	Recording Flow Meter with Totalizer	
BOD, Carbonaceous 5 day, 20C	mg/L	Max Max Max Max	20.0 30.0 45.0 60.0	Annual Average Monthly Average Weekly Average Single Sample	Daily; 24 hours	24-hr FPC	
Solids, Total Suspended	mg/L	Max Max Max Max	20.0 30.0 45.0 60.0	Annual Average Monthly Average Weekly Average Single Sample	Daily; 24 hours	24-hr FPC	
Coliform, Fecal	#/100mL	Max Max Max Max	200 200 400 800	Annual Average Monthly Geo Mean 90th Percentile Single Sample	Daily; 24 hours	Grab	
pH	s.u.	Min Max	6.0 8.5	Single Sample Single Sample	Continuous	Meter	
Chlorine, Total Residual (For Disinfection)	mg/L	Min	0.5	Single Sample	Continuous	Meter	

Figure 4. Testing requirements of WWTP for the MWW sent to Case Study C

Benefits and Challenges

Case Study C reported that the biggest challenge with using treated MWW is the aspect of intermittent flow provided by the municipality. The site uses the reservoir as a storage option to lessen the effects of variable flow. The reservoir provides additional storage capacity that gives Case Study C approximately 21 days of run time if all four units are running at typical capacity factors. Even with additional storage, "C" has had previous close calls with being short on water, as well as issues with having too much water in the reservoir due to extreme storm events like hurricanes.

Case Study C does have the option to shut down influent to the reservoir once it reaches a certain water level and pull from their reservoir for water usage. This action is coordinated with the WWTP. Another challenge experienced by "C" is algae growth within the reservoir, which has become more noticeable through the years. Case Study C treats the reservoir for algae monthly and uses ultrasonic buoys.

Advice for Future Users/Lessons Learned

Case Study C mentioned several things that could be applicable for future users as a consideration for MWW. These are listed below.

System Design

- Make sure to account for intermittent flow expected from the WWTP
  - Does the site have enough storage capacity to handle municipality excursions or maintenance issues?
  - Is the site storage (i.e. reservoirs) at risk of overflow from storm events?
- Consider inclement weather events when designing water storage options
- Consider installing continuous analyzers for important requirements, like pH, DO, or a constituent related to algae monitoring, such as TSS or chlorophyll-A.
  - Do not depend on the municipality for excursion notices
  - Dissolved oxygen (DO) would be an important consideration if the water stagnates in the pipeline

Verification

Verification for Case Study C was completed by several plant and utility personnel, including multiple Environmental Compliance Specialists and Engineering.

Case Study D

Overview

Case Study D is a 164-MW (nameplate capacity) NGCC plant in Nebraska. "D" utilizes approximately 0.2 MGD of effluent from a local municipal wastewater treatment facility to supply their cooling, service, and demin water. The plant was constructed with the plan to bring treated MWW from a treatment plant located roughly 2 miles away, and "D" has been doing so since commercial operations began in 2003.

Drivers

Table 7. Key drivers of MWW use and reasoning for Case Study D

	Driver	Benefit	Challenge
Quantity	X	X	
Quality	X		X
Reputation	X		
Regulatory			
Cost			
Other: Proximity	X		
Other: Environmental	X		

Case Study D reported that several drivers impacted their decision to use treated MWW. Operationally, the closest surface water to the site is of low flow and poor quality, and test wells showed groundwater that was very high in iron, manganese, and hardness. Socially, "D" wanted to be more environmentally conscious by reusing MWW. The site also recognized that farmers in Nebraska rely heavily on well water for crop irrigation, and therefore "D" wanted to minimize their impact on groundwater resources and the environment.

System Information

Treated municipal wastewater is supplied from a nearby WWTP. Incoming water is transported through a 2-mile pipeline and into a 3.5-million-gallon raw water tank. Operators at "D" can decide when to pull water from the WWTP; it is not a continuous process. When the influent stream first enters the plant, several water parameters including pH, conductivity, and total ammonia are measured. A bleach injection is also located where the influent is pumped in, and dosing is increased when the influent water has higher ammonia levels. Additional bleach is added to the raw water storage tank and free chlorine is monitored to avoid pathogens, with a set residual of 1 – 3 ppm. From this tank, water can either be sent directly to the cooling tower as a make-up stream, or to the site's water treatment plant. This tank also serves as a backup for fire suppression. The site's cooling towers were initially designed for 3.5 cycles of concentration, but "D" reports being able to push up to 4 – 4.5. The limiting factor is chloride levels within the water since the site's condenser tubes are 316L SS. Sulfuric acid is fed into the cooling towers for pH control.

Table 8. Characteristics of incoming treated MWW for Case Study D

Constituent	Units	Average Influent
Organophosphate	ppm	5.3
Specific conductivity	µS/cm	1330
pH	-	7.6
Free Cl (Raw Water Tank)	ppm	1.9

The water treatment plant includes 2 fully redundant parallel trains: coagulant injection and mixing, multimedia filters (sand, anthracite, garnet), and ultrafiltration (UF). Bleach is fed before the ultrafilters. After UF treatment, the water is stored in the service water tank, where it is either pulled directly to feed the fire suppression system or sent to the demin plant. Demin treatment includes cartridge filters upstream of a 2-stage, 2-pass RO system. Before the ROs, sodium bisulfite (SBS) is fed to ensure the removal of any remaining residual chlorine still present from the dosing point before the UF. RO permeate is fed into a GE-based electrodeionization (EDI) system, and then to a mixed-bed bottle. Case Study D reports that the mixed bed acts as a polisher step. After treatment, demin water is sent to the demin water tank. Demin is utilized for boiler water make-up, gas turbine power augmentation (mass flow adjustments), and gas turbine emission control (NO_x injection).

A system flowchart for Case Study D is included below:

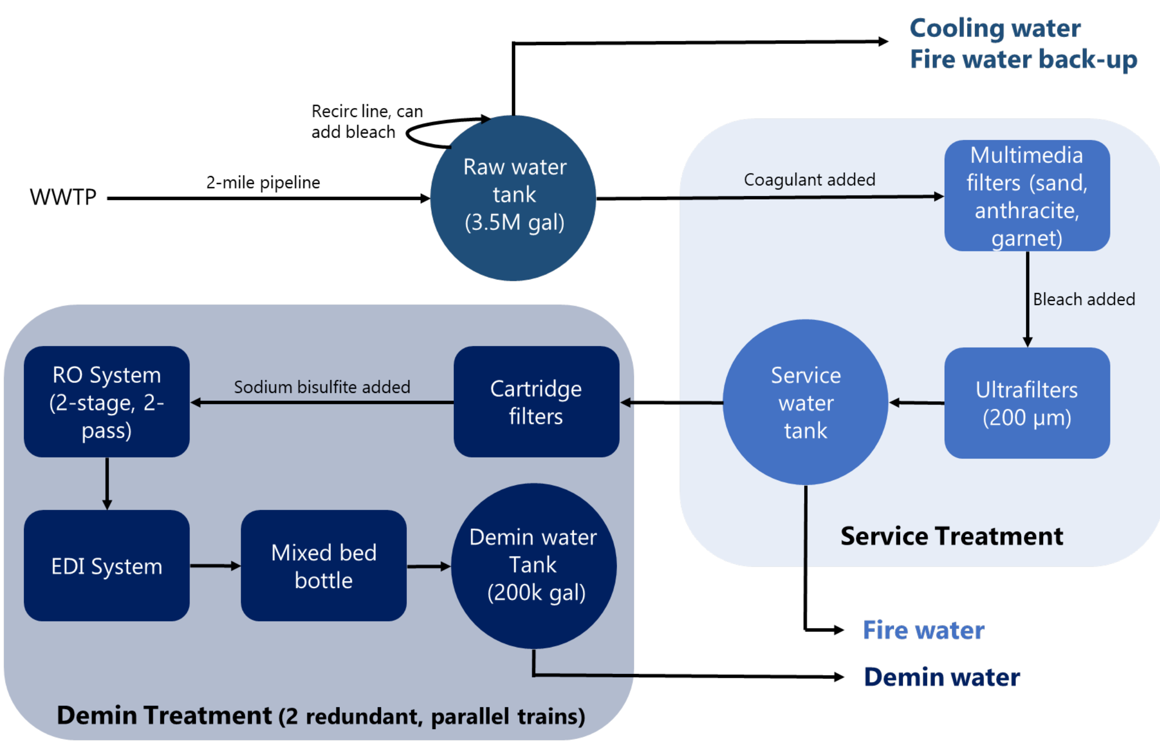

Figure 5. Process flow for Case Study D

Case Study D's power plant is designed in such a way that a mirror image can be created, and an additional combined cycle plant can be added. Therefore, the existing water treatment plant is oversized. The philosophy taken when creating the process was to ensure redundancy and be able to support parallel trains. The system can feed RO train A through the EDIs, and RO train B through the mixed bed, which is why the mixed bed currently acts as a polishing step after the EDIs.

All produced wastewater from the power plant, such as cooling tower blowdown and RO reject, gets sent to a local 12-million-gallon retention pond before being pumped back to the WWTP again for re-processing.

Relationship to Municipality

Case Study D reports having good lines of communication with the WWTP. The treatment plant does notify “D” if there are excursions with the wastewater, and the powerplant provides notices to the WWTP of when they’ll be discharging wastewater from the holding pond back to the WWTP. If an excursion does occur at the WWTP, Case Study D can shut off the pipeline supply into the plant and run using the onsite raw water storage tank capacity. Capacity time is dependent on whether the site is operating in combined-cycle or simple-cycle mode. “D” reports being able to run 1 – 2 weeks in simple-cycle, but only several days in combined-cycle mode, where they use up to 1 MGD.

Case Study D is not aware of what the WWTP monitors for and does not have access to water quality data from them. As previously mentioned, “D” does measure specific conductivity, pH, and the presence of free ammonia in the influent MWW. The plant measures free ammonia because when “D” first started operating, the WWTP would send MWW high in ammonia, which would reduce the disinfection efficiency of the chlorine and require higher dosing levels. “D” reports not having any issues with ammonia currently.

Regarding the legal contract between Case Study A and the nearby WWTP, “D” does not pay to receive water from the WWTP, but they do pay to send wastewater back from their retention pond. Pricing is based on the volume. Maintenance of the system, including the pipelines to and from the WWTP and pumps, is the responsibility of the power plant.

Benefits and Challenges

“D” reported that their biggest start-up challenge was handling the high ammonia dosing from the municipality. When the high-ammonia wastewater was combined with the free available chlorine provided by bleach treatment, “D” had higher-than-normal chlorine demands due to the production of monochloramine from ammonia interaction. High ammonia levels have since been lowered in the incoming MWW. Initial lessons learned from this challenge are included in the next section.

One current challenge is issues with RO scaling and biofouling. Antiscalants are injected into the ROs, but the site is still experiencing ΔP issues. The most recent issue was in the cartridge filters before the RO system. Currently “D” injects a non-oxidizing biocide at the cartridge filters once per week.

One concern related to the system is the volume of oxidative agents used (i.e. bleach) and how they might impact the WWTP if sent back with residual remaining. This is because WWTPs utilize bacteria, or “bugs” in their treatment system, which can disable the entire system if killed by chlorine residuals. “D” reported that the concern is mitigated by employing the high-volume retention pond to hold wastewater before it is pumped back to the WWTP. This provides enough residence time to dilute the wastewater and ensure no free residuals remain by the time wastewater is pumped back to the WWTP.

One last challenge that Case Study D reports is the fact that their site's demin tank is open to the atmosphere, which impacts the demin water by making it slightly acidic and increasing conductivity.

Advice for Future Users/Lessons Learned

Case Study D mentioned several things that could be considered lessons learned at their site, and advice for future users. These are highlighted below.

Lessons Learned

- During the site's initial issues with high ammonia, "D" began experiencing biological issues in the UF and RO systems that required multiple clean-in-places (CIPs). However, the site's free available chlorine (FAC) measured at 8 ppm. Case Study D learned that they were receiving false positives on their FAC due to the monochloramines being produced from the interaction of free chlorine and ammonia. The monochloramines increased the FAC readings but did not have as strong of a disinfection ability as free available chlorine. Monochloramines are also called combined chlorine since they're created by free chlorine combining with other molecules (such as ammonia).

  $$FAC\ (Free\ Available\ Chlorine) = TC\ (Total\ Chlorine) - CC\ (Combined\ Chlorine)$$

  Case Study D recommended that future users familiarize themselves with the Chlorine breakpoint curve to understand how a FAC measurement might not indicate how much free available residual is present in the water. Enough chlorine must be added to reach the "breakpoint" before it becomes available. Before reaching a breakpoint, chlorine is present in the combined form, which is not as effective at disinfection. Below is a graph demonstrating this phenomenon, with the breakpoint highlighted in red:

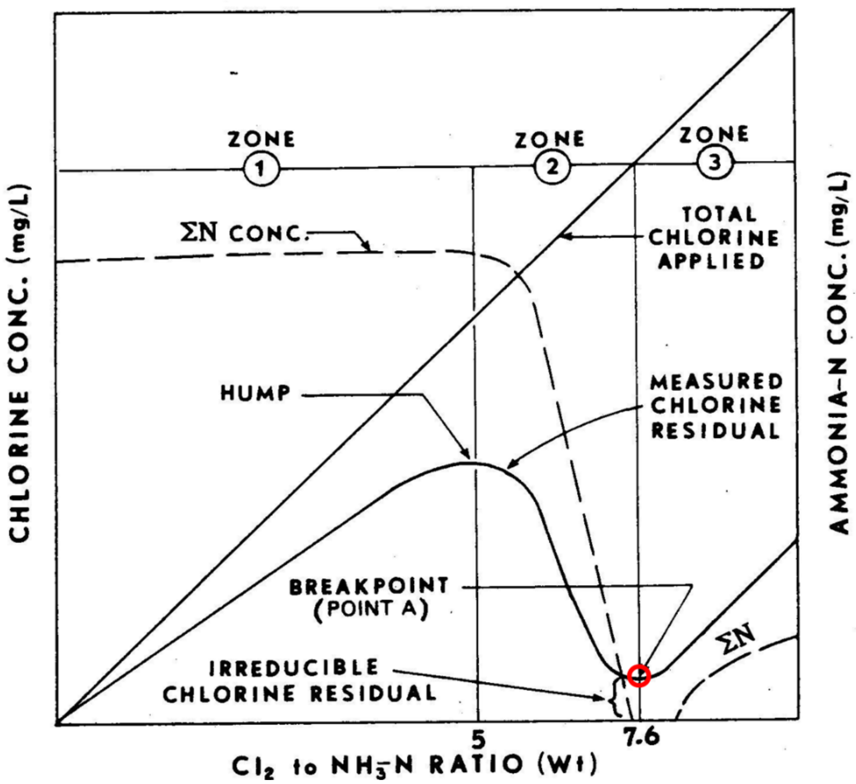

Figure 6. Graphical representation of breakpoint chlorination [3]

- Case Study D also realized that they were not making full use of their MMFs due to not using coagulants. The falsely high FAC measurements, combined with larger organic particles that were passing through the MMFs and making it to the UFs, caused biofouling. "D" began injecting coagulants before the MMFs to capture more solids.
- Case Study D modified their raw water tank by installing a recirculation line which now allows them to dose additional bleach (after the influent bleach injection point) to maintain steady residual chlorine levels even when there is no influent MWW entering the tank. For example, if the site shuts off its influent line to run off the raw water tank only, the recirc line allows it to monitor free chlorine in the tank.

System Design:

- Use variable speed pumps if planning to pump wastewater back to WWTP
  - The initial design for "D" used fixed-speed pumps
  - Requires more coordination with WWTP personnel when planning to send back wastewater
- Use DBNPA as a non-oxidizing biocide if needed
  - The site originally used Isothiazalone
  - Discontinued because contact led to sensitivity issues (operators could get reactions after being over-exposed)
- If using MWW to create demin, demin tanks should be closed to the atmosphere.

Verification

Verification for Case Study D was completed by the site Plant Manager, Operations Supervisor, and the utility's Director of Generation Operations.

Case Study E

Overview

Case Study E is a 1,250-MW (nameplate capacity) NGCC plant in Georgia. "E" utilizes 10 – 12 MGD of treated municipal wastewater from a nearby municipality to supply their cooling water. This site originally planned to use MWW and has been doing so for the past 22 years.

Drivers

The current owners and operators of the site purchased it 9 years after the site was originally designed; therefore, exact drivers cannot be stated. However, it is known that the site is not in proximity to any surface water. This is the assumption for why treated MWW was chosen as the water source, and the plant was designed initially to take this effluent from a nearby municipality.

Table 9. Key drivers of MWW use and reasoning for Case Study E

	Driver	Benefit	Challenge
Quantity	X	X	
Quality			X
Reputation			
Regulatory			
Cost			

System Information

Treated municipal wastewater is supplied from a nearby WWTP via a treated wastewater reservoir. Incoming water to the plant is pumped from the reservoir across the street and to "E". The pipeline for this is approximately 350 feet long. MWW use of the site varies depending on season and units running but averages 10 – 12 MGD.

After the treated MWW leaves the pipeline it is first routed through in-line screen filters to remove any debris coming from the reservoir. After the screens, water passes through sand filters, and then the water is dosed with bleach and purate (chlorine dioxide) and stored on-site to be used as cooling water makeup. Cooling tower CoCs average around 4.5 with a conductivity level of around 4,500 – 5,000. "E" does daily internal tests to measure chlorides and phosphorus to adjust blowdown rates. The site uses potable water for their service and demin water sources.

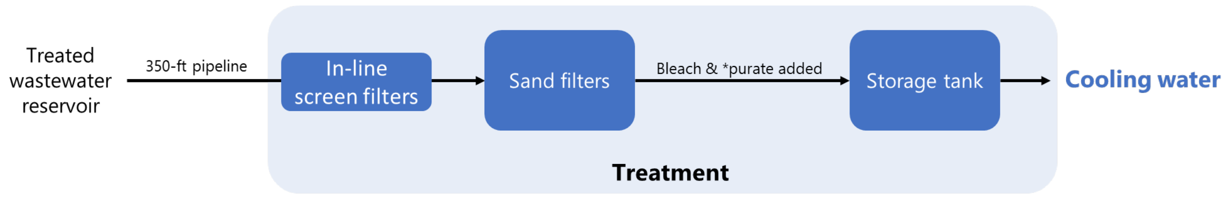

Figure 7. Process flow for Case Study E, *onsite generation of chlorine dioxide

Case Study E sends all wastewater generated on the site back to the WWTP. For the MWW effluent, "E" monitors for several different water quality parameters that are shared with the WWTP and has provided the table listing them below:

Table 10. Monitoring completed by Case Study E on wastewater sent back to the WWTP

Twice a Month	Monthly	Quarterly (Sludge Only)	Semi-Annual
COD	COD	Arsenic	Chromium
BOD5	BOD5	Cadmium	Copper
	pH	Chromium	Lead
	Oil & Grease (TPH)	Copper	Mercury
	Oil & Grease (Total)	Lead	Nickel
	Ammonia (NH3)	Mercury	Zinc
	Phosphorus	Molybdenum	Antimony
	Total Suspended Solids (TSS)	Nickel	Arsenic
	Temperature	Selenium	Cadmium
		Zinc	Cyanide
			Molybdenum
			Selenium

Relationship to Municipality

Case Study E reports having a good relationship with the municipality since the WWTP is across the street from the power plant, which facilitates quick communication. "E" does not have access to the water quality data of the WWTP and has not received notifications or been directly impacted by an excursion at the WWTP since 2000. "E" also reported not experiencing any sort of stormwater surges, since they pull from the WWTP reservoir after treatment and the area does not contain combined sewer systems. Case Study E does have the capability to close the pipeline if needed for poor influent MWW quality but has not done so. "E" does close the valve during system outages or work done on the plant or pumphouse. "E" can also fill the clearwell and then shut the pipeline down to complete overnight maintenance, but this is not routine.

Regarding the system ownership between Case Study E and the municipality, “E” is responsible for maintenance from the pumphouse to the facility. The WWTP is responsible for the 350-ft pipeline from their reservoir.

Verification

Verification for Case Study E was completed by several onsite personnel, including the Plant Manager.

Case Study F

Overview

Case Study F is a 3937-MW nameplate capacity, 4,238-MW maximum capacity (after power uprate), nuclear power plant located in Arizona. “F” utilizes 65 – 85 MGD of treated municipal wastewater from two different sources. The first source is a nearby city’s WWTP. The other source comes from a different WWTP that processes the combined wastewater of five cities. These two effluent streams supply Case Study F’s cooling water. This site originally planned to use MWW and has been doing so for 38 years.

Drivers

Table 11. Key drivers of MWW use and reasoning for Case Study F

	Driver	Benefit	Challenge
Quantity	X	X	
Quality			X
Reputation			
Regulatory			
Cost			

Due to the site’s location in a very arid region of the United States, it was originally designed to use treated municipal effluent. The site receives water from two municipal sources, and the populations of these cities are large enough to provide MWW for the site’s water treatment plant, which has a maximum capacity of 90 MGD. Case Study F reported that the two sources were set up at the same time, and not brought on separately as a way to increase water availability.

System Information

Treated municipal wastewater is supplied from 2 nearby municipalities, with considerations to accept RO reject brine from a third city in the future. The two sources of MWW connect at the same junction box, which is then combined and pumped through a 36-mile pipeline to the plant. At the plant influent, the site monitors for the following water quality parameters:

turbidity, pH, alkalinity, calcium, magnesium, silica, phosphates, TSS, conductivity, ammonia, chlorides, potassium, fluoride, sodium, sulfates, and nitrates. Averaged characteristics of the incoming MWW can be found below:

Table 12. Characteristics of incoming treated MWW for Case Study F

Constituent	Units	Average Influent
Conductivity	µS/cm	1,700
pH	-	7.5
TSS (Total Suspended Solids)	mg/L	22
Total Alkalinity	mg/L	168
Chlorides	mg/L	369

Once on-site, the MWW is sent to the water treatment plant. The water treatment plant starts with a trickling filter to remove excess ammonia through the nitrification process. Afterward, water passes through a first-stage clarifier, where lime is added to raise the pH and precipitate out magnesium, silica, and phosphates. Then the water goes to a second stage clarifier where carbon dioxide is added to lower the pH and sodium carbonate (soda ash) is added to precipitate out calcium. After the second stage clarifier, water is passed through multi-media polishing filters (anthracite, sand), where sulfuric acid is added to additionally lower the pH, and sodium hypochlorite is added to prevent any biological growth within the filters. Additional suspended solids are removed in the MMFs. Afterward, the water is stored in the site's two water storage reservoirs (45-acres and 85-acres), with a total capacity of greater than 1 billion gallons. The process is shown below in Figure 8:

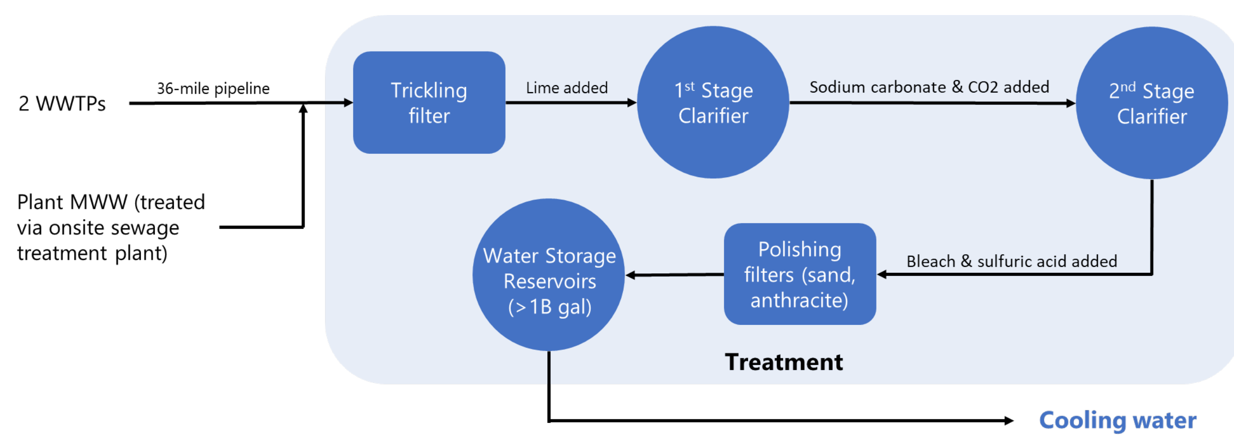

Figure 8. Process flow for Case Study F

Water can be pulled from the reservoirs for cooling water make-up. Additional chemicals (sulfuric acid for pH control, sodium hypochlorite for biological control, dispersant, foam control) are added to the cooling tower system. The site uses an average of 65 MGD in the winter and 85 MGD in the summer. The water treatment system was designed to be able to treat up to 90 MGD. The site is currently completing evaluations to understand if they have additional margins for this capacity.

Silica and calcium are the current parameters that are limiting factors for cooling tower blowdowns. Case Study F may also blow down for chlorides, depending on the levels in their influent water. “F” does not treat for chlorides. Generally, reservoir TDS is around 900 – 1,000 ppm, and TDS concentrations in the cooling tower circulating water systems are limited to 30,000 ppm per the site’s air quality permit.

In addition to the municipality MWW being passed through the site’s water treatment plant, domestic wastewater produced on-site is also added to the MWW influent stream before the trickling filters, to be treated onsite. Case Study F uses RO-treated well water for their demin and potable water. The RO reject is also added to the water treatment plant before the first stage clarifier.

The site is zero liquid discharge. All wastewater on the site is sent to the site’s evaporation ponds, which are between 600 – 700 acres and can be as deep as 30 – 50 feet. Case Study F did report that the evaporation ponds require an aquifer protection permit to show that the wastewater is not impacting any groundwater. The permit includes what can and cannot be put in the ponds and is required by the state to operate.

Relationship to Municipality

Case Study F reported having overall good relationships with the cities, including frequent communication. “F” does not have direct access to the municipalities’ water quality data but can request it if needed. “F” reports monitoring the following parameters in the MWW influent: turbidity, pH, alkalinity, calcium, magnesium, silica, phosphates, TSS, conductivity, ammonia, chlorides, potassium, fluoride, sodium, sulfates, and nitrates.

The site did report that they typically receive notices of excursions, but that timeliness has been an issue in the past. Excursion water may have already entered the pipeline by the time that a notice is received. If the notice is provided before water is in the pipeline, “F” can close the pipe and have enough water storage capacity in the reservoirs to run for several weeks without needing to open the pipeline. If the notice is provided too late, and excursion water enters the 36-mile pipeline, it is more difficult and time-consuming for Case Study F to handle. Most likely, the site will accept the excursion water into their reservoirs and treat it using additional chemicals. If Case Study F does not want to accept the excursion water in their pipeline, they would have to remove the water with external pumps and determine a permitted way to discharge it.

Regarding the legal contract between Case Study F and the municipality, “F” pays the municipalities to receive the MWW. The initial purchasing price was $25/acre-ft, and the current pricing is approximately $220/acre-ft. The price goes up annually and will shift into a tiered pricing starting in 2026. “F” has a contract through 2050 with the WWTPs. In terms of system ownership, all interface connections are owned and maintained by the plant. The pipeline is emptied every 3 years to perform an internal inspection for pipe condition in order to prevent leaks and provide proactive maintenance when needed. During this time, pipeline water is discharged into an irrigation canal parallel to the pipeline (20 – 30 million gallons).

Benefits and Challenges

Case Study F stated that excursions are random and most often caused by someone in the city discharging something that then negatively impacts the receiving WWTP. Generally, the municipality calls "F" to warn them of changes to the system. If impacted water is already in the pipeline when "F" receives an excursion notice, they typically see increased chemical treatment costs as an impact. For example, a discharge to the WWTP impacted clarifier operations, which caused influent water to Case Study F to be higher in ammonia and required additional treatment chemicals.

"F" reported that they do have the ability to close the pipe if they receive an excursion notification in time and run off their 45-acre and 85-acre water storage reservoirs. With both reservoirs combined, the site has approximately 14 days of run time during summer with all units online. In the winter with unit outages occurring, this can be extended to approximately 20 days.

"F" mentioned that they send some of their treated cooling water to an additional power plant. This plant is also ZLD but uses brine concentrators rather than evaporation ponds and has reported struggling with organic levels from the treated effluent sent by "F" as well as algae growth in their on-site storage reservoirs.

Advice for Future Users/Lessons Learned

Case Study F shared thoughts on how they'd redesign the system if they could. These are listed below:

Lessons Learned

- Treated MWW sources from larger cities or combined cities may lead to higher experiences of excursions from the municipality.

System Design

- For ZLD sites, ensure that the equipment you have for evaporation is sufficient.
  - "F" has had to expand their evaporation ponds multiple times due to insufficient volume.
  - There is no separate pipeline that can supply used wastewater back to the municipality if necessary.
- Related to the point above, build more redundancy into the plant when possible
  - Case Study F reported that they have experienced redundancy issues several times. As the plant run life was extended, currently installed equipment aged but could not easily be replaced without impacting electricity production due to lack of redundant

equipment. For example, having to remove a water storage reservoir from service to repair, but only have one reservoir, makes operations difficult.

- Adding redundant components later into the plant life may incur greater costs, which should be considered when determining how the plant and related energy demand may look 30-40 years after initial start-up.

Verification

Verification for Case Study F was completed by the site's Operations supervisor.

Case Study G

A seventh case study involving an NGCC site that switched from using groundwater to municipal wastewater in Florida will be included in a future update of this deliverable.

3 CONCLUSION

This deliverable summarizes six different case studies of power generation stations that use treated municipal wastewater (MWW), with a seventh to be included in a future update. Discussion with each case study explores the reasoning(s) behind using MWW, benefits and challenges that came from this decision, site interactions and relationships with the municipality, and lessons learned that the case study can provide to current or future MWW users. While each case study has its own unique experiences, common themes emerged across most or all, which have been summarized below.

Drivers:

- Most case studies were initially driven by limited water accessibility, with secondary drivers including regulations, reputation, and environmental concerns.
- Alternative water sources like groundwater were frequently ruled out due to poor quality.
- Water quantity or quality are frequently both drivers and challenges for sites.

System Information:

- All case studies use either zero liquid discharge (ZLD) systems or send their wastewater back to the municipality instead of discharging through an NPDES permit.
- Most sites rely on their municipality for water and were not designed to include a backup source.
- Water treatment systems vary based on the intended use of MWW (cooling, service, demin) and incoming water quality. Several case studies were willing to share information regarding the water quality of their influent MWW stream.

Relationship to Municipality:

- Having close working relationships with the municipality is crucial for timely excursion notifications and coordinating any planned work or operational issues.
- Most sites reported that the timeliness of excursion notices was the biggest issue.
- Most case studies do not have access to WWTP effluent water quality data regularly. Several use onsite monitoring for key parameters due to limited accessibility from the WWTP side, as well as a difference in measured parameters for WWTPs versus power plants.
- Financially, case studies that are not ZLD generally pay to receive the treated MWW and send it back.

Benefits and Challenges:

- The main benefit of using treated MWW is the ability to site a power plant in otherwise unsuitable locations.

- The most common challenge that case studies experienced was TSS slugs from WWTP excursions, which can increase chemical treatment costs and potentially damage water treatment equipment further upstream.
- Sites without influent water holding systems (reservoirs or raw water tanks) struggle with residence time as a common challenge.
- Another common challenge is the ability to reroute influent MWW that is out-of-spec, or a lack of predetermined influent water quality specifications. Several case studies reported not being able to shut off their pipeline, and a lack of accountability on the WWTP to ensure required influent water quality standards are met.

Lessons Learned:

- WWTPs that handle larger populations will most likely also experience higher rates of excursions.
- Sites that route influent MWW directly to a treatment system often struggle with fluctuating influent water quantity and quality. Sites with a front-end reservoir or storage tank can use them as an equalization (EQ) tank and have more residence time if the WWTP shuts down unexpectedly.

Advice for Future Users:

- Ensure that redundancy is built into water treatment plants whenever possible, including ZLD systems for sites that do not send their wastewater back to the municipality.
- Determine influent MWW quality requirements, with mechanisms to reroute out-of-spec water. Include continuous analyzers to confirm these requirements are being met.
- Consider backup water sources if possible. If no backup source is available, include a holding reservoir or large raw water storage tank in the design to provide protection for the power plant against excursions and unplanned shutdowns at the WWTP.

4 REFERENCES

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[3] NSW Health, "Continual breakpoint chlorination," 9 April 2013. [Online]. Available: https://www.health.nsw.gov.au/environment/factsheets/Pages/breakpoint-chlorination.aspx. [Accessed 2024].

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PROGRAM
Water Treatment Technologies, P238

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PLANT CODE TABLE

CASE STUDY	PLANT CODE
A	24674
B	24675
C	09555
D	27676
E	10677
F	03678

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