Hazen Technical Memorandum

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Water Supply and Treatment Alternatives Analysis

Job no

Table of Contents

List of Figures

List of Tables

List of Acronyms

Abbreviation	Definition
AACE	Association for the Advancement of Cost Engineering
ADEM	Alabama Department of Environmental Management
CPI	Consumer Price Index
Fe	Iron
ft	Feet
gal	Gallon
GPM	Gallons Per Minute
GSA	Geological Survey of Alabama
hr	Hour
in	Inches
M	Million
MAWSS	Mobile Area Water & Sewer System
MCL	Maximum Contaminant Level
MDD	Maximum Day Demand
mg	Milligrams
MG	Million Gallons
MGD	Million Gallons Per Day
mg/L	Milligrams Per Liter
mi	Miles
min	Minute
Mn	Manganese
NRW	Non-Revenue Water
O&M	Operations and Maintenance
pH	Power of hydrogen
PPM	Parts Per Million
psi	Pounds per Square Inch
PWW&SB	Prichard Water Works and Sewer Board
QC	Quality Control
sf	Square Foot
TMF	Technical, Management, Financial
USGS	United States Geological Survey

Executive Summary

The Prichard Water Works and Sewer Board's (PWW&SB) public drinking water system serves both the residents of Prichard and the neighboring town of Chickasaw, while the sewer system only serves residents from the City of Prichard. The PWW&SB water system is currently under a Consent Order and in receivership.

PWW&SB currently purchases 100% of its water from the Mobile Area Water and Sewer System (MAWSS). The purpose of this report is to determine the feasibility of alternative water sources. This report identifies local water sources, both groundwater and surface water, and evaluates their viability as sustainable cost-effective alternatives.

Big Creek Lake and Eight Mile Creek were the only potentially viable surface water sources identified in the Prichard area. Eight Mile Creek was removed from consideration due to reports of elevated pathogen levels, which do not meet stream standards established by the Alabama Department of Environmental Management (ADEM, email correspondence with Aubry White, 5/15/24). Big Creek Lake is the primary water source for MAWSS. Since the water allocations associated with the Lake are entirely owned by MAWSS, the feasibility of obtaining a withdrawal permit is uncertain. Furthermore, the cost to convey and treat the water from Big Creek Lake would be prohibitive due to geographic separation and elevated costs associated with surface water treatment. Therefore, both potential surface water sources were removed from further consideration.

Groundwater, specifically from the deeper Miocene and, potentially, Pliocene aquifers which are not under the direct influence of surface water, may be a viable source water alternative for PWW&SB. These aquifers are not currently used for public water supply systems in the area. If PWW&SB elects to pursue this alternative, extensive aquifer testing and groundwater modeling would be required to assess the potential long-term viability of this source since aquifer water quality and capacity data are limited. Multiple groundwater source scenarios were analyzed, including a centralized or decentralized well field, treatment processes consisting of sequestration of the iron and manganese, oxidation and filtration, and manganese greensand filtration. Required standby capacity from either system redundancy or maintained through MAWSS was considered. Treatment alternatives are based on limited available groundwater water quality data from the area. The recommended treatment options for meeting drinking water quality requirements in a cost-effective manner are aeration/filtration or chlorination/filtration.

In the near term, it is recommended that PWW&SB remain on MAWSS water while addressing the technical, management, and financial (TMF) capacity requirements in the ADEM permit code and explicitly stated in the Consent Order 24-037-CDW. TMF capacity development "*is a process for water systems to acquire and maintain adequate technical, managerial and financial (TMF) capacity. TMF capacity enables water systems to have the capability to consistently provide safe drinking water to the public…Capacity development is a fundamental component of the 1996 Safe Drinking Water Act (SDWA) Amendments. The SDWA Amendments provide a framework for states and water systems to work together to protect public health. Every state has developed a Capacity Development Program to assist public water systems in building TMF capacity.*." (Environmental Protection Agency. (2024). EPA. https://www.epa.gov/dwcapacity/learn-about-capacity-development). One critical way PWW&SB can demonstrate improved TMF will be through the reduction of system water losses from the current rate of over 50% to closer to the industry goal of 25%. As the leakage and other TMF issues are addressed, PWW&SB could further pursue groundwater as an alternative source. However, much work is required to better understand the long-term feasibility of using the Miocene and Pliocene aquifers as a sustainable water source.

The following tasks are recommended to further evaluate the feasibility of the Miocene and Pliocene aquifers:

- Development of a Miocene/Pliocene aquifers pilot test well program to better assess water quality and well yield in the deeper aquifers not currently used.
- Groundwater modeling based on data from the aquifer performance testing phase of the pilot program to inform well spacing, siting, and long-term sustainability.
- Development of a trigger-based roadmap that will provide a phased transition to the Miocene/Pliocene aquifers if this source appears viable. Broadly, this will consist of:
    - Demonstrating improved TMF capacity, a prerequisite pursuant to Consent Order 24-037-CDW;
    - Reducing system water losses to a trigger level of 25% over a period of an estimated 19 years;
    - Design, permitting, and construction of a local wellfield and treatment system.

1. Introduction

The Prichard Water Works and Sewer Board (PWW&SB) public drinking water system serves both the residents of Prichard and neighboring town of Chickasaw, as shown on the map in **Figure 1-1.** Based on the 2020 Census, Prichard's population was approximately 19,300 and Chickasaw had a population of 6,400 residents.

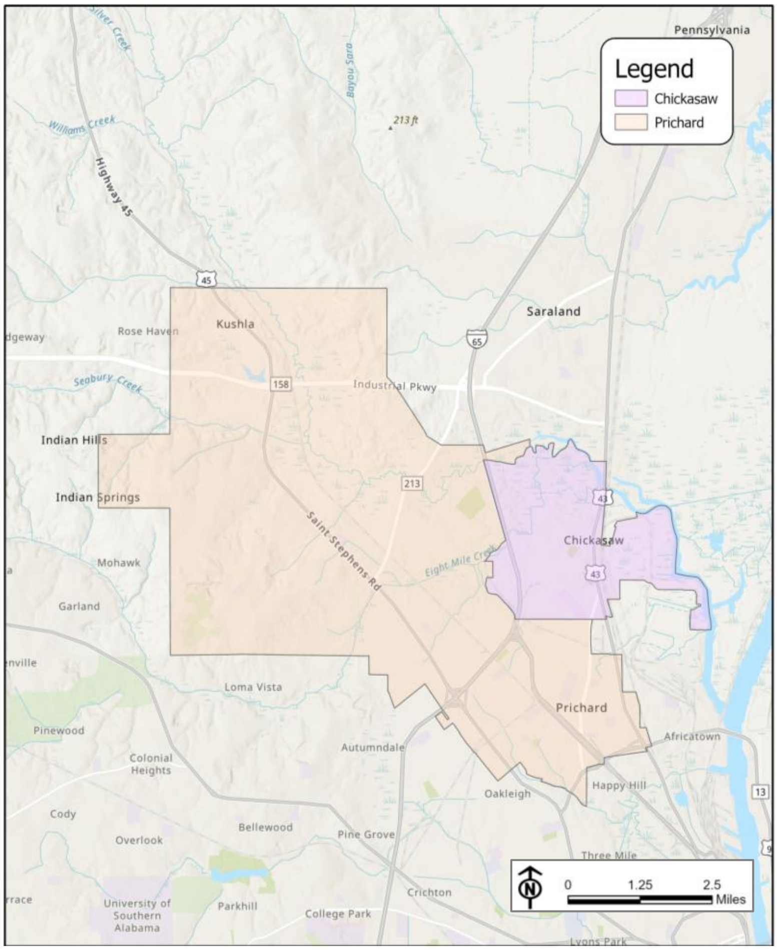

Figure 1-1 Map of Prichard and Chickasaw City Limits

PWW&SB currently purchases all of its water from the Mobile Area Water and Sewer System (MAWSS). The purpose of this report is to assess alternative water source options in the Prichard area and to provide a cost feasibility analysis of the options identified. The viable alternative water source options are then compared to the current water source supply, MAWSS, using a net present value (NPV) analysis. This report also provides a trigger-based roadmap outlining methods and goals for PWW&SB to demonstrate improved technical, management, and financial (TMF) capabilities, and if achieved, a path to transition away from MAWSS as the primary drinking water source.

2. Water Supply and Treatment Alternatives Assessment

The purpose of this water supply and treatment alternatives assessment is to identify local water sources, both groundwater and surface water, and to determine their viability as a sustainable, cost-effective alternative to purchasing treated water from MAWSS. The assessment began with a data collection and literature review effort to consolidate local information regarding the potential water sources. After determining feasibility of the water sources, a net present value (NPV) analysis was conducted for the selected water sources and associated distribution and treatment. Results from this analysis are presented in this section.

2.1 Purchased Water from MAWSS Assessment

PWW&SB purchases the entirety of its potable water supply from MAWSS. The current contract expires on August 31, 2027; however, it could be renewed should the two parties find agreeable terms. The cost of water under the contract is determined by a cost-of-service study performed by MAWSS and is subject to change each year. The 2024 rate that PWW&SB pays for water from MAWSS is $2.75 per 1,000 gallons (gal), resulting in an average monthly cost of approximately $364,000 and an annual cost of $4.4M. PWW&SB has spent $2.6M in the first half of Fiscal Year 2024, which is above the budgeted amount of $2.2M.

As shown in **Figure 2-1**, the points of connection to the MAWSS system are located near the intersections of:

- Bay Bridge and Grover Street;
- Sweeneys Lane and Dubose Street;
- Viaduct Road and Howell Street;
- Jarett Road and Bear Fork Road;
- Short Street and Chastang Street;
- Industrial Street East and North Beltline Highway;
- O’Neal Lane and U.S. Route 43

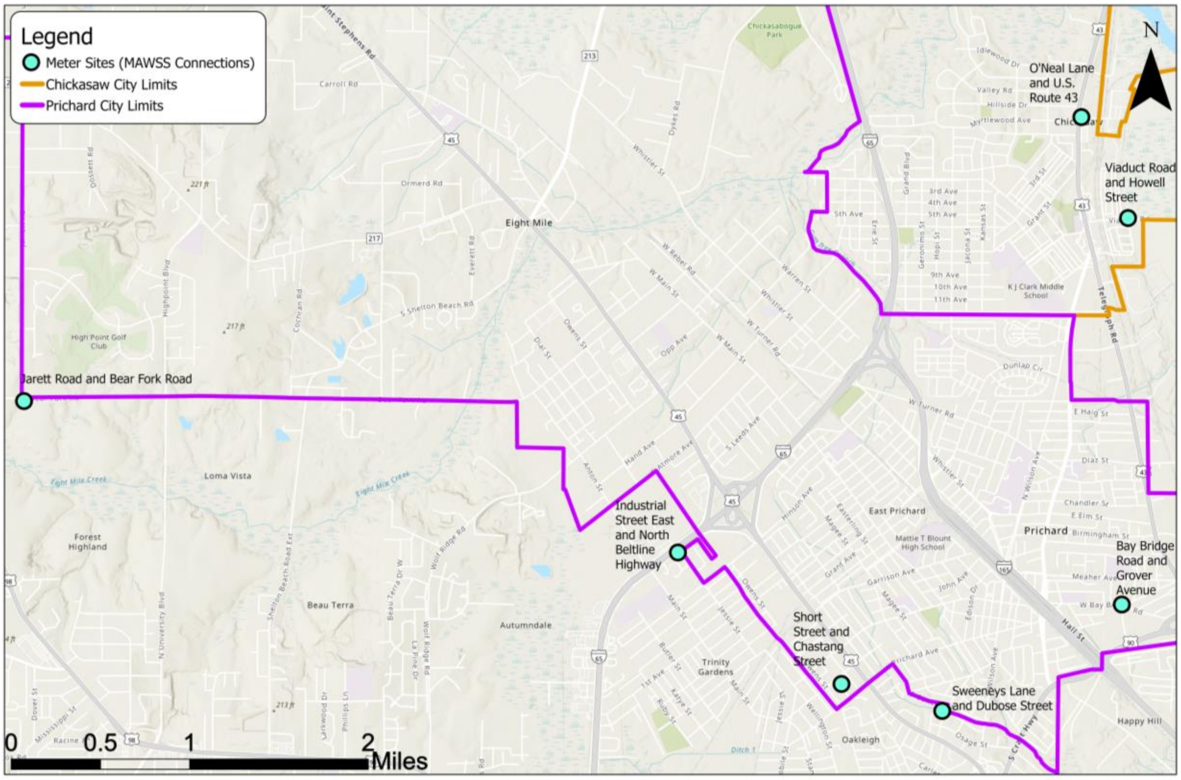

Figure 2-1 Locations of the Connections Points to MAWSS Distribution System

2.2 Surface Water Supply Assessment

An area of review was performed to identify potential surface water sources in the PWW&SB area, and the only two potentially viable water source options identified were Big Creek Lake and Eight Mile Creek. Eight Mile Creek was removed from consideration due to high pathogen levels. The Alabama Department of Environmental Management (ADEM) confirmed that Eight Mile Creek cannot be considered as a water supply source (per a May 15, 2024 email from Aubry White, ADEM’s Water Division Chief).

Multiple issues were found regarding Big Creek Lake as a potential water source for PWW&SB. First, Big Creek Lake is the primary water source for MAWSS, and the water allocations associated with the lake are entirely owned by MAWSS. The feasibility of obtaining a withdrawal permit is uncertain. Second, the cost to treat surface water is relatively high compared to treating most groundwaters. Lastly, the cost to convey water from Big Creek Lake to Prichard would be significant due to the distance between a potential intake plant. **Figure 2-2** shows that the conveyance required would be approximately 11 miles (mi).

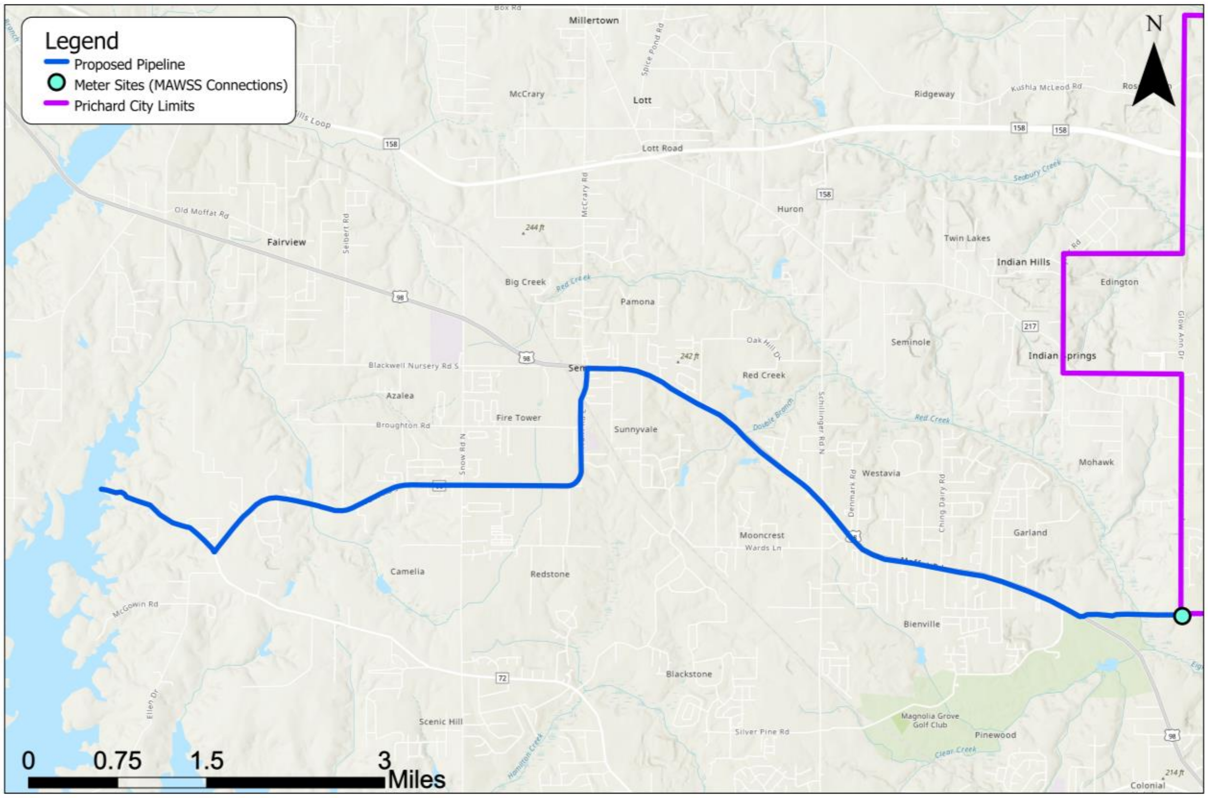

Figure 2-2 Preliminary Alignment of Big Creek Raw Water Line

Big Creek Lake was therefore removed from consideration.

2.3 Groundwater Supply Assessment

2.3.1 Background

The aquifers beneath Prichard can be differentiated as the surficial aquifer (also sometimes referred to as the alluvial, coastal, or watercourse aquifer) and the deeper, confined to semi-confined, aquifers that are Pliocene to Miocene in age. These aquifers have been locally mapped through a series of cross sections completed by O'Donnell & Associates in 2015 and by Cook Hydrogeology in 2020. It is important to note that these cross sections were created with limited data due to the limited number of documented wells in the area; many of the existing wells are old with poor to non-existent available capacity and water quality data.

Although shallower and, therefore, less costly with respect to well installation, the surficial aquifer may yield less water than the Pliocene and Miocene aquifers (O'Donnell & Associates, 2015; Cook Hydrogeology, 2020). The surficial aquifer would also be more vulnerable to seasonal changes and issues with water quality. ADEM code 335-7-5-12 states that any community wells directly influenced by surface water are considered a surface source and must comply with the more costly treatment methods outlined in 335-7-6. Due to these concerns, the alluvial aquifer is not recommended as a viable water source for PWW&SB.

The Pliocene and Miocene aquifers were evaluated as potential water sources for PWW&SB. The Pliocene aquifers occur within the Citronelle formation and are limited to the area west of Prichard as the formation thins eastward. The full Miocene series is present in southern Mobile and Baldwin Counties and is 2,500 feet thick. It is primarily composed of clay, silt, sand, and gravel with some beds of limestone and lignite (Geologic Survey of Alabama, 2018). The Geological Survey of Alabama (GSA) also states that Miocene stratigraphy is difficult to delineate due to an absence of geographically correlatable index fossils. It is also structurally discontinuous, faulted in the Mobile graben system, with some syndepositional movement. The GSA also recognizes that the lack of well data in the area confounds correlation efforts (Geologic Survey of Alabama, 2018).

The Miocene and Pliocene aquifers are composed of discontinuous sand land lenses of variable thickness. Two cross sections were reviewed to confirm this assumption. The location of the cross sections is illustrated in **Figure 2-3**. The cross sections are presented in **Figure 2-4** and **Figure 2-5**. Based on the previously performed hydrogeologic mapping of the area mentioned above, wells completed to approximately 500 feet below land surface may encounter multiple productive Miocene sand lenses capable of yielding significant amounts of water. A test well program is recommended to address the risks inherent in developing a Miocene/Pliocene aquifer groundwater source with little available data, as described in more detail in the following section, 2.3.2.

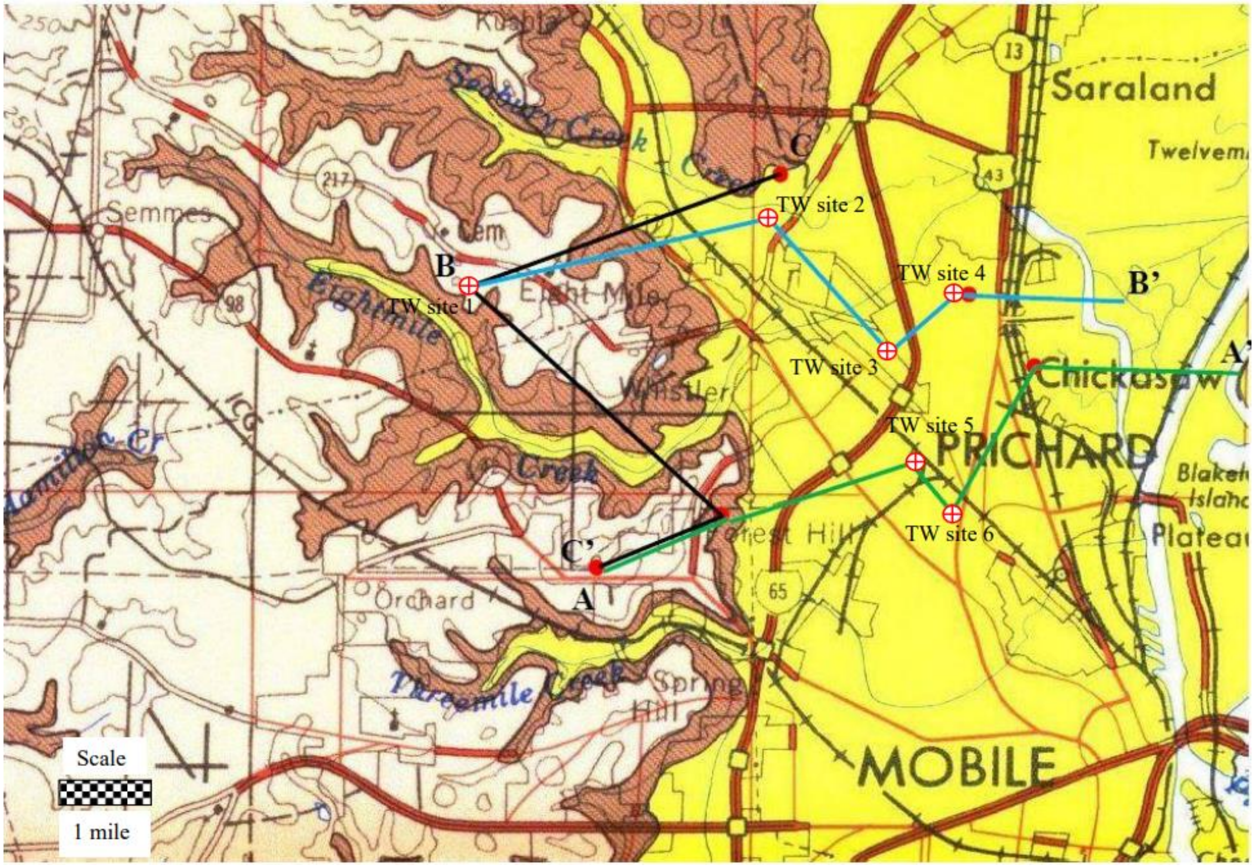

Figure 2-3 Location of Cross Sections for Geologic Review (Cook Hydrogeology, 2022)

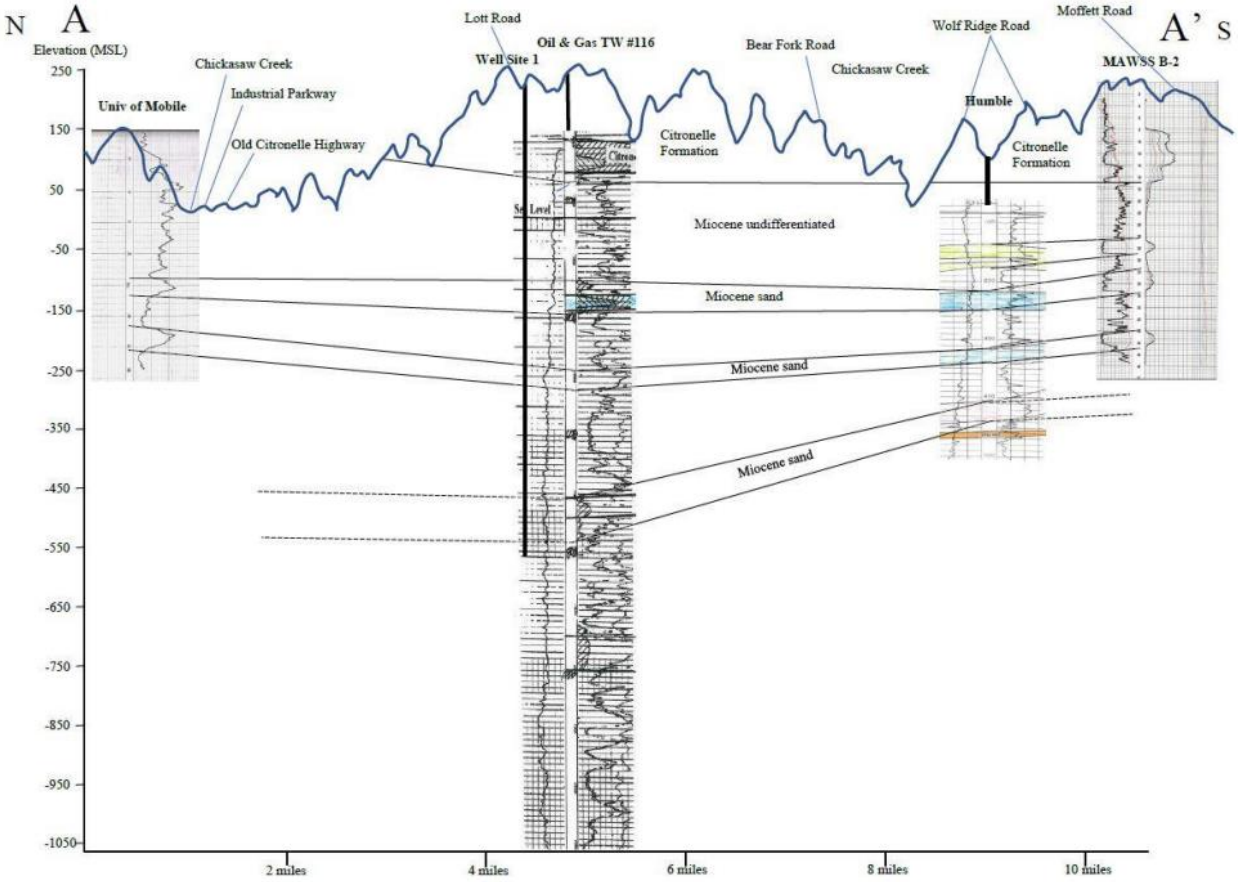

Figure 2-4 Geologic Cross Section "A" Within Study Area (Cook Hydrogeology, 2020)

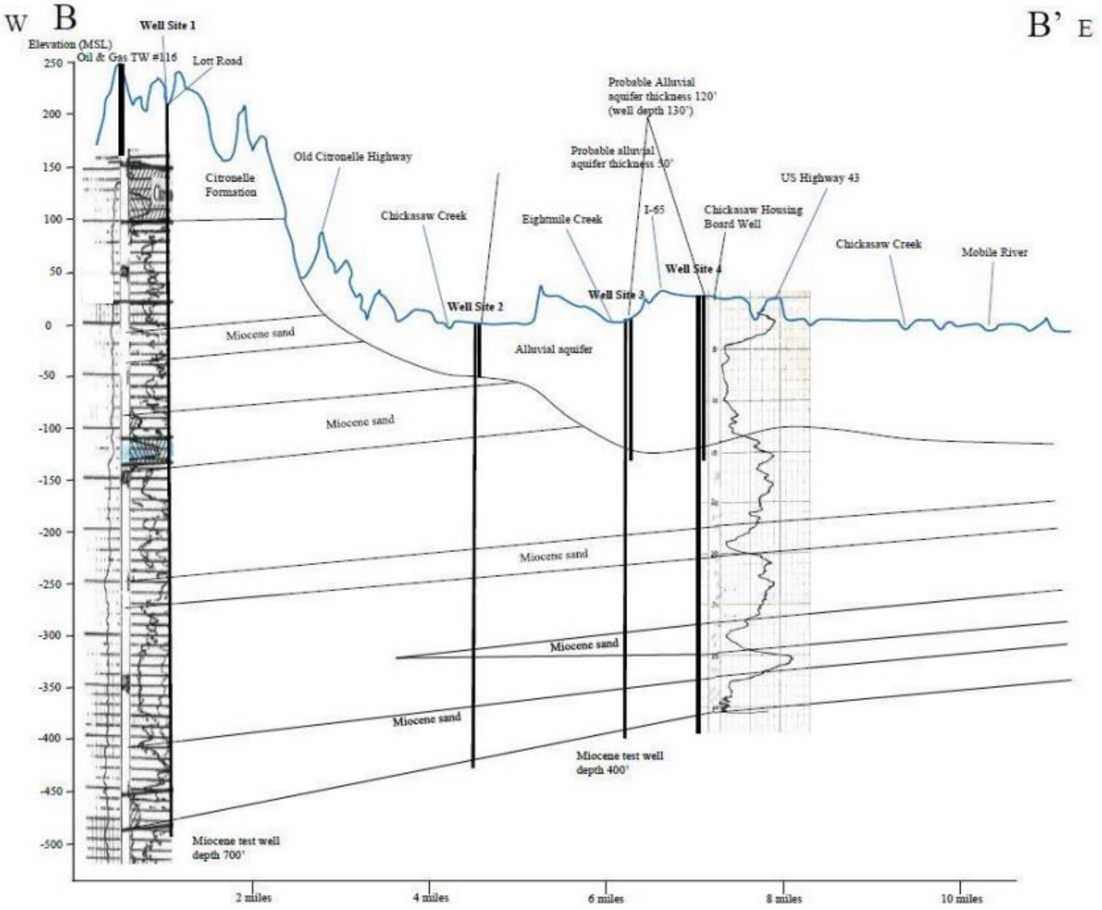

Figure 2-5 Geologic Cross Section "B" Within Study Area (Cook Hydrogeology, 2020)

2.3.2 Groundwater Source Risk Mitigation

There are significant risks associated with using groundwater. Because of the limited available data, a test/production well program is recommended before proceeding with the construction of full-scale withdrawal and treatment facilities. At least three test production wells are recommended to provide water for water quality testing, to determine aquifer performance, and provide data for groundwater modeling. Proposed test well locations are shown in **Figure 2-6.** Detailed testing and analysis of drill cuttings should be performed during well completion to refine the previously mapped Pliocene and Miocene units capability to yield significant groundwater. The test well program would likely consist of a minimum of one year of testing, including extended aquifer performance testing and water level monitoring to observe potential interference between wells, indications of significant seasonal or sustained water level trends or variability and water quality changes that may lead to increases in treatment costs or a need for additional wells. Data from the test well program can be used to develop a calibrated numerical groundwater model for simulation of longer-term pumping scenarios. While the results of this investigation and modeling may provide a basis for groundwater system siting, design, and permitting, long-term performance will need to be monitored. Wellfields are dynamic systems, often requiring changes in operation, distribution of pumping, and treatment. It is important to note that in areas where aquifers have not been historically developed for public water supply systems, long-term (decadal) scale groundwater data are not available. Stress on aquifers resulting from new wellfields, longer-term recharge variability, and climate uncertainty can cause declining water levels, loss of well capacity, and water quality changes that necessitate changes in the withdrawal facilities (pumps and wells), treatment, and/or a change in the supply source entirely.

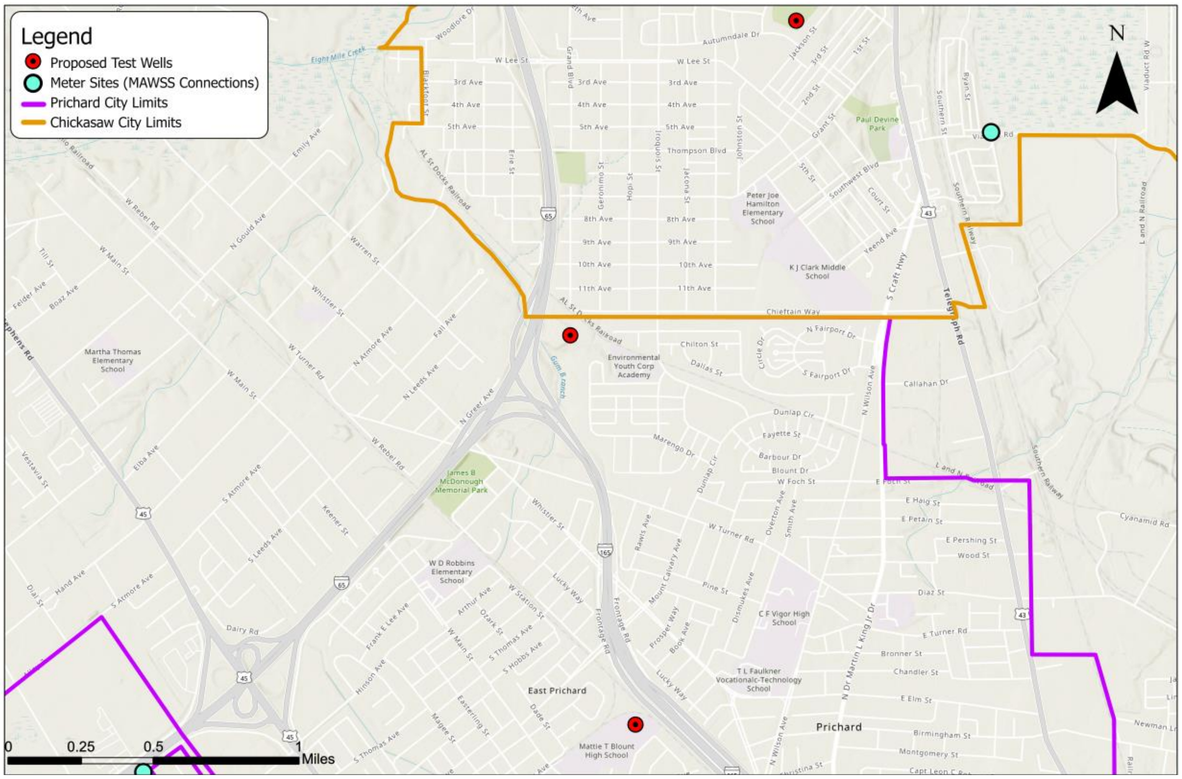

Figure 2-6 Proposed Test Well Locations

Table 2-1 shows the summary of pertinent available water quality from the testing of an Alluvial well that was completed in 2020 by Cook Hydrogeology, along with the available Miocene well data that is several decades old that was presented in O’Donnell & Associates, 2015. Although the data are limited, both the Alluvial and Miocene aquifers show elevated iron concentrations, often at or above the USEPA’s Secondary Drinking Water Standards’ threshold of 0.3 mg/L. The Miocene aquifer was found to have elevated color above the secondary standard. No data are available on organic carbon levels or manganese, so it is not possible to positively attribute the color to natural organic matter or manganese. However, given the elevated iron concentrations in the Miocene and elevated manganese in the Alluvial aquifer, it is plausible that manganese may also be elevated in the Miocene. Therefore, the groundwater treatment system was based on a need to treat water that has concentrations near or above the USEPA’s Secondary Drinking Water Standards for iron and manganese.

Table 2-1 Pertinent Water Quality Data

Water Quality Parameter	Alluvial-Upper Prichard Water Quality (Cook Hydrogeology, 2021)	Miocene Water Quality (O'Donnell & Associates 2015)	Secondary Drinking Water Standards (USEPA)
pH	5.1 - 5.5	6.8 - 8.7	6.5 - 8.5
Iron (mg/L)	0.3	0.08 - 0.6	0.35
Manganese (mg/L)	0.03	No data	0.05
Color (units)	No data	22.1	15

2.4 Preliminary Design and Cost Estimate of Potentially Viable Source Water Alternatives

Based on the above information, treatment design and associated cost estimates were developed for a Miocene aquifer source water using the scenarios presented below in **Table 2-2**. Note that the design capacity is 3.16 MGD and there are four treatment systems, two wellfield systems, and two standby capacities for a total of 16 scenarios.

Table 2-2 Matrix of Water Treatment Design Scenarios Evaluated

Capacity	Treatment System	Wellfield System	Standby Capacity
3.16 MGD (Max day demand with 25% system water losses)	Sequestration of iron and manganese	Centralized	Provided by MAWSS
	Aeration followed by filtration	Decentralized	Provided through system redundancy
	Chlorine oxidation followed by filtration		
	Manganese greensand		

2.4.1 Capacity Evaluation

The average day demand based on the monthly MAWSS invoices between April 2022 and February 2024 was found to be approximately 4.4 MGD. The ADEM CAP Review estimates that 56% of the average day demand is lost to system leaks and theft (ADEM Compliance Review, 2023). The base water demand for PWW&SB, accounting for system water losses, was calculated by removing the estimated 56% system losses and multiplying the 4.4 MGD average day demand by (1-0.56). The estimated base water demand for PWW&SB is, therefore, 1.94 MGD. It should be noted that the current system losses are relatively high compared to industry standard goals of 10-25%.

ADEM has confirmed that no groundwater allocation will be approved until PWW&SB can demonstrate improved TMF sustainability. While ADEM did not specify a target water loss that would be deemed acceptable, an industry standard of 25% was used to calculate average day and max day demands using the following logic:

- Estimated base system demand of 1.94 MGD
- System water loss goal of 25%, or 0.49 MGD
- Average daily demand of 2.43 MGD (1.94 plus 0.49 MGD)
- Max daily demand of 3.16 MGD (2.43 MGD times 1.3 peaking factor)

The 1.3 peaking factor was previously calculated during the 2020 hydraulic modeling that used daily billing data to calculate a peaking factor from average and max daily values.

Using the recommendations included from Hazen's asset management team it is estimated that 76% of the water main system would be replaced over a 20-year period with an annual improvement cost of $12M (Hazen and Sawyer, 2024). Using a linear association, it is estimated that PWW&SB will reduce water losses by approximately 3.84% per year as water mains are replaced. This 3.8% average reduction of system losses is estimated to be 0.093 MGD/year. As shown in **Appendix A**, if a linear reduction in water losses is achieved, PWW&SB would reach the target water loss rate of 25% in the year 2043.

It is more likely that water loss reductions will be asymptotic as compared to linear due to the nature of the improvements approach, such as, replacing the largest identifiable defects earlier in the program. However, due to the limited information regarding location and flows of current system losses the linear method of estimation was used. As PWW&SB begins water main system replacements, a more accurate reduction projection can be developed and a trigger-based approach to capital planning.

2.4.2 Treatment System Evaluation

As mentioned above, treatment requirements for Miocene aquifer water include iron and manganese removal. Both iron and manganese are present in the dissolved state in groundwater. Typical treatment options include sequestration, removal via oxidizing iron and manganese into particulate form followed by removal through granular media filtration, and permanganate and greensand filtration. **The efficacy of sequestration is questionable and was eliminated from further consideration at this point.** If additional well pilot studies show that the contaminants are present in low concentration close to the secondary maximum contaminant levels, then sequestration may be viable.

There are several options for removal of iron and manganese by oxidation and filtration. Oxidation can be accomplished using aeration or the application of a chemical oxidant including chlorine, potassium (or sodium) permanganate, chlorine dioxide or ozone. Chlorine dioxide and ozone must be generated on site and are significantly more complicated and expensive to operate and are not recommended. Filtration options include typical granular media filters (anthracite over sand) or greensand. These alternatives are described in more detail below.

2.4.2.1 Aeration

In addition to being an oxidant, aeration can strip dissolved carbon dioxide from the water which can increase the pH. The effectiveness of aeration in oxidizing iron and manganese is a function of pH. At pH values around 6.5, it takes about 20 minutes to oxidize iron and several hours (6 -12 hours) to oxidize manganese. The rate of oxidation increases significantly with pH levels above 6.5. Therefore, sodium hydroxide is typically used to increase pH into the 7.5 – 8.0 range when using aeration to oxidize iron and manganese.

After oxidation the water must be filtered to remove the precipitated iron and manganese. In addition, any oxidized iron and manganese that has settled in the aeration basin must be periodically removed. Chlorine is typically added prior to filtration to enhance removal and provide a residual for the distribution system. The complete process flow diagram is shown in **Figure 2-7**.

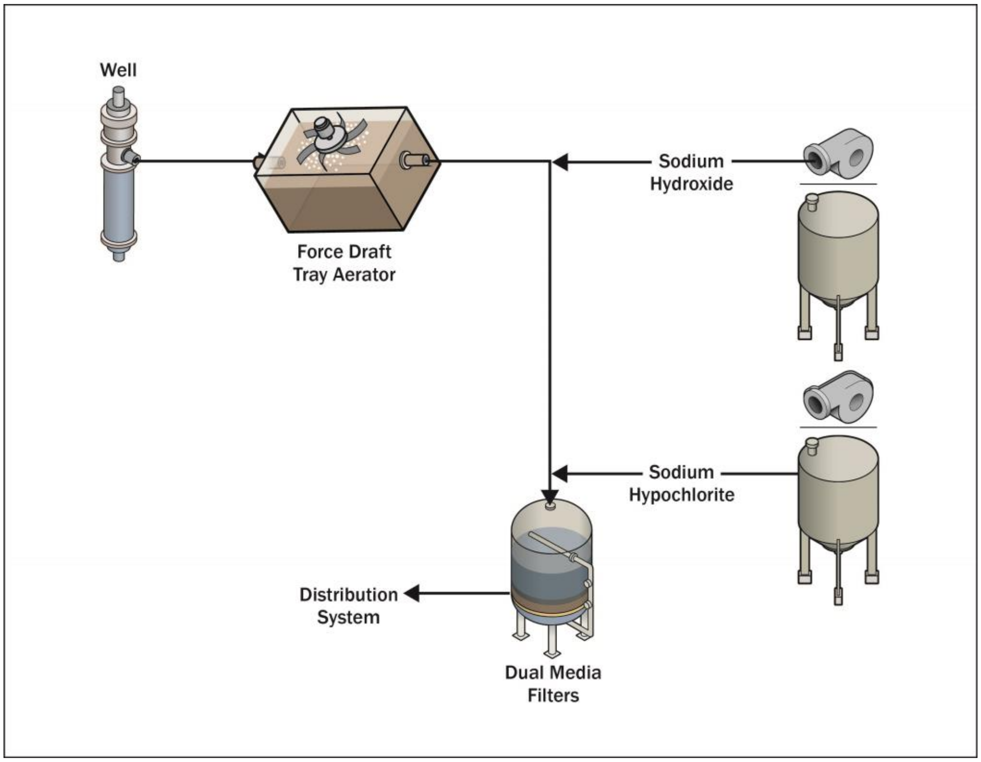

Figure 2-7 Schematic of an Aeration and Filtration System

2.4.2.2 Chlorination

Chlorine can also be used to oxidize iron and manganese. Oxidation of iron is very rapid and occurs within minutes. Oxidation of manganese by chlorine is commonly practiced by applying chlorine prior to a granular media filter through what is known as an induced-greensand effect.

The filtration process after oxidation can be either gravity or pressure filtration. For iron and manganese removal with aeration or chlorination, the filter media is typically sand or anthracite/sand. In either case, the media must be conditioned by coating with a layer of manganese dioxide which acts as a catalyst to adsorb manganese. The conditioning is typically accomplished using chlorine and potassium permanganate as oxidants to form the manganese dioxide coating. To help form a manganese dioxide coating on the new filter media, the media is typically soaked overnight in a strong solution of potassium permanganate. Chlorine is added prior to the filter and an in-line static mixer is typically used to ensure complete mixing of the added chlorine. A schematic of the process is shown in **Figure 2-8**.

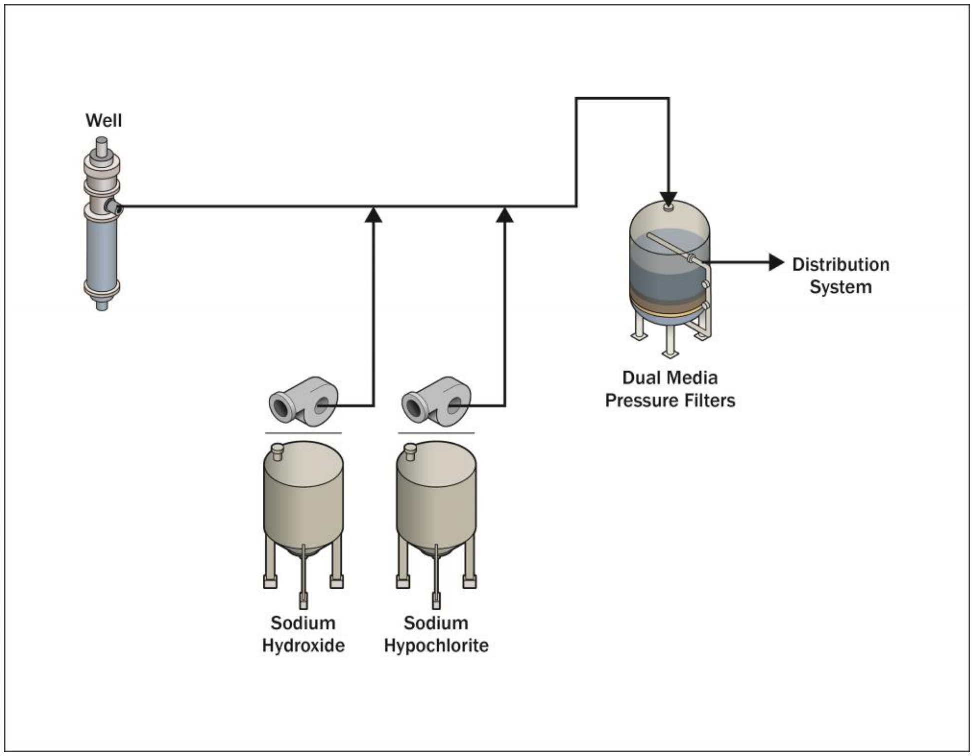

Figure 2-8 Chlorine Oxidation and Filtration Schematic

2.4.2.3 Manganese Greensand Filtration

Manganese greensand has been used for removal of iron and manganese sin the 1950s. Historically, the greensand media was naturally occurring iron, potassium, alumino-silicate material found in the eastern US. Today, most utilities use a synthetic gel-type ion exchange resin (Greensand Plus) which has a capacity six to seven times greater than the natural material. In either case, the media must be regenerated either continuously or intermittently with potassium permanganate. The media is typically placed in pressure filters so well water can be pumped directly from the ground through the filters into the distribution system.

A schematic of the greensand filtration process is shown in **Figure 2-9**.

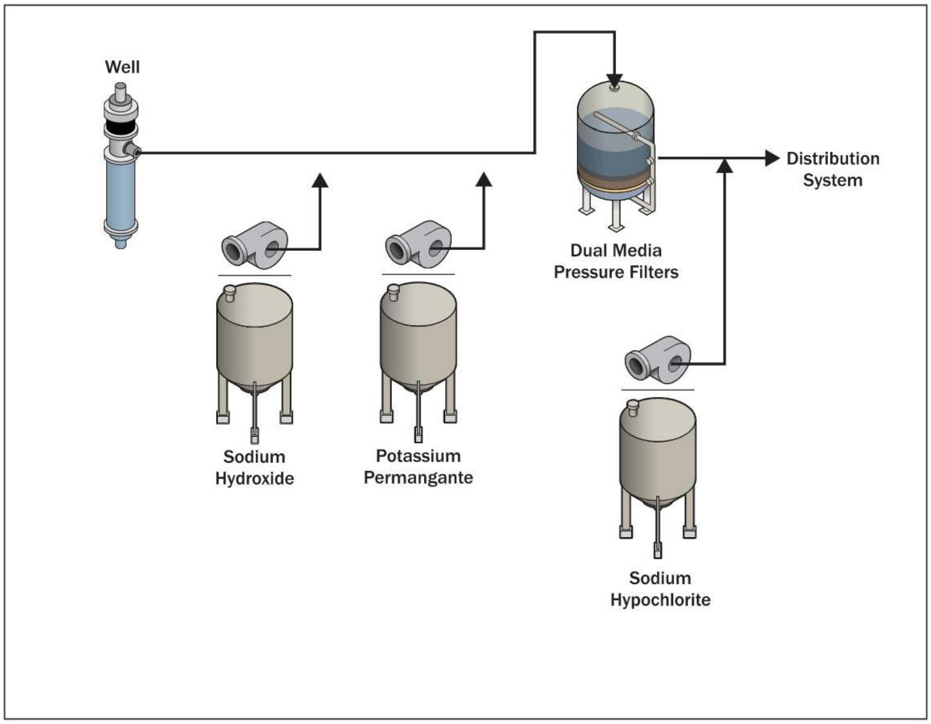

Figure 2-9 Schematic of Greensand Filtration Process

All of the filtration alternatives need to be periodically backwashed. The waste backwash wastewater with iron and manganese residuals can usually be sent directly to the sewer or to a backwash reclamation tank for settling of the contaminants and reuse of the clear supernatant. A very small volume of sludge could then be sent to the sewer. This sludge is inert and does not exert any loads (biological or chemical) on a wastewater treatment plant and is usually accepted under normal operating conditions. If there is no sewer available, the settled solids can be periodically removed by a tank truck.

2.4.3 Comparison of Centralized and Decentralized Well Locations

Two distribution system approaches were considered for the groundwater source scenario. The centralized scenario would include wells being more centrally located around a water treatment facility. The potential benefits of this include economies of scale while building the water treatment facility. **Figure 2-10** shows potential locations of the wells and water treatment plant for a centralized system approach. Note that additional pilot testing is recommended to determine the feasibility of this approach.

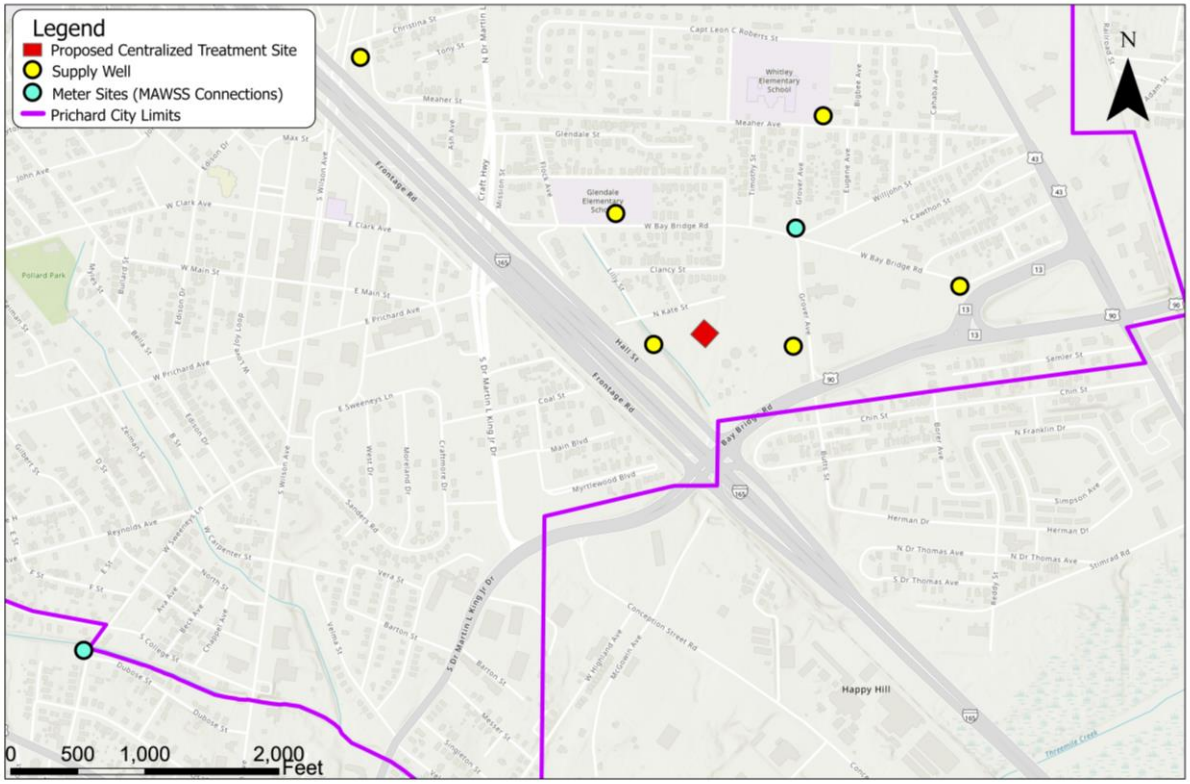

Figure 2-10 Centralized Well System

A decentralized system consists of distributed wells located throughout the Prichard area, with each of the well sites having an individual treatment system. The well locations in this scenario were chosen by proximity to points of connection to the MAWSS system, which would reduce the overall infrastructure costs by using existing valves and pipes to connect the treated well water to the PWW&SB distribution system. Another potential benefit of a distributed system is the inherent reduction in risk through the use of multiple wells and locations. **Figure 2-11** shows potential well locations with a distributed network approach, and as can be seen, the well locations are located near the MAWSS meter sites (shown in blue). The previously discussed proposed test well drilling program and groundwater modeling will inform important aspects of the technical feasibility of each alternative, including recommended well spacing and siting.

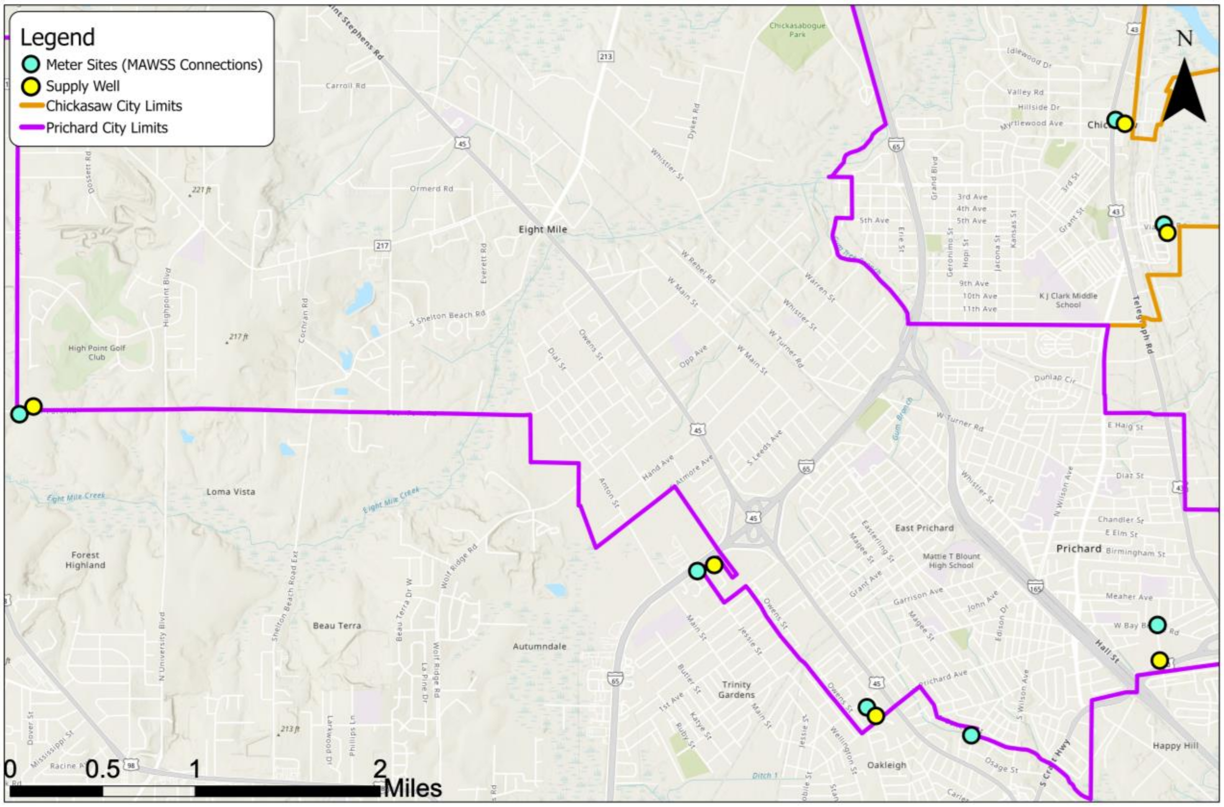

Figure 2-11 Distributed Well Supply

2.4.4 Standby Capacity

Standby capacity is needed to ensure utilities can provide the delivery of safe drinking water through demand fluctuations, emergency situations, maintenance and repairs, population growth, and to maintain system pressure.

Two methods of standby capacity were considered for PWW&SB; purchasing through MAWSS, or through system redundancy in the proposed groundwater well system. The MAWSS standby capacity will cost $2.63/1000 gal (email correspondence with MAWSS). Redundancy capital costs were calculated by multiplying the total capital costs for each treatment scenario by 20% to capture the cost of increasing the wellfield from 5 to 6 wells.

2.5 Water Supply Cost Summary of Viable Alternatives

A projected cost estimate was prepared for Miocene ground water as the source supply, treatment methods of aeration/filtration, chlorine/filtration, and greensand filtration, incorporating both a distributed and centralized well system, and for two different standby capacity scenarios; one being provided by MAWSS and the other being provided through system redundancy. The Class V cost estimates were performed in accordance with the Association for the Advancement of Cost Engineering (AACE) International Recommended Practice 18R-97 Cost Estimate Classification System as applied in

Engineering, Procurement, and Construction for the process industries. It should be noted that the expected accuracy range of a Class V cost estimate is -20% to -50% on the low range, and +30% to +100% for the high range.

The capital and operation and maintenance (O&M) costs were generated using vendor supplied values, best practice values, and cost estimates from recently completed projects. Capital costs were based on the maximum daily demand of 3.16 MGD and the O&M costs were based on the average daily demand of 2.43 MGD.

A net present value (NPV) assessment was calculated for each treatment scenario using an assumed net escalation rate of 3% over a 20-year period.

The cost estimates for each treatment method along with the associated capital and O&M costs can be found in **Table 2-3**. The more detailed cost estimates and assumptions can be found in **Appendix A.** Capital costs include the cost for completion of the wells, well house and chemical building, aeration and filtration system, chemical pumps and storage, pipeline, and well pilot tests. The O&M costs include chemicals, labor, electrical, and purchasing water from MAWSS.

2.5.1 Treatment Technology and Wellfield Distribution NPV

Table 2-3 summarizes the NPV results for the water treatment options considered for both a centralized and decentralized well system. The NPV estimates were based on a 6 well system, which would have an estimated total capacity of 4.3 MGD. As previously discussed, the max daily demand is 3.16 MGD, and each well is expected to produce 0.7 MGD, meaning 5 wells are required for max daily demand, plus one additional well for redundancy. Capital costs were derived using a six well system (N+1) and a per well cost was based on discussions with local well drillers. Operation and maintenance costs were calculated using annual chemical, electrical, and labor costs associated with an average daily demand of 2.43 MGD. Standing capacity costs were calculated by multiplying all capital costs by 20%, which comes from increasing the well system from 5 wells to 6 wells.

The manganese greensand treatment has a higher NPV than aeration/filtration and chlorine/filtration. This is primarily due to the high cost of potassium permanganate that is required for greensand operation. **Due to the high NPV of manganese greensand, it is not recommended as a treatment option for PWW&SB at this time.**

The NPV costs for a decentralized system were slightly higher for all water treatment alternatives than those for a centralized system. This is mostly due to building treatment facilities at all well locations. Although the NPV is slightly higher for a decentralized system, the benefits of a decentralized system include a reduced risk and increased redundancy. **Because of the similar NPV costs and associated benefits of a decentralized system, it is the recommended option for further consideration.**

2.5.2 Standby Capacity NPV

The standby capacity is important as it provides a layer of protection for PWW&SB's water supply. As noted earlier, two scenarios were compared: one with MAWSS supplying all of the average daily flow in standby capacity, and the second scenario uses redundancy within the PWW&SB treatment system. The calculated standby capacity values are shown in **Table 2-3.** The MAWSS standby capacity will cost $2.63/1000 gal (email correspondence with MAWSS). Redundancy capital costs were calculated by multiplying the total capital costs for each treatment scenario by 20% to capture the cost of increasing the wellfield from 5 to 6 wells.

The cost of maintaining a standby water supply capacity from MAWSS is only 12 cents less per thousand gallons than purchasing the water at the current rate of $2.75/1000 gallon. This makes any need to maintain large standby capacities cost prohibitive. **However, ADEM has stated that constructing an extra production well, so that the wellfield is capable of producing flows that exceed demands, would eliminate the need to maintain the standby capacity from MAWSS, making the redundancy option a more cost-effective approach (**ADEM, email correspondence with Aubry White, 5/15/24)**.**

2.5.3 Comparison to Purchasing MAWSS Water

As mentioned above, the findings of this report suggest that the best potential water source alternative for PWW&SB would be a Miocene or Pliocene aquifer source water using a distributed wellfield. Either aeration/filtration or chlorine/filtration for iron and manganese removal are more cost-effective than greensand filtration. The most cost-effective alternative to meet system redundancy/standby capacity requirements would be the construction of an additional well. A comparison to the cost of purchasing MAWSS water is presented in Table 2-3**Table 2-3**. As shown the groundwater source option NPV is between $35-$36M, with a high range value (+100%) of $70-$72M, compared to an NPV of $40M for MAWSS as the source water.

The NPV for the groundwater source option goes beyond the twenty-year estimate and includes the purchasing of MAWSS water in the years 19-22, during which time, PWW&SB will be conducting the permitting, design, and construction of the well field. The NPV of the two alternatives, groundwater source and purchasing MAWSS water, are similar. It should be noted that the NPV costs are based on the Class V estimates as previously mentioned, and more detailed cost estimates should be developed as part of the next steps.

Table 2-3 NPV of Viable Water Source Alternatives

Description	Aeration and Filtration Centralized	Aeration and Filtration Decentralized	Chlorine and Filtration Centralized	Chlorine and Filtration Decentralized	Manganese Greensand Centralized	Manganese Greensand Decentralized	MAWSS
System Flow							
Average Day Flow (MGD)	2,420,000	2,420,000	2,420,000	2,420,000	2,420,000	2,420,000	2,420,000
Max Day Flow (MGD)	3,146,000	3,146,000	3,146,000	3,146,000	3,146,000	3,146,000	3,146,000
Number of Well Locations	6	6	6	6	6	6	-
Capital Costs							
Well Cost (total)	$6,199,800	$6,199,800	$6,199,800	$6,199,800	$6,199,800	$6,199,800	-
Well House/Chemical Building	$162,000	$972,000	$162,000	$972,000	$162,000	$972,000	-
Aeration System	$174,997	$1,049,983	-	-	-	-	-
Filtration System	$232,211	$1,393,266	$238,546	$1,431,276	$238,560	$1,431,360	-
Filter Backwash Tank	-	-	-	-	$112,000	$672,000	-
Polyphosphate Pump and 100 Gal Storage Tank	$4,151	$24,906	$4,151	$24,906	$4,151	$24,906	-
Caustic Pump and 100 Gal Storage Tank	$4,151	$24,906	$4,151	$24,906	$4,151	$24,906	-
Sodium Hypochlorite Pump and 100 Gal Tank	$4,158	$24,948	$4,158	$24,948	$4,158	$24,948	-
Sodium Permanganate Pump and Storage Tank	-	-	-	-	$22,639	$135,836	-
Pipeline	$3,024,000	$720,000	$3,024,000	$720,000	$3,024,000	$720,000	-
Well Pilot Test	$3,251,500	$3,251,500	$3,251,500	$3,251,500	$3,251,500	$3,251,500	-
Subtotal Capital	**$13,056,968**	**$13,661,309**	**$12,888,306**	**$12,649,336**	**$13,022,959**	**$13,457,256**	**$0**
Operations and Maintenance							
Polyphosphate	$2,516	$2,516	$2,516	$2,516	$2,516	$2,516	-
Caustic	$92,797	$92,797	$92,797	$92,797	$92,797	$92,797	-
Sodium Hypochlorite	$67,705	$67,705	$84,631	$84,631	$67,705	$67,705	-
Sodium Permanganate	-	-	-	-	$514,783	$514,783	-
Labor Requirements	$394,200	$394,200	$394,200	$394,200	$394,200	$394,200	-
Electrical Costs	$41,760	$41,760	$41,760	$41,760	$41,760	$41,760	-

Table 2-3 NPV of Viable Water Source Alternatives

Description	Aeration and Filtration Centralized	Aeration and Filtration Decentralized	Chlorine and Filtration Centralized	Chlorine and Filtration Decentralized	Manganese Greensand Centralized	Manganese Greensand Decentralized	MAWSS
Purchase MAWSS Water	-	-	-	-	-	-	$2,429,075
Subtotal Operations and Maintenance (Annual)	$598,978	$598,978	$615,905	$615,905	$1,113,761	$1,113,761	$2,429,075
Subtotal Operations and Maintenance (PV)	**$9,794,155**	**$9,794,155**	**$10,070,923**	**$10,070,923**	**$18,211,587**	**$18,211,587**	**$39,718,858**
Standing Capacity							
Standing Capacity (MAWSS) (Annual)	$2,323,079	$2,323,079	$2,323,079	$2,323,079	$2,323,079	$2,323,079	-
Standing Capacity (MAWSS) PV	$37,985,671	$37,985,671	$37,985,671	$37,985,671	$37,985,671	$37,985,671	-
Standing Capacity (Redundancy)	$2,611,394	$2,732,262	$2,577,661	$2,529,867	$2,604,592	$2,691,451	-
Purchase MAWSS Water Years 19-23	$9,895,147	$9,895,147	$9,895,147	$9,895,147	$9,895,147	$9,895,147	-
Total Present Worth of Alternative (Redundancy Capacity)	**$35,357,664**	**$36,082,873**	**$35,432,037**	**$35,145,273**	**$43,734,285**	**$44,255,441**	**$39,718,858**
Total Present Worth of Alternative (Redundancy Capacity) (Low Range -50%)	**$17,678,832**	**$18,041,436**	**$17,716,019**	**$17,572,637**	**$21,867,142**	**$22,127,721**	**$39,718,858**
Total Present Worth of Alternative (Redundancy Capacity) (High Range +100%)	**$70,715,327**	**$72,165,746**	**$70,864,074**	**$70,290,546**	**$87,468,570**	**$88,510,883**	**$39,718,858**

2.6 Trigger Based Roadmap Development

Given the anticipated TMF requirements of ADEM, a preliminary trigger-based roadmap was developed to illustrate the next recommended steps for Prichard with respect to water source alternative supply. The roadmap includes the investigation of the groundwater source followed by the reduction of water loss in the system. This approach will reduce costs and risk while promoting confidence in the utility's ability to function as a sustainable entity. It is recommended that the triggers include completion of a Miocene/Pliocene pilot test well program, completion of a Class I or II cost estimate for the groundwater source option, and reduction of system losses to 25%. Once these triggers are achieved, design, permitting, and construction can proceed. The following items should be considered when PWW&SB validates and adopts the trigger-based roadmap:

- The first component of the roadmap is to focus on reducing system leaks which is an essential component of demonstrating improved TMF. While ADEM has not stated a specific water loss percentage that would be acceptable, a standard industry goal is 10 – 25%. For the purpose of this roadmap, it is recommended that system losses be reduced to 25% before initiating next steps. Using the recommendations included from Hazen's asset management team it is estimated that 76% of the water main system would be replaced over a 20-year period with an annual improvement cost of $12M (Hazen and Sawyer, 2024). Using a linear association, it is estimated that PWW&SB will reduce water losses by approximately 3.84% per year as water mains are replaced. This 3.8% average reduction of system losses is estimated to be 0.093 MGD/year. As shown in **Appendix A**, if a linear reduction in water losses is achieved, PWW&SB would reach the target water loss rate of 25% in the year 2043.

- The second component of the roadmap should be to reduce the risks associated with the Miocene/Pliocene aquifers source. This would be accomplished through a pilot test well program, and associated groundwater modeling, that will evaluate the sustained water quality and yield over a period of time (at least one year). PWW&SB should only move forward with the roadmap if the water quality and yield are acceptable.

- In parallel with the pilot test, PWW&SB should develop more refined cost estimates to better understand the cost implications of switching to groundwater. This should include the costs of well completion, well house and chemical buildings, chemical costs, labor, and electrical costs. It should also include any upgrades needed to comply with future corrosion control and distribution system disinfectant residual regulatory requirements.

- If the pilot test well results and more refined cost estimates are satisfactory, and system water losses are reduced to 25%, PWW&SB should then begin the design, permitting, and construction process of a decentralized oxidation/filtration water system. The recommended maximum day design rate is 3.16 MGD for the groundwater system, and it is estimated that the design, permitting, and construction process will take three years to complete (2047). During completion of the groundwater system PWW&SB should retain its contractual relationship with MAWSS (estimated to be 2047).

2.7 Recommendations

It is recommended that PWW&SB maintain MAWSS as the water source until a sustained TMF capacity can be demonstrated, at which point PWW&SB can consider engaging with ADEM regarding the implementation of a groundwater source option.

The preliminary system design recommendations include:

- Capacity – Reduced max daily demand of 3.16 MGD and average daily demand of 2.43 MGD (reflecting the improved water loss of 25%)
- Treatment type – Aeration/filtration or chlorination/filtration
- Plant approach – Decentralized well system
- Standby capacity - Provided through well system redundancy

It is recommended that PWW&SB perform a pilot test well program to better assess water quality and well yield and to develop a trigger-based roadmap considering the options presented above. A pilot test is outlined in **Section 2.3.2**, which will consist of three pilot wells in operation for one year.

The estimated capital and operational costs for this recommended alternative water source are presented in **Table 2-4**, which show an expected capital cost between $13M-$14M, and a 20-year NPV O&M cost of $28M-$29M. It should be noted that to achieve the recommended 25% system water losses necessary to demonstrate the required TMF for ADEM approval, an estimated $240M investment in water main replacement is needed over the next 20 years (Hazen and Sawyer, Asset Evaluation Technical Memorandum, May 30, 2024).

Table 2-4 Recommended Groundwater Supply NPV

	Aeration and Filtration NPV ($)	Chlorination and Filtration NPV ($)
Capital Costs	$13.7M	$12.6M
Standing Capacity (Redundancy)	$2.7M	$2.5M
Purchase Water From MAWSS (2043- 2045)	$9.9M	$9.9M
Operation and Maintenance (PV)	$9.8M	$9.8M
Total Net Present Value	**$36.1M**	**$35.1M**
Total Present Worth of Alternative (Redundancy Capacity) (Low Range -50%)	**$18.0M**	**$17.6M**
Total Present Worth of Alternative (Redundancy Capacity) (High Range +100%)	**$72.2M**	**$70.3M**

3. References

Geological Survey of Alabama, 2018. Assessment of groundwater resources in Alabama, 2010-16: Alabama Geological Survey Bulletin 186, plus separately bound volume of 105 plates.

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Hazen and Sawyer, 2024. PWW&SB Asset Evaluation Technical Memorandum.

Alabama Department of Environmental Management, 2023. ADEM Compliance Assistance Program Review of the Prichard Water System. Prepared for the Prichard Water Works and Sewer Board.

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July 1, 2024

Appendix A: Water Supply & Treatment Alternatives Analysis

NPV Analysis of PWWSB Current and Viable Water Sources

	Aeration and Filtration Centralized	Aeration and Filtration Decentralized	Chlorine and Filtration Centralized	Chlorine and Filtration Decentralized	Manganese Greensand Centralized	Manganese Greensand Decentralized	MAWSS
System Flow							
Average Day Flow (MGD)	2,420,000	2,420,000	2,420,000	2,420,000	2,420,000	2,420,000	2,420,000
Max Day Flow (MGD)	3,146,000	3,146,000	3,146,000	3,146,000	3,146,000	3,146,000	3,146,000
Number of Well Locations	6	6	6	6	6	6	
Capital Costs							
Well Cost (total)	$6,199,800	$6,199,800	$6,199,800	$6,199,800	$6,199,800	$6,199,800	-
Well House/Chemical Building	$162,000	$972,000	$162,000	$972,000	$162,000	$972,000	-
Aeration System	$174,997	$1,049,983	-	-	-	-	-
Filtration System	$232,211	$1,393,266	$238,546	$1,431,276	$238,560	$1,431,360	-
Filter Backwash Tank	-	-	-	-	$112,000	$672,000	-
Polyphosphate Pump and 100 Gal Storage Tank (Corrosion Inhibitor)	$4,151	$24,906	$4,151	$24,906	$4,151	$24,906	-
Caustic Pump and 100 Gal Storage Tank	$4,151	$24,906	$4,151	$24,906	$4,151	$24,906	-
Sodium Hypochlorite Pump and 100 Gal Tank	$4,158	$24,948	$4,158	$24,948	$4,158	$24,948	-
Sodium Permanganate Pump and Storage Tank	-	-	-	-	$22,639	$135,836	-
Pipeline	$3,024,000	$720,000	$3,024,000	$720,000	$3,024,000	$720,000	-
Well Pilot Test	$3,251,500	$3,251,500	$3,251,500	$3,251,500	$3,251,500	$3,251,500	-
Subtotal Capital	**$13,056,968**	**$13,661,309**	**$12,888,306**	**$12,649,336**	**$13,022,959**	**$13,457,256**	**$0**
Operations and Maintenance							
Polyphosphate	$2,516	$2,516	$2,516	$2,516	$2,516	$2,516	-
Caustic	$92,797	$92,797	$92,797	$92,797	$92,797	$92,797	-
Sodium Hypochlorite	$67,705	$67,705	$84,631	$84,631	$67,705	$67,705	-
Sodium Permanganate	-	-	-	-	$514,783	$514,783	-
Labor Requirements	$394,200	$394,200	$394,200	$394,200	$394,200	$394,200	-
Electrical Costs	$41,760	$41,760	$41,760	$41,760	$41,760	$41,760	-
Purchase MAWSS Water	-	-	-	-	-	-	$2,429,075
Subtotal Operations and Maintenance (Annual)	$598,978	$598,978	$615,905	$615,905	$1,113,761	$1,113,761	$2,429,075
Subtotal Operations and Maintenance (PV)	**$9,794,155**	**$9,794,155**	**$10,070,923**	**$10,070,923**	**$18,211,587**	**$18,211,587**	**$39,718,858**
Standing Capacity							
Standing Capacity (MAWSS) (Annual)	$2,323,079	$2,323,079	$2,323,079	$2,323,079	$2,323,079	$2,323,079	-
Standing Capacity (MAWSS) PV	$37,985,671	$37,985,671	$37,985,671	$37,985,671	$37,985,671	$37,985,671	-
Standing Capacity (Redundancy)	$2,611,394	$2,732,262	$2,577,661	$2,529,867	$2,604,592	$2,691,451	-
Purchase MAWSS Water Years 19-22	$9,895,147	$9,895,147	$9,895,147	$9,895,147	$9,895,147	$9,895,147	-
Total Present Worth of Alternative (Redundancy Capacity)	**$35,357,664**	**$36,082,873**	**$35,432,037**	**$35,145,273**	**$43,734,285**	**$44,255,441**	**$39,718,858**
Total Present Worth of Alternative (Redundancy Capacity) (Low Range -50%)	**$17,678,832**	**$18,041,436**	**$17,716,019**	**$17,572,637**	**$21,867,142**	**$22,127,721**	**$39,718,858**
Total Present Worth of Alternative (Redundancy Capacity) (High Range +100%)	**$70,715,327**	**$72,165,746**	**$70,864,074**	**$70,290,546**	**$87,468,570**	**$88,510,883**	**$39,718,858**

Assumptions

Item	Value
Base Cost for Reduction ($/yr)	$11,200,000.00
Base Reduction Rate (%/yr)	0.038
Escalation Factor	1
Standby Capacity Rate ($/1000gal)	$2.63
Standby Capacity Flow	$2,511,360.00
Standby Capacity Cost/Month	$198,146.30
Standby Capacity Cost/Year	$2,377,755.65
Max Day Multiplier	1.3
Non revenue water loss (percent)	0.56
Average Day Demand (gal/d)	4,400,000
Non Revenue Water (gal/d)	2,464,000
Estimated Base Flow (gal/d)	1,936,000
Future Design Flow (Base Plus 25%) (gal/d)	2,420,000
Future Max Day Design (gal/d)	3,146,000
Purchase Price from MAWSS ($/1000gal)	2.75
Flow Rate per well (gal/d)	720,000
Total Wells Required	6.00
Aqua Mag Polyphosphate (gal/MGD-year)	375
50% Caustic Soda (gal/MGD-year)	5,500
12.5% Sodium Hypochlorite at 3 mg/L (gal/MGD-year)	9,125
Sodium Permanganate (gal/MGD-year)	15,877
Aqua Mag Polyphosphate ($/gal)	$1.98
50% Caustic Soda ($/MGD)	$4.98
12.5% Sodium Hypochlorite ($/MGD)	$2.19
Sodium Permanganate ($/MGD)	$9.57
Well Construction Cost ($/well)	$1,033,300.00
8" Pipeline per well (decentralized) (ft)	800
8" Pipeline cost ($/ft)	150
16" Pipeline cost ($195/ft)	195
Centralized Pipeline (ft/well)	3,000
Labor Costs ($/hr)	$45.00
Sequestration Power Consumption (Kwh/MGD)	122,126
Aeration/Filtration Power Consumption (Kwh/MGD)	122,126
Chlorine Oxidation/FiltrationPower Consumption (Kwh/	122,126
Manganese Greensand Power Consumption (Kwh/MG	122,126

Estimated Reduced Flow Timeline

Year	Cost	Percent Reduction	NRW Flow Reduced	Remaining NRW	Revenue Flow	Total Flow	Estimated System Loss (%)	Total Flow (Average)	Total Flow (Max Day)	MAWSS Purchased Amount (GPD)	MAWSS Purchased Amount ($/year)
1	$ 11,200,000	4%	93,632	2,370,368	1920000	4,290,368	55%	4,290,368	5,577,478	4,290,368	$4,306,456.88
2	$ 11,200,000	4%	93,632	2,276,736	1920000	4,196,736	54%	4,196,736	5,455,757	4,196,736	$4,212,473.76
3	$ 11,200,000	4%	93,632	2,183,104	1920000	4,103,104	53%	4,103,104	5,334,035	4,103,104	$4,118,490.64
4	$ 11,200,000	4%	93,632	2,089,472	1920000	4,009,472	52%	4,009,472	5,212,314	4,009,472	$4,024,507.52
5	$ 11,200,000	4%	93,632	1,995,840	1920000	3,915,840	51%	3,915,840	5,090,592	3,915,840	$3,930,524.40
6	$ 11,200,000	4%	93,632	1,902,208	1920000	3,822,208	50%	3,822,208	4,968,870	3,822,208	$3,836,541.28
7	$ 11,200,000	4%	93,632	1,808,576	1920000	3,728,576	49%	3,728,576	4,847,149	3,728,576	$3,742,558.16
8	$ 11,200,000	4%	93,632	1,714,944	1920000	3,634,944	47%	3,634,944	4,725,427	3,634,944	$3,648,575.04
9	$ 11,200,000	4%	93,632	1,621,312	1920000	3,541,312	46%	3,541,312	4,603,706	3,541,312	$3,554,591.92
10	$ 11,200,000	4%	93,632	1,527,680	1920000	3,447,680	44%	3,447,680	4,481,984	3,447,680	$3,460,608.80
11	$ 11,200,000	4%	93,632	1,434,048	1920000	3,354,048	43%	3,354,048	4,360,262	3,354,048	$3,366,625.68
12	$ 11,200,000	4%	93,632	1,340,416	1920000	3,260,416	41%	3,260,416	4,238,541	3,260,416	$3,272,642.56
13	$ 11,200,000	4%	93,632	1,246,784	1920000	3,166,784	39%	3,166,784	4,116,819	3,166,784	$3,178,659.44
14	$ 11,200,000	4%	93,632	1,153,152	1920000	3,073,152	38%	3,073,152	3,995,098	3,073,152	$3,084,676.32
15	$ 11,200,000	4%	93,632	1,059,520	1920000	2,979,520	36%	2,979,520	3,873,376	2,979,520	$2,990,693.20
16	$ 11,200,000	4%	93,632	965,888	1920000	2,885,888	33%	2,885,888	3,751,654	2,885,888	$2,896,710.08
17	$ 11,200,000	4%	93,632	872,256	1920000	2,792,256	31%	2,792,256	3,629,933	2,792,256	$2,802,726.96
18	$ 11,200,000	4%	93,632	778,624	1920000	2,698,624	29%	2,698,624	3,508,211	2,698,624	$2,708,743.84
19	$ 11,200,000	4%	93,632	684,992	1920000	2,604,992	26%	2,604,992	3,386,490	2,604,992	$2,614,760.72
20	$ 11,200,000	4%	93,632	591,360	1920000	2,511,360	24%	2,511,360	3,264,768	2,511,360	$2,520,777.60
21	$ 11,200,000	4%	93,632	497,728	1920001	2,417,729	21%	2,417,729	3,143,048	2,417,729	$2,426,795.48
22	$ 11,200,000	4%	93,632	404,096	1920002	2,324,098	17%	2,324,098	3,021,327	2,324,098	$2,332,813.37
23	$ 11,200,000	4%	93,632	310,464	1920003	2,230,467	14%	2,230,467	2,899,607	-	$0.00
24	$ 11,200,000	4%	93,632	216,832	1920004	2,136,836	10%	2,136,836	2,777,887	-	$0.00
25	$ 11,200,000	4%	93,632	123,200	1920005	2,043,205	6%	2,043,205	2,656,167	-	$0.00
26	$ 11,200,000	4%	93,632	29,568	1920006	1,949,574	2%	1,949,574	2,534,446	-	$0.00

🟦 Highlight indicates the approximate trigger water system losses of 25% (year 19), and completion of the wellfield system (Year 22)

Sequestration Treatment System

Item	Description	Quantity	Unit	Unit Cost	Installation Factor	Capital Total	Annual Operating Cost	Comments/Reference
1	350 sf Well House/Chemical Building	1	EA	$70,000	1.08	$75,600		$200/SF, security.
2	Polyphosphate Pump & 100 gal. storage tank	1	EA	$2,965	1.4	$4,151		Totes for Storage
3	Aqua Mag Polyphosphate	908	gal/year	$1.98	1.4		$2,516	Cost/gal
4	Caustic Pump & 100 gal. storage tank	1	EA	$2,965	1.4	$4,151		Totes for Storage
5	50% Caustic Soda	13,310	gal/d	$4.98	1.4		$92,797	Cost/gal
6	Sodium Hypochlorite Pump & 100 gal Tank	1	EA	$2,970	1.4	$4,158		Totes for Storage
7	12.5% Sodium Hypochlorite	22,083	gal/year	$2.19	1.4		$67,705	Cost/gal
8	Estimated Labor Requirement	730	hrs/year	$45	1.0		$32,850	2 hr/day
9	Estimated Electrical Costs	295,545	kwh/d	$0.14	1.0		$41,760	90 hp, 67 kw
					Subtotals	**$89,000**	**$238,000**	
					30% Sitework, concrete & electrical	**$26,700**		
					30% Contingency	**$26,700**		
					25% Engineering/design fee	**$23,000**		
					Estimated Capital Costs	**$165,400**		

Aeration/Filtration Treatment System

Item	Description	Quantity	Unit	Unit Cost	Installation Factor	Capital Total	Annual Operating Cost	Comments/Reference
1	750 sf Well House/Chemical/Treament Building	1	EA	$150,000	1.08	$162,000		
2	Tray Aeration System	1	LS	$124,998	1.4	$174,997		Package Plant
3	Dual Media Pressure Filter System	1	LS	$165,865	1.4	$232,211		Package Plant
4	Polyphosphate Pump & 100 gal. storage tank	1	EA	$2,965	1.4	$4,151		Totes for Storage
5	Aqua Mag Polyphosphate	908	gal/yr	$1.98	1.4		$2,516	Cost/gal
6	Caustic Pump & 100 gal. storage tank	1	EA	$2,965	1.4	$4,151		Totes for Storage
7	50% Caustic Soda	13,310	gal/yr	$4.98	1.4		$92,797	Cost/gal
8	Sodium Hypochlorite Pump & 100 gal Tank	1	EA	$2,970	1.4	$4,158		Totes for Storage
9	12.5% Sodium Hypochlorite	22,083	gal/yr	$2.19	1.4		$67,705	Cost/gal
10	Estimated Labor Requirement	8,760	EA	$45	1.0		$394,200	4 hr/day
11	Estimated Electrical Costs	295,545	kwh	$0.14	1.0		$41,760	90 hp, 67 kw

Subtotals	**$582,000**	**$599,000**
30% Sitework, concrete & electrical	**$175,000**	
30% Contingency	**$175,000**	
25% Engineering/design fee	**$146,000**	
Estimated Capital Costs	**$1,078,000**	

Chlorine Oxidation/Filtration Treatment System

Item	Description	Quantity	Unit	Unit Cost	Installation Factor	Capital Total	Annual Operating Cost	Comments/Reference
1	750 sf Well House/Chemical/Treament Building	1	EA	$150,000	1.08	$162,000		
2	Dual Media Pressure Filter System	1	LS	$170,390	1.4	$238,546		Package Plant
3	Polyphosphate Pump & 100 gal. storage tank	1	EA	$2,965	1.4	$4,151		Totes for Storage
4	Aqua Mag Polyphosphate	908	gal/year	$1.98	1.4		$2,516	Cost/gal
5	Caustic Pump & 100 gal. storage tank	1	EA	$2,965	1.4	$4,151		Totes for Storage
6	50% Caustic Soda	13,310	gal/year	$4.98	1.4		$92,797	Cost/gal
7	Sodium Hypochlorite Pump & 100 gal Tank	1	EA	$2,970	1.4	$4,158		Totes for Storage
8	12.5% Sodium Hypochlorite	22,083	gal/year	$2.19	1.4		$67,705	Cost/gal
9	Estimated Labor Requirement	8,760	EA	$45	1.0		$394,200	4 hr/day
10	Estimated Electrical Costs	295,545	kwh	$0.1413	1.0		$41,760	90 hp, 67 kw
					Subtotals	**$414,000**	**$599,000**	
					30% Sitework, concrete & electrical	**$125,000**		
					30% Contingency	**$125,000**		
					25% Engineering/design fee	**$83,000**		
					Estimated Capital Costs	**$747,000**		

Manganese Greensand

Description	Quantity	Unit	Unit Cost	Installation Factor	Capital Total	Annual Operating Cost	Comments/Reference
750 sf Well House/Chemical/Treament Buil	1	EA	$150,000	1.08	$162,000		
Greensand Pressure Filter System	1	LS	$170,400	1.4	$238,560		Package Plant
Polyphosphate Pump & 100 gal. storage ta	1	EA	$2,965	1.4	$4,151		Totes for Storage
Aqua Mag Polyphosphate	908	gal/year	$1.98	1.4		$2,516	Cost/gal
Sodium Permanganate Feed Pump	1	EA	$2,970	1.4	$4,158		
Permanganate Storage Tank 40%	1	LS	$13,201	1.4	$18,481		
40% Sodium Permanganate	38,422	ga/year	$9.57	1.4		$514,783	
Caustic Pump & 100 gal. storage tank	1	EA	$2,965.0	1.4	$4,151		Totes for Storage
50% Caustic Soda	13,310	ga/year	$4.98	1.4		$92,797	Cost/gal
Sodium Hypochlorite Pump & 100 gal Tank	1	EA	$2,970.0	1.4	$4,158		Totes for Storage
12.5% Sodium Hypochlorite	22,083	gal/year	$2.19	1.4		$67,705	Cost/gal
Filter Backwash Tank	1	EA	$80,000	1.4	$112,000		25' x 30' x 16' deep
Estimated Labor Requirement	8,760	EA	$45	1.0		$394,200	4 hr/day
Estimated Electrical Costs	295,545	kwh	$0.1413	1.0		$41,760	90 hp, 67 kw
				Subtotal	**$548,000**	**$1,113,761**	
				30% Sitework, concrete & electrical	**$165,000**		
				30% Contingency	**$165,000**		
				25% Engineering/design fee	**$110,000**		
				Estimated Capital Costs	**$988,000**		

Well Construction Costs

Item	Description	Quantity	Unit	Unit Cost	Installation Factor	Capital Total	Annual Operating Cost	Comments/Reference
1	All-in cost of well drilling/construction, testing and equipping, per well. 10 wells for 4.6 MGD assuming 500 GPM each and n+1	6	EA	$650,000	1	$3,900,000	*	Multiple calls with well drillers in Al. received 2 sets of numbers so far: one stated $650,000 for an 8-in (OD final casing) well and $800,000 for a 10-in well, the other said around $500,000
2	Security, Site Development, 400 ft, 10 ft Chain link Fencing	6	EA	$13,600	1	$136,000		
3	Land Acquisition	6	acre	$3,000	1	$30,000		Amount needed uncertain Mobile County Revenue Commission (bisclient.com)
					Subtotals	**$4,066,000**		* Can expect that the wells will require rehabilitation to maintain suficient flow rates. Frequency uncertain (possibly every 3 to 5 years), influenced by the geologic formation and water quality. Could be more than $100,000 per well per rehabilitation
					30% Contingency	**$1,220,000**		
					25% Engineering/design fee	**$1,017,000**		
					Estimated Total Capital Costs	**$6,303,000**		
					Estimated Total per well	**$1,050,500**		

Pipeline Costs												
Distributed Well System						Centralized Well System						
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**	**Item**	**Description**	**Percent Split**	**Quantity**	**Unit**	**Unit Cost**	**Capital Total**
1	8" Pipeline per well	800	ft	$150	$120,000	1	8" Pipeline per well	60%	10800	ft	$150	$1,620,000
						2	16" Pipeline per well	40%	7200	ft	$195	$1,404,000
											Total (for entire system)	**$3,024,000**