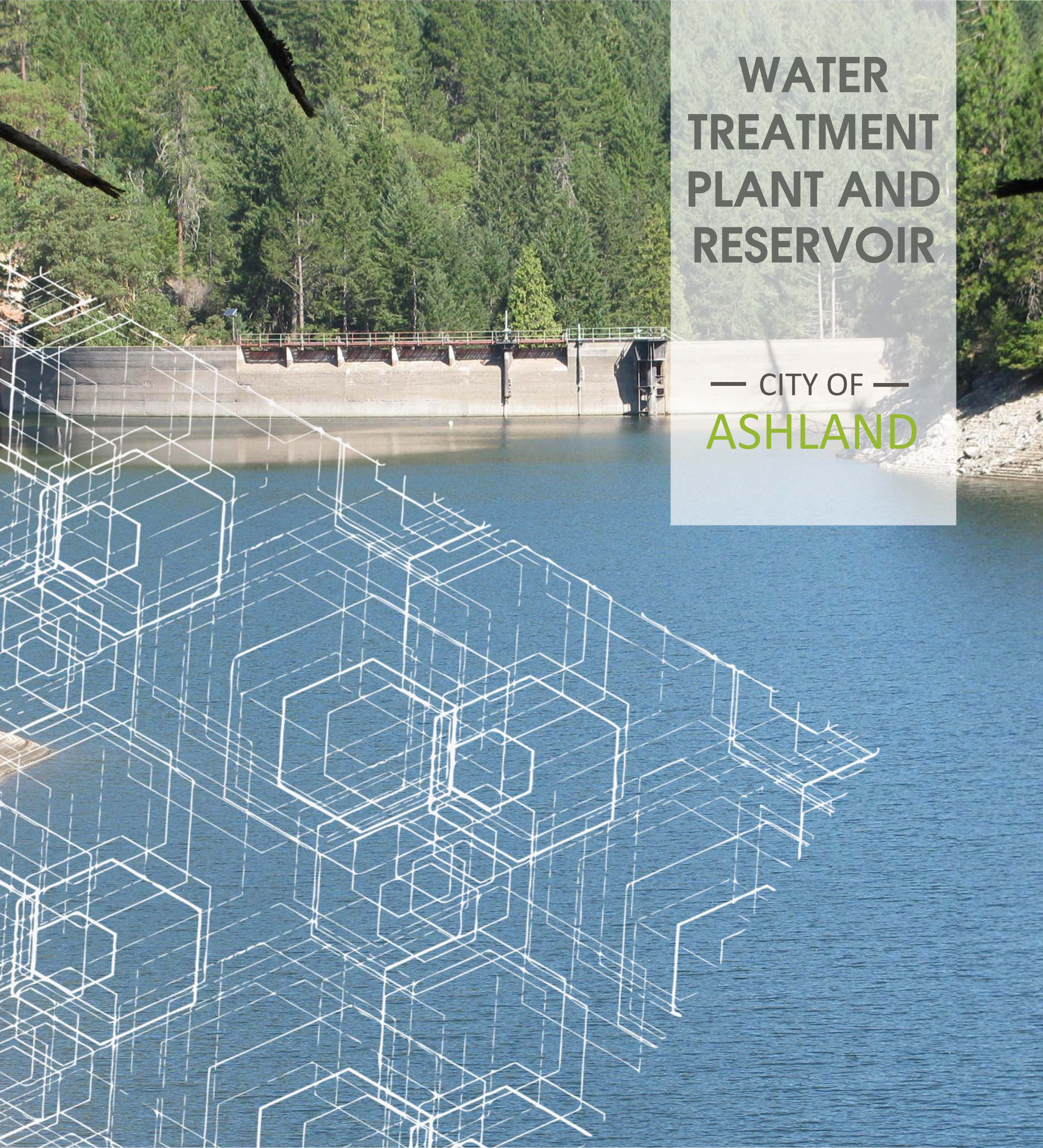
WATER TREATMENT PLANT AND RESERVOIR

— CITY OF —

ASHLAND



WATER QUALITY ANALYSIS AND TREATMENT PROCESS SELECTION

PROJECT NO. 217002

November | 2017

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KELLER associates

City of Ashland

Water Quality Analysis and Treatment Process Selection

CITY OF ASHLAND OREGON

REGISTERED PROFESSIONAL ENGINEER
73236-PE
OREGON
MARCH 11, 2003
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LIST OF ABBREVIATIONS

ACH	aluminum chlorohydrate
alum	aluminum sulfate hydrate
AWWA	American Water Works Association
BW	backwash
^oC	degrees Celsius
$CaCO_3$	calcium carbonate
CE	categorically exempt
CO_2	carbon dioxide
cf	cubic feet
Cl_2	chlorine
CMU	concrete masonry unit
CPU	central processing unit
CT	disinfectant concentration times contact time
DBP	disinfection by-product
D/DBP	Disinfectants/Disinfection By-Products
DEQ	Oregon Department of Environmental Quality
DIC	dissolved inorganic carbon
DO	dissolved oxygen
DOC	dissolved organic carbon
DSL	Department of State Lands
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
F	fluoride
Fe	iron
FE	filter effluent
FERC	Federal Energy Regulatory Commission
FLR	filter loading rate
FRP	fiberglass-reinforced plastic
ft	feet
FTW	filter-to-waste
GAC	granular activated carbon
GACE	granular activated carbon effluent
gph	gallons per hour

gpm	gallons per minute
gpm/sf	gallons per minute per square foot
hp	horsepower
HRT	hydraulic residence time
HSPS	high-service pump station
IBC	International Building Code
I&C	Instrumentation and Controls
IESWTR	Interim Enhanced Surface Water Treatment Rule
IFC	International Fire Code
I/O	Input/Output
kW	kilowatt
LCR	Lead and Copper Rule
L/d	depth-to-diameter ratio
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
µg/L	micrograms per liter
MIB	methylisoborneal
Mn	manganese
MRDL	Maximum Residual Disinfectant Level
NaOH	sodium hydroxide
NEPA	National Environmental Policy Act
ng/L	nanograms per liter
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOM	natural organic matter
NPDES	National Pollutant Discharge Elimination System
NPW	net present worth
ODFW	Oregon Department of Fish and Wildlife
OHA	Oregon Health Authority
OSSC	Oregon Structural Specialty Code
OWRD	Oregon Water Resources Department
PAC	powdered activated carbon
PCTP	Pony Creek Treatment Plant
PLC	Programmable Logic Controller
PP&L	Pacific Power and Light
PPS	Pilot Plant Study

PRV	Pressure Reducing Valve
PS	Pump Station
Report	Conceptual Design Report
scfm	standard cubic feet per minute
SCADA	Supervisory Control and Data Acquisition
SCM	streaming current monitor
sf	square feet
SH	Sodium Hydroxide
SHPO	State Historic Preservation Office
SPM	Sodium Permangante
T&O	taste and odor
TAP	Talent/Ashland/Pheonix
TID	Talent Irrigation District
TOC	total organic carbon
TSS	total suspended solids
TM	technical memorandum
UBC	Uniform Building Code
UBWV	unit backwash volume
UFRV	unit filter run volume
UPC	Upper Pony Creek
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Department of Fish and Wildlife Services
UV	ultraviolet
UVA	ultraviolet absorbance at 254 nm
V	volts
VFD	variable frequency drive
WTF	Water Treatment Facility
WTP	Water Treatment Plant
WWW	waste wash water

EXECUTIVE SUMMARY

This report contains the evaluations, analyses, and decision-making methodology to select a recommended water treatment process for a new Water Treatment Plant (WTP). The process selection and recommendations presented in this report assume that the City of Ashland relocates the treatment plant out of the existing canyon, consistent with previous recommendations. Through a separate future planning effort, the City intends to reevaluate continued use and upgrades of the existing treatment plant. For the purpose of this evaluation, the new WTP would be designed for an ultimate production capacity of 10 million gallons per day (mgd), which should treat the water needed to meet the City's demands for the next 20 years. The plant will likely need to be developed in multiple phases due to funding limitations.

Through a parallel related effort, a siting study was completed, identifying what is referred to as the Granite Low site as the preferred treatment plant site should the City move forward with relocating the plant (refer to Technical Memorandum, Siting Study). For this site, raw water from Reeder Reservoir will be obtained from the existing powerhouse tailrace and conveyed to the new WTP through what is referred to as the existing Talent Irrigation District (TID) pipeline. TID raw water will also be supplied from the Terrace Street pump station. Raw water pressures will be approximately 60 psi entering the Granite Low site, suggesting that a pressurized treatment process that can retain this hydraulic grade will have both cost and energy conservation benefits, estimated to be $1,018,000 in conserved energy expressed as 20-year present worth cost.

In addition to supplementing / replacing the existing plant, the new plant will improve finished water quality by reducing taste and odor concerns, and protecting the community against algal toxins. The recommended treatment improvements are based on costs, applicability to the source water quality conditions, environmental sustainability, and operational flexibility and simplicity. Other factors were also considered, including site constraints and maintaining space for potential future improvements.

In summary, the proposed raw water supply and treatment improvements are recommended to include the following elements, where some improvements can be deferred after the initial expansion increment based on water quality and capacity needs:

Raw Water Supply

- Connect to the powerhouse tailrace for raw water supply
- Repurpose the TID pipeline to reverse flow direction in the southern portion of the TID line and carry raw Reeder Reservoir water from the existing tailrace north to the new WTP; the northern end of the pipeline would be used to convey TID water from the Terrace Street pump station south to the new WTP location at the Granite Low site.

Treatment Processes

- Pre-oxidation with sodium permanganate to oxidize / precipitate iron and manganese, if present (chemical feed to raw Reeder water likely to be located at the existing plant; could use existing permanganate system if desired by operators).
- Sodium hydroxide for pH increase to accelerate iron / manganese precipitation and increase alkalinity (chemical feed to raw Reeder water likely to be located at the existing plant; could use existing sodium carbonate feed system if desired by operators).

- Aluminum chlorohydrate coagulation to precipitate color and naturally-occurring organic matter (NOM) for removal by filtration.
- Carbon dioxide for pH decrease to improve color and NOM removal while maintaining alkalinity (optional).
- Pressurized membrane filtration to remove coagulated NOM, iron, manganese, and algae.
- Granular activated carbon (GAC) to remove residual taste and odor causing compounds (Geosmin), organics, and algal toxins.
- Designed for future addition of ozone with installation deferred.
- UV disinfection for inactivation of pathogens.
- Chlorine addition for distribution system disinfectant residual.
- Backwash supply from the pressurized distribution system.
- Backwash waste and spent chemical cleaning solutions to equalization and discharge to sanitary sewer.

The proposed raw water supply and treatment processes are described further in this report.

SECTION 1 - INTRODUCTION

1.1 Project Purpose

The existing City of Ashland water treatment plant (WTP) is aging, is in a hazardous flood zone, and does not have adequate treatment processes to protect the community from algal toxins or to remove tastes and odors that occur in summer. The City has worked over the last decade to plan and obtain financing to replace the existing water treatment plant. The City's planning efforts have included master planning, coordination with the public, the Ashland Water Citizen Advisory Committee (AWAC), the City Council, and relevant State of Oregon Agencies. Rates and funding for the needed projects are now in place. This report continues the planning effort by reviewing and selecting treatment processes for Ashland's new Water Treatment Plant.

1.2 Funding

This project is funded in part through the Safe Drinking Water Revolving Loan Fund which is co-administered by the Oregon Business Development Department – Infrastructure Finance Authority and the Oregon Health Authority – Drinking Water Program.

1.3 Related Projects and Studies

There are several related projects that impact the new Ashland WTP. Chapter 2 discusses the geographic relationship between the projects that are described below.

Terrace Street Pump Station Renovation

This pump station conveys water from the Talent Irrigation District (TID) canal to the existing WTP. The pump station is being renovated to improve safety, address deferred maintenance, and to add the capability to pump water to and through the new WTP. Decisions on the new WTP location and treatment process impact the Terrace Street Pump Station renovations.

Park Estates Pump Station Renovation

This pump station pumps water from Crowson I storage reservoir to Crowson Pressure Zones 7 and 8. This pump station is being renovated to improve efficiency, provide fire protection, address deferred maintenance, and also to allow the full volume of stored water in Crowson I Reservoir to be utilized. This pump station provides the City access to this additional estimated 1 million gallons (MG) of finished water, reducing the amount of additional new storage required.

New Crowson II Finished Water Storage

A new Crowson II finished water storage reservoir is being considered and could be co-located with the new WTP. However, the City may defer construction of Crowson II in favor of increasing the budget for water treatment and obtaining more initial treatment capacity. This may allow the City to abandon the existing WTP at the end of Phase 1 construction of the new plant, providing efficiency benefits for the City. The sizing of a potential new Crowson II reservoir is being addressed with the ongoing water master planning efforts. If built, Crowson II could also serve as the chlorine disinfection contact basin (if required) for the new WTP and provide plant wash water. The sizing and design of Crowson II should be addressed in future preliminary design efforts.

Existing TID Pipeline Condition Assessment

The TID pipeline runs from the Terrace Street Pump Station to the existing WTP and is directly adjacent to the potential sites for the new plant. Efforts are underway to assess the condition of the TID pipeline to determine if it can be used feasibly to deliver raw water, saving the City money. The concept is to repurpose the southern portion of the TID pipeline to flow Reeder Reservoir raw water from the existing plant location north to the new WTP. The function of the northern portion of the TID pipeline would remain as-is, flowing raw water from the TID canal to the south, but the pipeline would be intercepted at the new WTP. Repurposing this pipeline will save the City money by reducing the capital expenses of the project. Keller Associates has completed an evaluation of the TID Pipeline (see 2017 Technical Memorandum titled, “Ashland Water Treatment Plant, Talent Irrigation District (TID) Pipeline Repurposing Evaluation”), in the which continued use of the pipeline for service to the Granite Low treatment site is recommended for the interim period until the plant can be expanded and the existing WTP abandoned, thus allowing the use of the newer 30-inch finish water pipeline to serve as the dedicated raw water supply for the Reeder Reservoir water source.

WTP Site Selection Study

A parallel effort to this process selection study, is a site selection study for the new WTP and Crowson II reservoir. There were three primary sites under consideration, the Concrete Pit, the Granite Pit, and the Asphalt Pit sites. The Concrete and Asphalt Pit sites are on the east side of Ashland Creek, while the Granite Pit is on the west side, with all sites being just south of the City, at the south end of Lithia Park. The City owns all of the sites. At the Concrete and Granite Pit sites, there are site options with different elevations, referred to as low plant and high plant options, that were considered. These site descriptions are discussed in detail in the Water Treatment Plant Siting Study that is a companion document t this study. The Asphalt Pit site could only support a low plant option due to the constraints of the site. This site selection effort is further described in this report due to the impact that it has on the treatment process evaluation. Through this process, the City selected the Granite Pit Low site for the new WTP.

Membrane Filtration Equipment Manufacturer Request for Qualifications

There is a parallel effort with this treatment process evaluation to request qualifications (RFQ) from manufacturers to supply membrane filtration equipment to the City for the new WTP. Statements of Qualifications were received and a short-list of three membrane filtration equipment suppliers was developed. At the time this report was prepared, the candidate equipment is being evaluated in a pilot-test (small scale test) on actual City raw water to better assess actual performance and determine sizing parameters. Following piloting efforts, the City can use pilot results to refine life cycle costs and assist in selecting a preferred membrane filter manufacturer.

SECTION 2 – SITE DESCRIPTION

The City owns and operates the water supply system to meet the water needs of the residents, businesses, institutions, and industries within the City limits. The City limits currently include 4,209 acres, with an Urban Growth Boundary of 4,733 acres. The water system extends to the northwest to Ashland Mine Road and to the southeast to properties along Highway 66. The system is bounded to the west by the topography of the Siskiyou Mountain Range, and to the east generally by the Interstate 5 (I-5) corridor.

2.1 Existing Water Sources

The City's primary source of raw water comes from the Ashland Creek watershed. In 1928, the City constructed Hosler Dam at the confluence of the West and East Forks of Ashland Creek. Reeder Reservoir, the resulting impoundment, provides 280 million gallons (MG) of storage for the City's water supply. The intake can be used to accept water from depths of 30-,60-, and 90-feet below the full pool water surface elevation. Water from the reservoir is conveyed in a penstock to the City's existing Powerhouse and Water Treatment Plant (WTP) located along Ashland Creek, approximately one mile below Reeder Reservoir. The Powerhouse contains a Pelton wheel generator that discharges to a tailrace at atmospheric pressure, before flowing into the existing WTP. The City also has an agreement with the Talent Irrigation District (TID) to provide additional raw water supply to supplement the Reeder supply. When needed, TID water is pumped from Ashland Canal by the City's Terrace Street Pump Station up to the existing WTP, where it is treated along with the Ashland Creek supply.

The recent completion of the Talent, Ashland, Phoenix (TAP) intertie has also allowed the City to supplement its water supply with finished water purchased from the Medford Water Commission. Water supplied from the TAP inter-tie enters the City's distribution system on the opposite side of the system from the WTP supply.

2.2 Existing System Facilities

The Ashland water system comprises Reeder Reservoir, the WTP, four finished water reservoirs that provide 7.1 MG of storage (Crowson, Granite, Fallon and Alsing), four pump stations (PS) (Hillview, South Mountain, Park Estates, and Strawberry), 32 pressure-reducing valve (PRV) stations, and over 126 miles of distribution piping. The WTP has a capacity of approximately 7.5 MGD. The treatment process currently consists of pre-oxidation, powder activated carbon addition, flocculation, direct filtration, and free chlorine disinfection.

2.3 WTP Flooding Hazard

The location of the existing WTP places the facility at risk of flooding, fire, and landslides. High flows in Ashland Creek during the 1997 flood caused significant damage to the WTP, disrupting the City's water supply.

The existing WTP was also damaged in the floods of 1963 and 1974. Because of its remote location within the steep walls of Ashland Creek Canyon, it is not practical to completely protect the plant from periodic flooding. The City plans to construct the new

WTP in a location that is less susceptible to flooding and with improved, all season access.

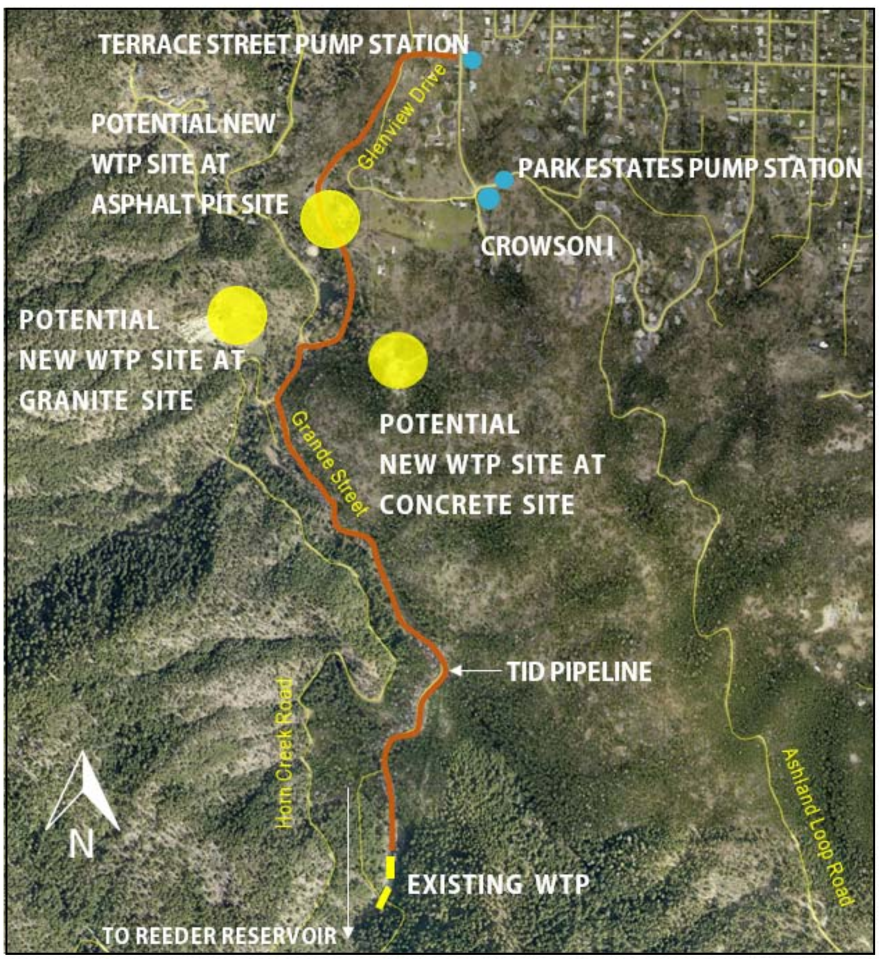
2.4 Project Scope and Phasing

The new WTP would be constructed in two phases. The initial phase is currently targeted for a 2.5 MGD plant which would supplement the production from the existing plant in Ashland Creek Canyon. Ultimately, the new plant would be expanded to 10 MGD capacity and the existing plant would be permanently decommissioned. The project may also include construction of a new finished water storage reservoir near the new WTP, Crowson II. If built, the new reservoir could also serve as the clearwell for the new WTP.

2.5 New Water Treatment Plant Potential Sites

Potential sites for the new WTP and Crowson II include the Concrete, Granite, and Asphalt Pits as shown in Figure 2.1. The Concrete Pit and the Granite Pit are each being evaluated for plant sites and both high and low elevations, while the Asphalt Pit can only support a low elevation plant due to the sites geography.

Figure 2.1: Existing Facilities and Potential New Facility Sites



2.6 Site Selection

Site evaluation and selection was completed as a parallel activity to this report and is described in a separate Siting Study report. The Granite Low site has been selected for placement of the new WTP. An example WTP layout for the Granite Low site is shown in Figure 2.2. The Granite Low site provides enough room for the new WTP and reservoir construction and was selected as the best available City-owned site for the project. The anticipated off-site piping tie-in locations are shown in Figure 2.3.

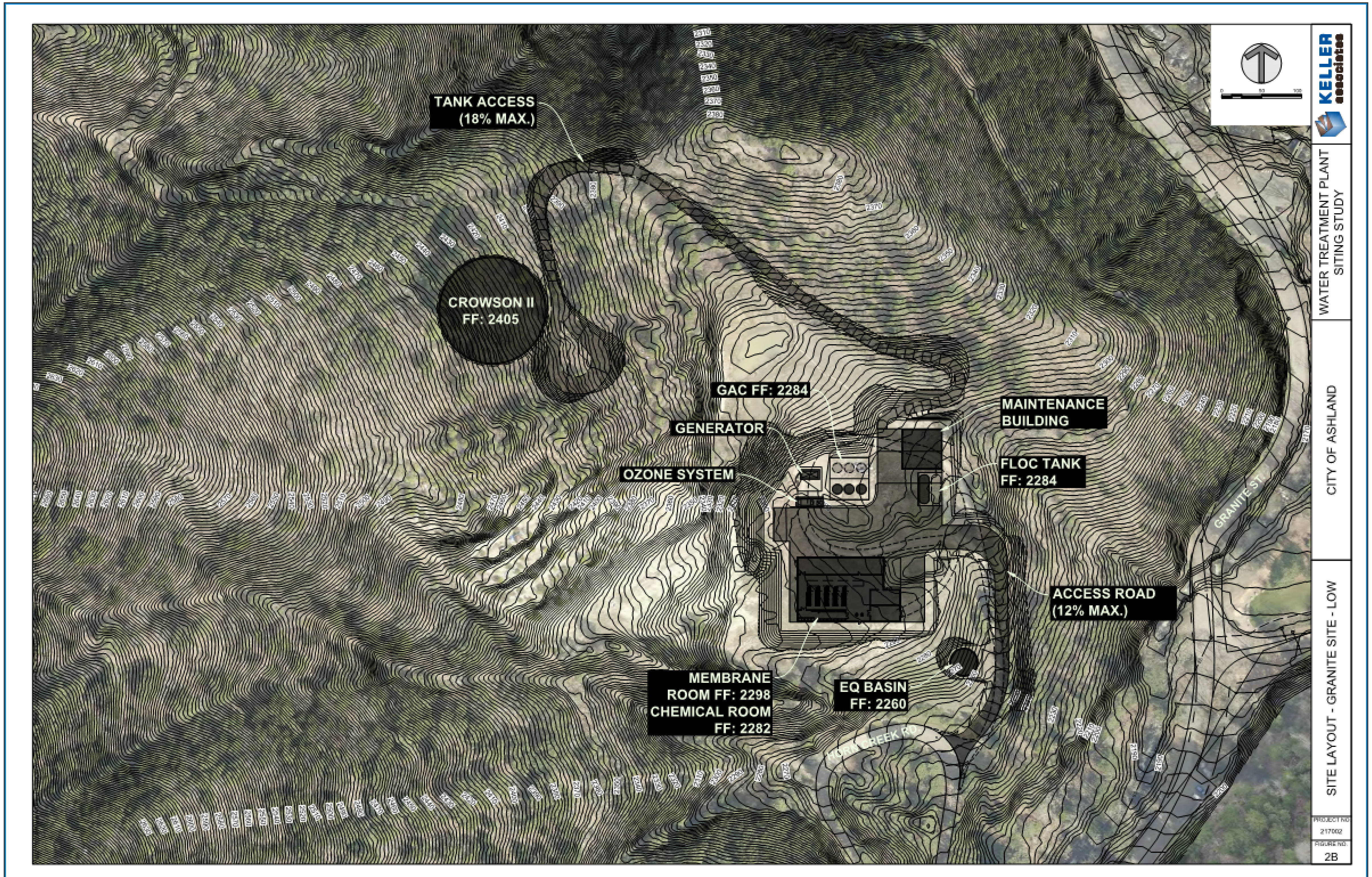


Figure 2.2. Example Plant Layout for Granite Low Site

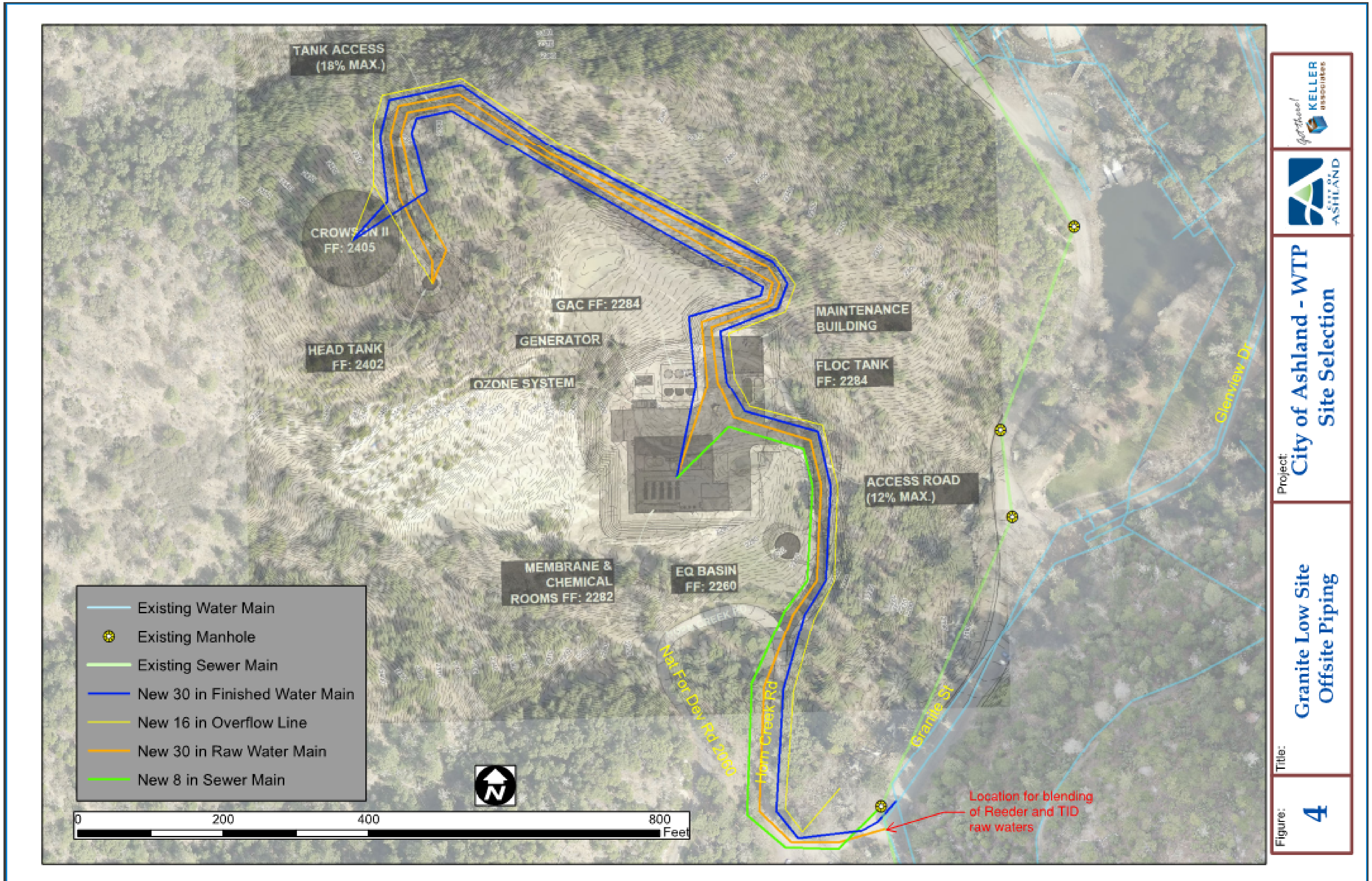


Figure 2.3. Potential Off-Site Piping Connections for Granite Low Site

2.7 Raw Water Supply and Hydraulics

Raw water will be supplied to the new WTP from the Powerhouse Tailrace. Flow can be diverted to the new plant from the existing plant via the existing 24-inch pipeline connection into the tailrace outlet structure. Keller Associates recommends that some modifications be made at the existing outlet to mitigate vortexing and air entrapment. However, minor modifications to the outlet structure are not anticipated to affect the power plant operations, hydraulics, or change the nature and use of the water. Coordination to address potential FERC permitting requirements are anticipated and should be included as part of the predesign effort for the proposed modifications.

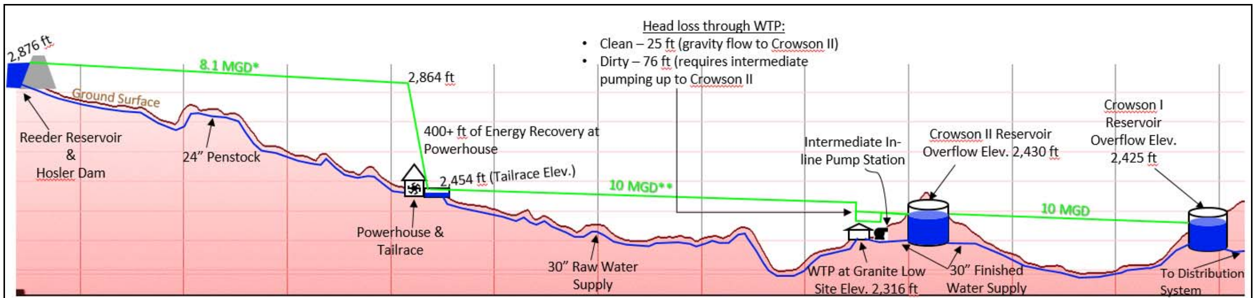
Consideration was given to connecting to the Penstock to obtain higher pressure water. However, the Penstock connection was found to reduce power production at the existing powerhouse, create control complications and risk, and not provide much benefit in terms of reducing the need for pumping energy. Additional details are provided in the Siting Study report.

Key elevations and pressures are summarized in Table 2.1. A more detailed hydraulic analysis is presented in the Siting Study report. Generally, headlosses in the raw water supply system would range up to 19.7 feet (8.5 psi) if the 24-inch TID pipeline is used, and up to 6.3 feet (2.7 psi) if a 30-inch raw water supply line is used at 10 MGD. The intent is to target 60 psi maximum static feed water pressure to the filtration system. To match 60 psi maximum pressure the filtration system elevation would be around 2316. The current Granite Low site layout establishes a filtration floor elevation of 2298 so some small adjustments will need to occur during preliminary design. Figure 2.4 shows the hydraulic profile from Reeder Reservoir to the new WTP and then down to the existing Crowson I storage reservoir. This figure was developed in the Siting Study completed by Keller Associates as a companion document to this report. Reference should be made to that document for more detailed information on site and plant hydraulics.

Table 2.1. Key Elevations and Pressures

Elev. Tailrace overflow weir (ft):	2454
Elev. New WTP filter room at Granite Low (ft):	2316
Elevation difference (ft):	138
Static pressure at new WTP (psi):	59.7
Overflow Elevation of Crowson 1 (ft):	2425

Figure 2.4. Granite Low Site Hydraulic Profile – Tailrace Connection



*Average flow in Penstock from 2013-2016 is 8.1 MGD.
**Max design flow through new WTP is 10 MGD, which can be supplied from Reeder Reservoir or a combination of Reeder Reservoir and the Terrace Street Pump Station.

2.8 Energy Considerations

There will be a substantial amount of potential energy in the raw water as it arrives at the Granite Low site due to the static water pressure created by the elevation difference. This energy can be retained if a pressurized water treatment process is used. A pressurized treatment process also has the advantage of having the treated water flowing by gravity all the way to the Crowson I reservoir when system headlosses are low (lower flows and clean filters). If a non-pressurized treatment process is used, then this energy (approx. 60 psi entering the plant) would have to be dissipated prior to entering the open treatment basin and then be added back into the water by pumping.

The recommended method for filtering water under pressure is membrane filtration. If granular media filtration were to be selected, it would be non-pressurized and would require a substantial amount of additional pumping. Expressed as a one-time present worth cost, the 20-yr increased pumping costs associated with selecting granular media filters over pressurized membrane filters is estimated to be $1,018,000 and has a higher capital construction cost due to more equipment and support processes. The details of this analysis are described in the Siting Study Report.

SECTION 3 – WATER QUALITY AND REGULATORY REVIEW

3.1 Water Quality Review

A detailed review of water quality is provided in a technical memorandum authored by HDR, it is included in Appendix A. Raw water will be supplied to the new WTP from Reeder Reservoir and also from TID's Ashland Canal.

Reeder Reservoir Cyanobacteria

Reeder Reservoir contains cyanobacteria and associated water quality concerns during the summer. An investigation into Reeder Reservoir water quality is documented in "Reeder Reservoir (Ashland Oregon) Water Quality and Sediment Assessment, 2007" by Jacob Kann and Joseph Eilers.

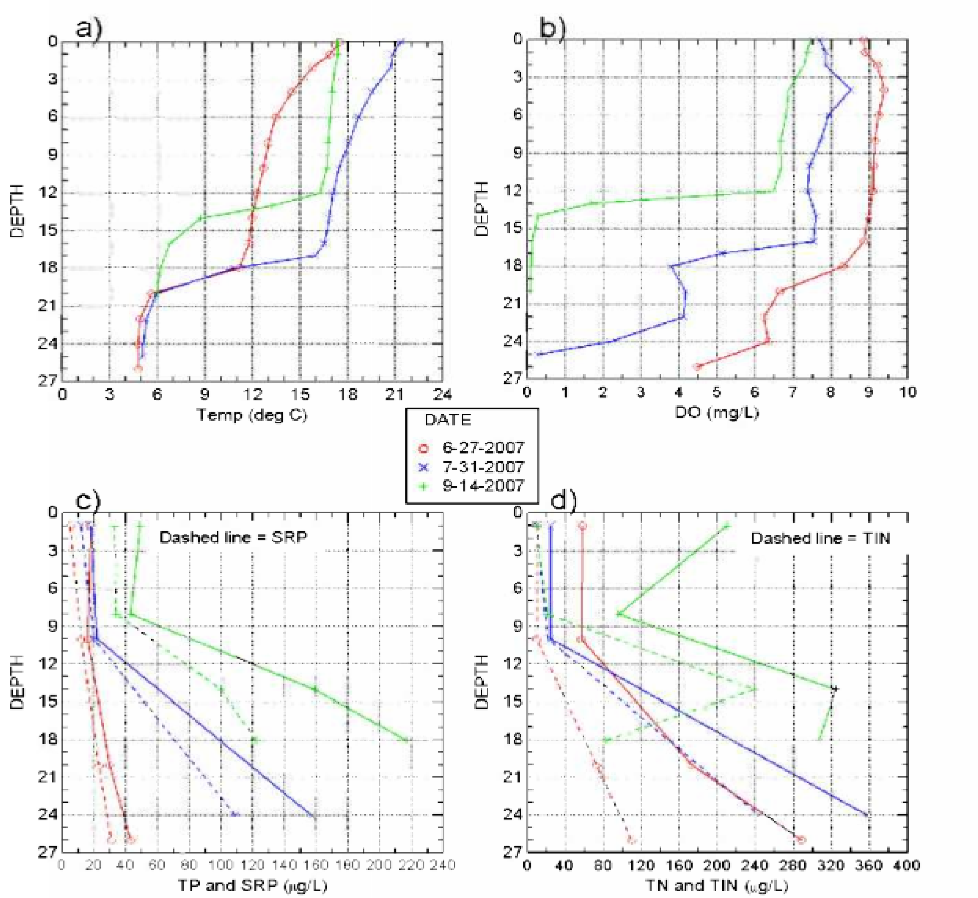
Kann and Eilers (2007) found significant concentrations of cyanobacteria formed in Reeder reservoir as early as mid-June (7,771 cells/ml exceeding the World Health Organization guideline for maximum amount of toxic algae of 2,000 cells/ml). The dominant species was found to be *Anabaena flos-aquae*. In October, they measured cell counts at the reservoir surface of 31,570,000 cells / ml (exceeding the WHO Alert Level III of 15,000 cells/ml). At a depth of 38-feet (approximating the WTP intake location), they measured 631 cells/ ml. 103 cells / ml were measured in the City's finished water. The algal toxin anatoxin-a was not detected during the study and the algal toxin microcystin was only detected once at 0.5 ug/L. Continued sampling of the water has not found detectable concentrations of microcystin again

City operations apply a non-copper based algicide (sodium carbonate peroxyhydrate) to control cyanobacterial blooms. This is quickly effective but the results don't last very long before additional applications are required. Lysing the cyanobacterial cells in this manner can release algal toxins into the water column.

Reeder Reservoir Stratification and Water Quality

Figure 3.1 below provides results of water quality sampling at depth within the reservoir.

Figure 3.1: Water Quality vs. Depth



Notes: Water quality at depth within Reeder Reservoir (Kann and Eilers, 2007). a) Temperature b) dissolved oxygen; c) total phosphorus (TP) and soluble reactive phosphorus (SRP); and d) total nitrogen (TN) and total inorganic nitrogen (TIN).

Reeder Reservoir exhibits summer stratification that impacts water quality significantly, similar to other Oregon reservoirs. This is observed in Figure 3.1a, with strong thermal stratification occurring at the end of July through at least the middle of September. Thermal stratification results in a denser, colder, lower section of water called the hypoliminion. The upper section of water is warmer and less dense, called the epilimnion. The boundary between the epilimnion and the hypolimnion is called the thermocline, where temperature changes significantly with small changes in depth. For example, Figure 3.1a shows the thermocline at a depth of 12- to 14-feet during September.

In a stratified reservoir with dense cold water on the bottom and warm less-dense water on the top, there can be no vertical mixing of water due to the density differences. Oxygen from the air can mix into the epilimion, but the oxygen cannot migrate down to the hypolimnion because there is no vertical mixing. Oxygen is consumed in the hypolimion due to microbial activity, but it is not replenished. This explains the shape of

Figure 3.1b, that shows Reeder Reservoir has become devoid of oxygen below 14-feet deep in September. Kann and Eilers (2007) estimate that this stratification could persist well into November.

Figure 3.1c shows significant increases in soluble reactive phosphorus (SRP) and total phosphorus (TP) in September, in both the epilimnion and the hypolimnion. A typical guideline to control cyanobacteria in surface water reservoirs is to keep phosphorus levels below 25 □g/L. In September, Reeder Reservoir was observed to contain about twice the recommended maximum amount of phosphorus in the epilimnion and about 10 times the recommended maximum amount of phosphorus in the hypolimnion. This is one reason that cyanobacteria proliferate in Reeder Reservoir over other less problematic species of algae. Kann and Eilers (2007) indicate that the low nitrogen to phosphorus ratios measured favor nitrogen-fixing cyanobacteria.

The conceptual model to explain this is that phosphorus is bound up with iron compounds in reservoir sediments. As oxygen is depleted in the sediments, iron is reduced and dissolves, releasing its attached phosphorus load into the water column. The reducing environment created also typically dissolves manganese into the water column if present. Kann and Eilers (2007) found the sediments to contain a substantial amount of phosphorus. Iron and manganese are contaminants in raw water that must be removed, typically by pre-oxidation and filtration. Phosphorus release is a major problem in Reeder Reservoir because it causes cyanobacteria to proliferate which leads to the potential release of algal toxins into the raw water as well as the taste and odor causing compounds Geosmin and methylisoborneol (MIB).

To date, there has been no deep reservoir sampling for iron and manganese in Reeder Reservoir. We recommend that sampling be considered for incorporation into any future depth sampling programs, particularly as the City contemplates potential future withdrawals from lower levels in the reservoir. Iron and manganese are typically problematic in surface water treatment, and require oxidation and filtration for removal, these are processes recommended for the new WTP.

Reservoir Recommendations

1. Upgrade filtration to a system that can prevent the algae from entering the City's drinking water supply.
2. Consider introducing oxygen at the reservoir sediments to maintain oxic conditions in the sediment and inhibit release of phosphorus, iron, and manganese into the bulk water column.
3. Use the variable level intake to avoid raw water with high densities of cyanobacteria.

Raw Water Quality

Raw water quality is summarized in Appendix A. Generally, the raw water can be characterized as follows:

- Generally low turbidity water
- Periods of low alkalinity and pH due to snowmelt
- Periods of high color, thought to be organic
- Moderate organic content

- Reservoir can contain significant densities of cyanobacteria
- Reservoir has been observed to contain algal toxins (microcystin)
- Raw water Geosmin (taste / odor compound) has been measured as high as 70 ng/L
- Has the potential for elevated iron / manganese concentrations due to reservoir stratification

Little is known about the quality of the TID water in the Ashland Canal. Generally, it has been sampled only when blended with Reeder Reservoir water. For this reason, a data collection plan, attached in **Appendix C** is currently being implemented to address this data gap.

3.2 Regulatory Review and Treated Water Goals

A detailed regulatory review and discussion of treated water goals is provided in **Appendix B**.

The regulations and goals for Ashland are similar to other drinking water treatment facilities in Oregon, including primary drinking water standards.

A few of the distinguishing goals include:

- The ability to remove iron and manganese
- Corrosion control by supplementing alkalinity and controlling pH
- Removal of color / control of disinfection byproduct formation
- Removal of algae / turbidity - filtration
- Reduction of tastes and odors caused by organic contaminants like Geosmin
- Capability to destroy or remove algal toxin
- Disinfection.

These distinguishing goals impact selection and arrangement of treatment processes for the project. With significant densities of cyanobacteria present in the raw water, we recommend following the industry best practice of not oxidizing the raw water when algal cells are present due to the potential to lyse the algal cells and release the internal toxins. Therefore, a guiding principal for process selection is to screen out (filter) the algal cells first, prior to applying oxidants to destroy tastes, odors, and any residual algal toxin. The City has a variable level intake and should continue the practice of using it to avoid taking raw water with high densities of cyanobacteria.

SECTION 4 – RAW WATER SUPPLY

4.1 Raw Water Supply Connection

Through the siting evaluation portion of this project, the City's preferred site for a new WTP (should the existing treatment plant be abandoned) is the Granite Pit Low location. The new WTP would receive raw Reeder Reservoir water from the Powerhouse Tailrace, conveyed through the existing TID pipeline. Connecting to the Powerhouse Tailrace would develop pressures of about 60 psi at this location as discussed in Section 2. This is on the higher end of normal operating pressures recommended for microfiltration membrane facilities, the primary filtration approach being considered to utilize the available head pressure. Consideration was given to supplying raw water from the penstock with even higher pressures. But this would have reduced power generation at the existing powerhouse, increased complexity and risks, with little additional benefit.

To implement the Tailrace connection concept and utilize the available head pressure, the plant would need to be an entirely pressurized treatment system, capable of operating at pressures up to 60 psi. Membrane and pressure filtration systems operate as closed treatment systems at the anticipated pressures, however they are sensitive to pressure transients. If a conventional treatment system is considered under these head pressure conditions, the open basins of the plant, similar to the existing plant, will require that the head pressure be dissipated to atmospheric pressure and the finished water to be repumped to deliver the water to Crowson I. Consideration will be given to controlling transient pressures or pressure dissipation, depending on the alternative selected, during the design process for the plant.

Considering the Granite low site, a pressurized plant option could preserve head pressure from the powerhouse tailrace through the new WTP. Additional pumping may be required during high flow periods or when the headloss through the plant increases. This supplemental pumping with a pressurized treatment process is significantly less than that required for an open-basin treatment approach where the entire production of the plant would need to be pumped to the full elevation of the reservoir. The overall supply schematic diagram is shown in Figure 4.1. See Section 2 or the siting study for more discussion.

4.2 Preoxidation

Reeder reservoir stratifies thermally in the summer (see Kann and Eilers, 2007). The thermal stratification limits the availability of oxygen at the reservoir bottom sediments. Anaerobic conditions can result in the release of iron, manganese, and phosphorus from the sediments into the reservoir raw water. Similar conditions and resulting in contaminant releases have been observed in Newport, Oregon and Coos Bay, Oregon raw water supplies.

There has been very limited sampling in Reeder Reservoir to determine if iron and/or manganese are present during summer stratification conditions. However, given our experience with other similar stratified Oregon reservoirs, we recommend selecting treatment approaches that allow the facility to treat for iron and/or manganese should they become present. It should also be noted that permanganate is a treatment chemical utilized by the City in the treatment process. Manganese staining can occur when permanganate feed exceeds the oxidant demand of the water. The new WTP will address this concern with online monitoring equipment to optimize the permanganate feed process.

Iron and manganese would typically be present in dissolved form. Metals that are dissolved can be oxidatized to precipitate the contaminants into a particulate form that can then be removed by downstream filtration. The oxidation of manganese can be a particularly slow reaction, the new and existing raw water pipelines will provide the reaction time prior to the new plant. To accelerate this reaction, if it proves necessary, pH adjustment can be incorporated at the point of oxidation.

Preoxidation is a concern when algae are present in the raw water. Oxidation of algae will cause the release of toxins creating a difficult treatment scenario. Raw water from Reeder Reservoir can be drawn from three locations that give the plant the ability to vary the elevation the water is drawn from. Changing the intake elevation will be at the discretion of the WTP operations staff to take water with lower densities of cyanobacteria. The pre-oxidant will also be fed at the discretion of the operator. The dose should be adequate to oxidize any metals, disinfection-by-product precursors, or organic material to improve treatment. If algae densities become significant in the raw water the operator can stop dosing the preoxidation chemical during the algal peaks, during this time iron and manganese will not be oxidized before the membranes. Depending on the concentrations of iron and manganese in the water the City may receive complaints from discolored water. This does not pose a health threat and is not a violation of any drinking water regulations because iron and manganese concentrations are secondary standards.

We propose to perform iron and manganese oxidation as the first treatment step, with chemical addition facilities located at the existing treatment plant site or powerhouse tailrace. The preoxidant and base could be new chemical feed facilities or could rely on existing chemical feed facilities within the existing WTP. If new, the chemical addition facilities would include neat chemical feed, injection, and mixing. Figure 4.1 shows the proposed pre-treatment system along with the overall supply system schematic diagram.

Proposed Chemicals

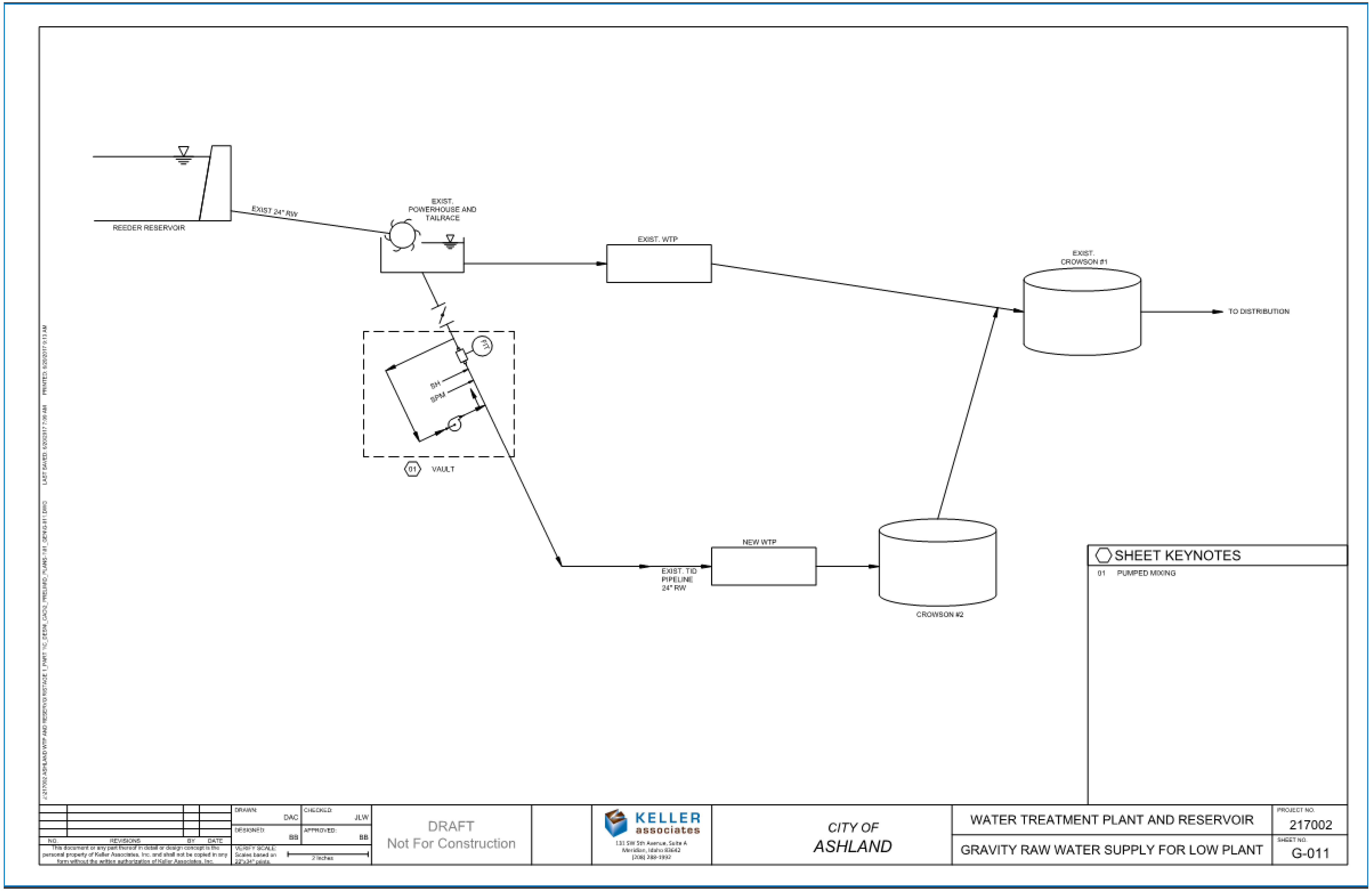
There are several chemical choices for preoxidation. The existing WTP uses potassium permanganate and that system could be modified to also serve the new WTP if desired by the operators. If a new chemical feed is desired, we propose to use sodium permanganate (SPM) because it is delivered ready for use and can be pumped directly into the raw water neat (as delivered). SPM is easier to feed at a consistent dose than potassium permanganate ($KMnO_4$) because it comes in solution and does not require the secondary dissolution of powder or crystal chemical to make the feed solution. SPM is selected primarily for operator convenience and is also consistent with the proposed installation at the Terrace Street Raw Water Pump Station, the alternate raw water supply for the new WTP. We anticipate that SPM would be delivered in 250-gallon tote containers. Dosing of the SPM would be flow-paced and the dosing rate would be checked with an on-line analyzer to alarm on over-feed conditions. The SPM pacing factor would be reduced manually by the operator until the permanganate level was zero at the entry to the new WTP.

For the base addition to increase pH and alkalinity, the City could choose to use the existing sodium carbonate (soda ash) feed at the existing WTP (if desired by operators). If a new chemical feed is desired, we propose the use of sodium hydroxide (SH or caustic soda). SH would be delivered in 250-gallon tote containers, ready to be pumped neat into the raw water. The SH would be flow paced with pH checked downstream.

Injection Point/s

We envision that the chemical delivery lines from the preoxidant storage and feed location to the injection point would be in braided vinyl tubing (BVT) housed in PVC conduit. The oxidant and base chemicals must be mixed effectively to react completely. We envision that a pumped flash mixing system would be used to allow mixing under pressure while minimizing headlosses. Injection would be through a quill into the pumped mixing system nozzle.

Figure 4.1: Proposed System Flow Schematic Diagram



SECTION 5 – COAGULATION - CLARIFICATION

This section describes coagulation and clarification processes that could be incorporated into the new WTP.

In general, it is anticipated that membrane filters would be preceded by autostrainers and coagulation only and not clarification. The reason for this is that the water source is relatively low in turbidity. In addition, it will preserve capital budgets, maximize capacity, and obtain effective processes to control taste / odors and algal toxins. It is anticipated that City operators will continue to use the variable level intake to avoid taking water with high densities of cyanobacteria. The autostrainer process is only included with the membrane filters and is not used with the other clarification processes and conventional filtration.

For options with ozone followed by granular media biofiltration, it is envisioned that clarification would be required. Clarification is needed to remove algae and coagulated organics primarily. A primary strategy in protecting the public against algal toxins is to remove algae prior to the application of strong oxidants to avoid lysing algal cells and releasing toxins.

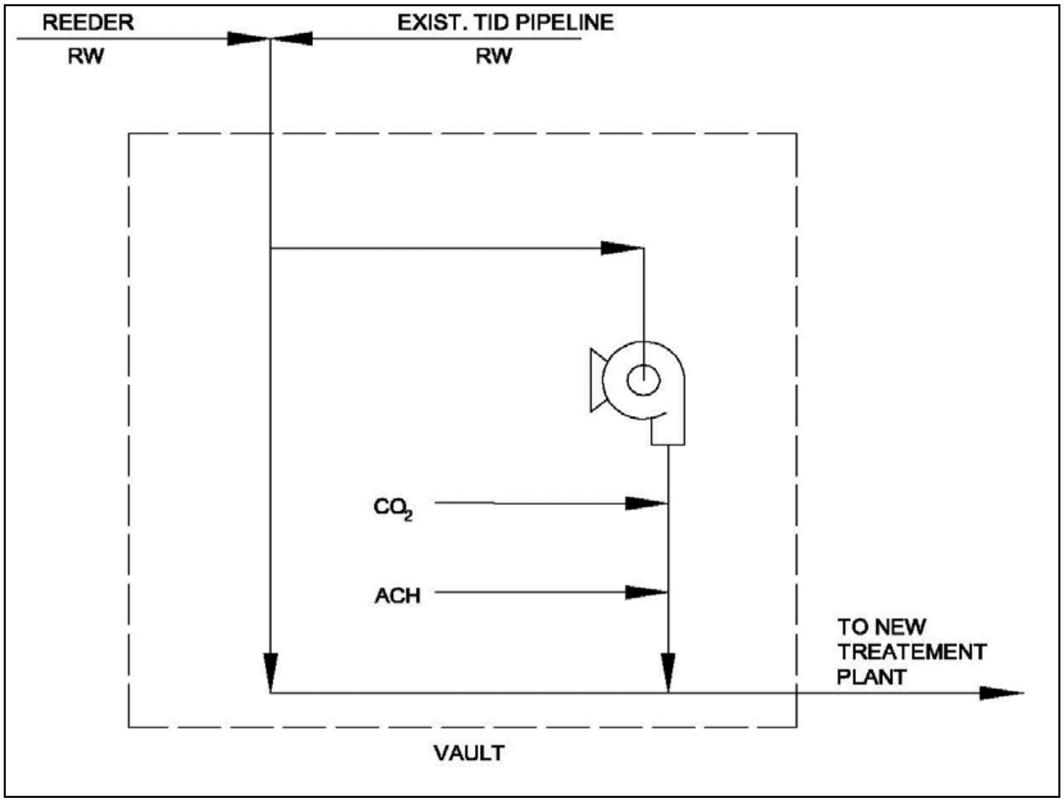
The methods of clarification that were considered for this report included dissolved air flotation (DAF), adsorptive clarification, and sand ballasted clarification. These methods are discussed in further detail in this section.

5.1 Chemical Pre-Treatment / Coagulation

Section 4 describes chemical pre-treatment with permanganate preoxidation and pH increase. The potential to add permanganate to TID raw water will also be incorporated into the renovated Terrace Street pump station. We recommend monitoring for pH and permanganate residual on each pipeline prior to mixing at the tee, to confirm proper process control with upstream chemical addition. The blending location is shown schematically in Figure 5.1 and the proposed physical location is shown in Figure 2.3.

The proposed coagulation pretreatment systems are shown in Figure 5.1. Raw water would be primarily supplied from Reeder Reservoir, but could also be supplied from the Talent Irrigation District (TID) canal using the Terrace Street Pump Station to meet increased City water demands such as peak day demands, drought, and/or emergency conditions. As shown in the Figure, the Reeder and TID supplies would blend at a tee, prior to flowing to the new WTP for treatment. The proposed physical location for blending Reeder and TID raw waters is shown in Figure 2.3.

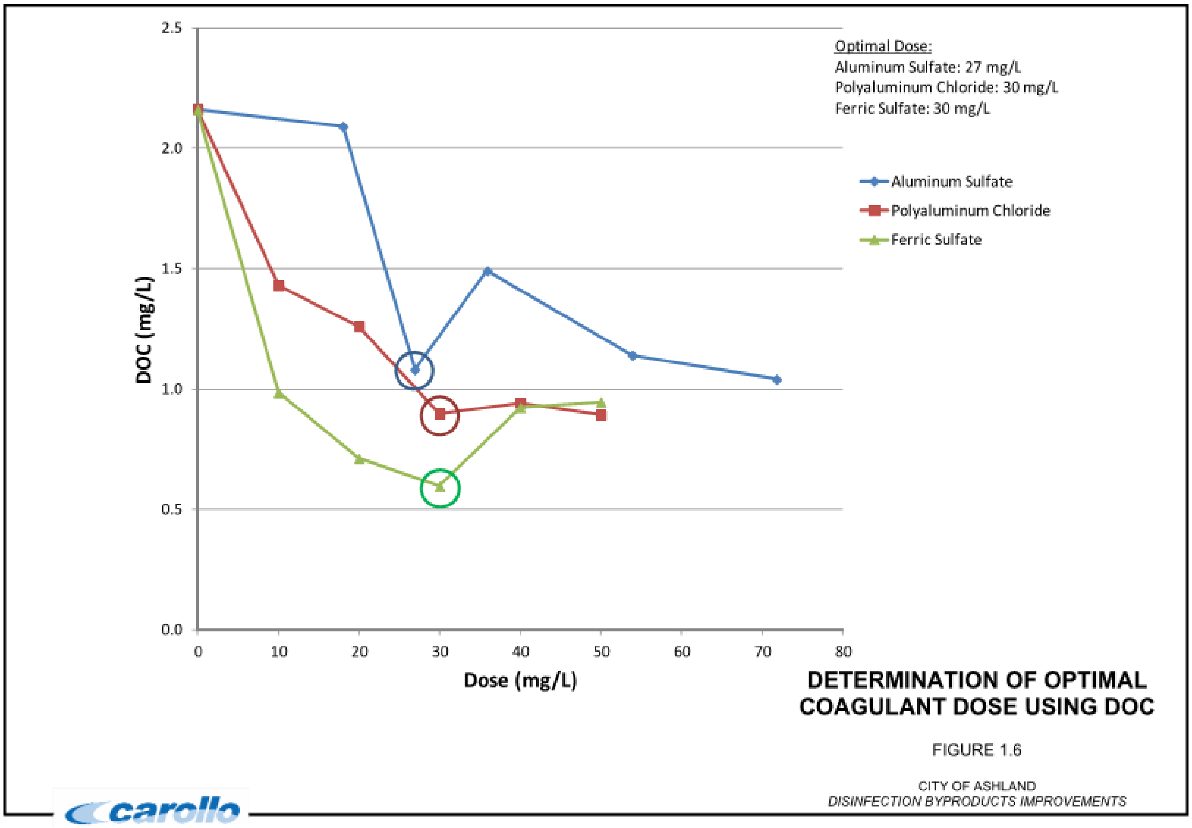
Figure 5.1: Pre-Treatment System Components



Coagulation is required to remove color and naturally occurring organic matter (NOM). NOM is a precursor to the formation of disinfection byproducts, exerts chlorine / ozone demand, and can foul membrane filters. NOM is typically in dissolved or colloidal form and requires coagulation to be removed during downstream filtration. Coagulation generally involves addition of an aluminum salt, such as alum (aluminum sulfate), aluminum chlorohydrate (ACH), or polyaluminum chloride (PACl). Each of these can be effective and jar testing or pilot testing can determine if one product performs better than another. Generally, we have found ACH and PACL to perform better, from the perspective of membrane permeability, when used in-line with membrane filters. ACH / PACl also minimize alkalinity consumption compared to other coagulants.

In a jar test, Carollo investigated the performance of coagulants to remove NOM from Reeder Reservoir water. Results are documented in “Disinfection Byproducts Improvements TM#1, Phase I Testing Results, Nov 2013. Figure 5.2 illustrates study results. At lower doses below 20 mg/L, ferric sulfate outperforms polyaluminum chloride which outperforms Alum with respect to removal of Dissolved Organic Carbon (DOC), a surrogate for NOM. Ferric sulfate is not preferred for use in the new WTP due to the City’s familiarity with aluminum salts, anticipated performance with aluminum based coagulants, and concern with fouling of membranes due to iron based coagulants. Polyaluminum chloride or ACH is recommended based on performance, operator convenience, and compatibility with membrane filtration. The impact of ACH on membrane modules will be tracked and recorded during the pilot study in late summer 2017. If granular media filtration is selected for use, Alum could be used as the coagulant. A determination based on water chemistry, the City’s experience with aluminum salts and expected filter performance would be evaluated as a coagulant decision is made.

Figure 5.2: Coagulant Performance Results (Carollo, 2013)



The performance in terms of color, NOM, and total organic carbon (TOC) or dissolved organic carbon (DOC) removal is typically improved at lower pH, down to a pH of 5.5. To achieve effective coagulation for Ashland, it is not anticipated that the pH would need to be reduced below 7, but this should be verified through pilot testing. Until further testing is available to optimize coagulant selection, we will assume that the coagulant will be ACH. Rather than increasing the coagulant dose to increase removal of NOM, we proposed to lower the water pH to reduce solids production.
Optimizing performance of coagulation involves the use of an acid to lower the pH. Ashland’s water has low alkalinity and one treatment goal is to increase or maintain alkalinity at 30 mg/L or higher to control corrosion. Most acids decrease alkalinity when they decrease pH. The exception is carbonic acid, or carbon dioxide, because it adds to the carbonate system (alkalinity) as the pH is dropped, having no net impact on alkalinity. For this reason, carbon dioxide is a good choice for lowering pH at the point of coagulation. Carbon dioxide is a compressed gas that is fed into a water side stream and then mixed with the process flow.

The benefit of adding an acid during coagulation is better removal of NOM / color, without having to add more coagulant. Adding more coagulant is not preferred due to the potential for impacting the recommended membrane filters downstream, increasing solids production, and the cost increase associated with additional chemical use. As shown in Figure 5.1, carbon dioxide and ACH could be feed into a pumped mixing system.

5.2 Autostrainers

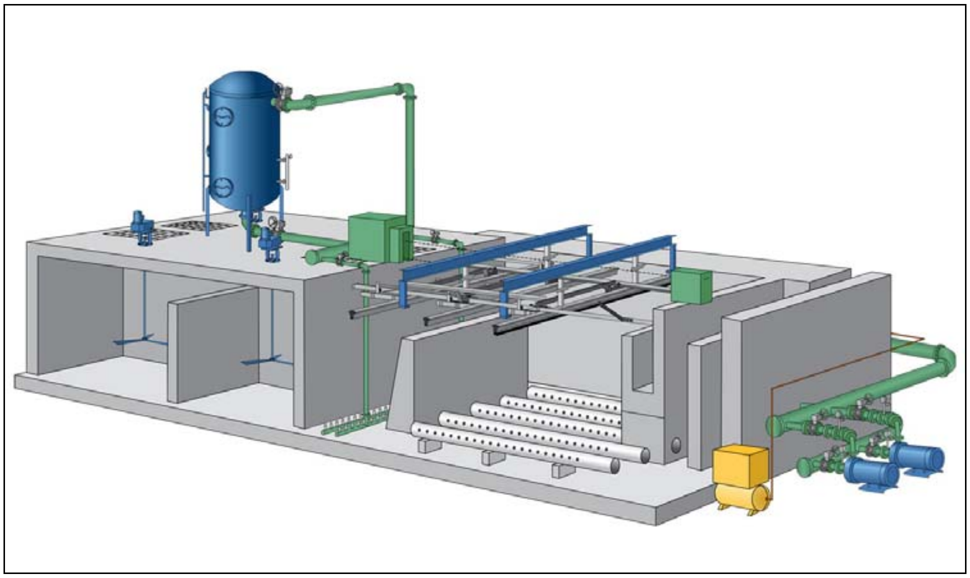
Autostrainers are used to remove large debris from water and protect downstream equipment. Autostrainers have automatic backwashing capability that can be configured to occur on time, volume, and/or headloss basis. The autostrainer configuration would be a 2 duty + 1 standby arrangement to account for one being out of service. The autostrainers are envisioned to be rated for 300 micron and above particle removal. The specification of the auto-strainer will occur after membrane selection with input from the selected manufacturer. This interaction is important due to the pore size and membrane configuration differences of the three manufacturers selected for the pilot study.

5.3 Dissolved Air Flotation (DAF)

DAF could be used to clarify water in advance of ozonation and granular media biofiltration. It would primarily be in place to remove algae but would also remove some portion of the turbidity also. Algae removal is desired prior to ozonation to avoid lysing cells and releasing algal toxin. Following oxidation of iron and manganese, coagulant would be added to the raw water before it enters into the Clari-DAF system. The Clari-DAF major components are a rapid mixer, an influent channel, the flocculation stages, the DAF cell, the air saturator system, a sludge channel, and an effluent weir. The DAF system is able to remove algae that results from algal blooms in Reeder Reservoir during summer months. This is accomplished by pumping air-saturated water through nozzles which form micro-sized bubbles below the incoming coagulated water. The bubbles lift pin-sized flocs formed in the coagulated water to the DAF cell water surface and form a blanket of sludge. The clarified effluent water is drawn off the bottom of the cell by a series of lateral draw-off pipes while the sludge blanket that forms at the top of the DAF cell is removed periodically by a mechanical scraper. Shown in Figure 5.2 is a model of the Clari-DAF system[1].

[1] Leopold, Xylem. Clari-DAF® Dissolved Air Flotation System for Potable Water Applications. Zelienople, PA: Xylem; 5/31/2017. 15 p. I17298

Figure 5.3: Clari-DAF® System for Potable Water Applications



DAF System Sizing

The Clari-DAF basin is sized for a 10 MGD plant flowrate. One duty train containing two duty basins and one standby basin would be required for the design. The dimensions, and key design criteria are outlined in Table 5.1

Table 5.1: 10 MGD DAF Train Dimensions and Design Criteria

Dimensions		
Variable	Units	Value
Width of train	ft	58
Length of train	ft	74.58
Height of train	ft	14
Loading rate based on collection area at design flow	gpm/sq ft	12.06
Recycle percentage at design flow	%	10
Recycle flow per train	GPM	696

Equipment List

A quote was obtained from Xylem Water Solutions Zelienople LLC for a DAF system. The included components are listed in Table 5.2.

Table 5.2: 10 MGD DAF Equipment List

Description	Quantity (10 MGD Design)
Mixers and flocculation equipment • Number of flocculation stages per basin • Axial impeller type rapid mixer • Axial impeller type vertical flocculators	 2 1 12
Air Compressors • Number of compressors per train (1 duty + 1 standby)	 1
Recycle system equipment • Number of pumps per train (1 duty + 1 standby) • Rotary screw type air compressor packages (1 duty + 1 standby) • Packed tower air saturation tank • Dissolved air dispersion manifolds	 2 2 2 6
Clari-DAF system basin equipment • Influent sluice gates • Influent weirs • Effluent weirs • Reciprocating skimmer systems • Sludge beach • Perforated launder pipes and assembly hardware • Spray wash systems	 3 3 3 3 3 21 3
System controls and instrumentation • DAF main control panel • Recycle pump VFD panels • Siemens 5100W, recycle flow magnetic flow meters • Rosemount effluent turbidimeters	 1 2 1 1
Butterfly valves	Inclusive
Spare parts	Inclusive

5.4 Trident® – Adsorptive Clarification

The purpose of the adsorption clarification system is to clarify water in advance of the conventional media filtration process. Adsorptive clarification would removal algae and general turbidity. The Trident package includes high-rate settling and adsorption clarification. The trident HS system would remove algae and T&O compounds before further treatment by ozonation, biofiltration, and chlorination. The Trident HS system (Figure 5.3[2]) has two main stages to it, chemical conditioning/tube settling and enhanced clarification.

[2] WesTech. *Trident® HS Multi-Barrier Package Water Treatment System*. WesTech Engineering Inc., 2016. Electronic.

Figure 5.4: Trident HS Water Treatment System

At the first stage, the coagulant and a polymer are added to begin the coagulation and flocculation process with sludge recycle to encourage flocculation and to maintain a steady state-solids concentration. The second stage is the buoyant media bed where solids are further reduced. Periodically, a combination of air and water are used to flush solid out of the media.

System Sizing

The Trident HS is sized for a 10 MGD plant flowrate. The dimensions, and key design criteria are outlined in Table 5.3.

Table 5.3: 10 MGD Trident Train Dimensions and Design Criteria

Dimensions		
Variable	Units	Value
Width	ft	15' 1"
Length	ft	47' 9"
Height	ft	10' 1"
Design flow per unit	gpm	1,400
Tube settler loading rate	gpm/sq ft	5
Adsorption clarifier loading rate	gpm/sq ft	15

Equipment List

The listed components in Table 5.4 were quoted from WesTech and include freight to jobsite and startup service.

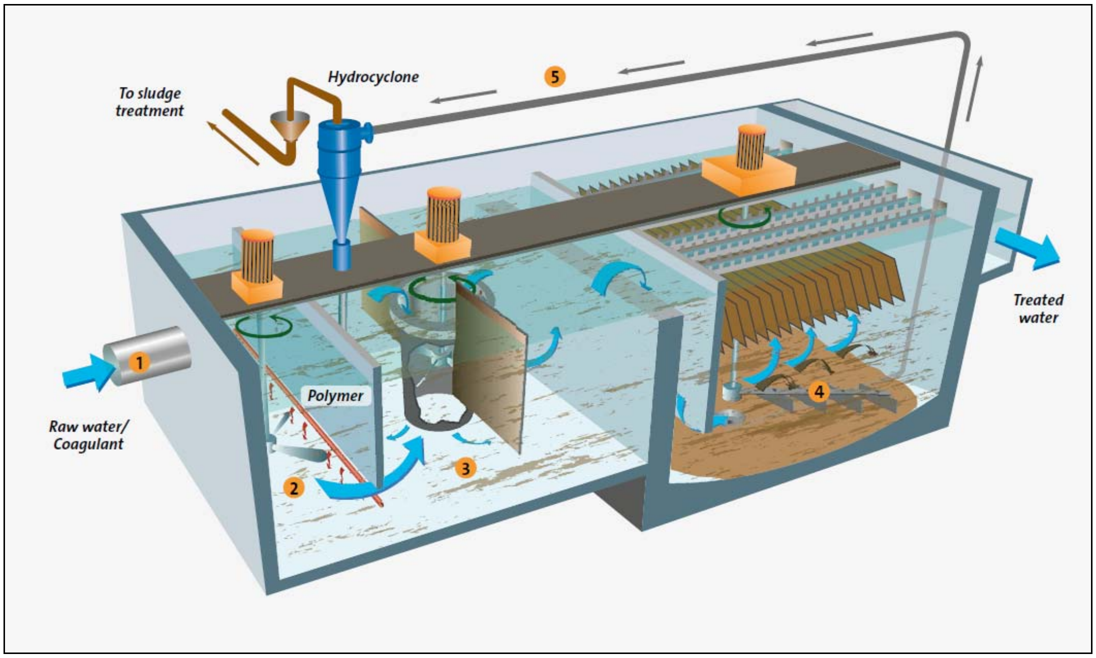
Table 5.4 10 MGD Trident Equipment List

Description	Quantity (10 MGD Design)
Model 3HS-2800A TRIDENT HS unit • Tube settlers • Sludge removal drive and header	6 Inclusive Inclusive
Pumping systems • Sludge recirculation pump • Clarifier transfer pump • VFD controller and integral motor starter	 1 1 Inclusive
Adsorption clarifier system • Retaining screen • Media	 Inclusive Inclusive
Coagulant feed system • Skid mounted coagulant feed package	 1
Skid mounted polyelectrolyte feed packages	2
Turbidimeters (influent, inter-clarifier)	2
Air wash blowers	2
Automatic and manual valves	Inclusive
Static mixer for combined influent flow	Inclusive
Magnetic flow meters	3
Ultrasonic level transmitters for tube clarifier	Inclusive
Compressed air system • Dryer • Motor starter	
Control system • Master and local panels • PLC for cleaning cycles • AQUARITROL III program for chemical dosage control system	 Inclusive Inclusive Inclusive

5.5 Sand Ballasted Clarification

The purpose of the sand ballasted clarification system is to provide pre-treatment to the Reeder Reservoir raw water for removal of algae and general turbidity prior to conventional filtration. Sand ballasted clarification is a treatment system that enhances the flocculation/clarification process, minimizing the process footprint and achieving high overflow rates. Sand ballasted clarification is used in applications where the raw water supply has extreme conditions or rapidly fluctuating sources. The four main processes of sand ballasted clarification are the mixing of coagulant with raw water, addition of polymer and reduced micro-sand for enhanced flocculation, clarification, and the separation of floc and sand for recycle as shown in Figure 5.4[3].

Figure 5.5: ACTIFLO Sand Ballasted Clarification Treatment System



System Sizing

The ACTIFLO system is sized for a 10 MGD plant flowrate with two treatment trains, where each train can handle a 10 MGD plant flowrate (1 duty + 1 standby). The dimensions and key design criteria are outlined in Table 5.5.

[3] Georger, Jim. *Kruger Proposal Ashland, OR*. Veolia, 2017. Print.

Table 5.5: 10 MGD ACTIFLO Train Dimensions and Design Criteria

Dimensions		
Variable	Units	Value
Width	ft	17' 6"
Length	ft	47' 6"
Height	ft	16'
Coagulation tank HRT	minute	2.05
Maturation tank HRT	minute	4.25
Settling tank HLR	gpm/sq ft	32
Sand recirculation flow (per pump) +/- 10%	gpm	210
Estimated total sludge waste flow +/- 10%	gpm	168
Estimated sludge solids concentration	%	0.01-0.5
Maximum influent turbidity	NTU	10
Maximum influent TOC	mg/L	4-6
Target effluent turbidity	NTU	≤2
Assumed effluent alkalinity	mg/L	>20

Equipment List

The listed components in Table 5.6 were quoted from Veolia water technologies and include freight to jobsite and startup service.

Table 5.6 10 MGD Sand Ballasted Clarification Equipment List

Description	Quantity (10 MGD Design)
Influent equipment • In-line rapid mixer • AC induction motor (2 HP) • Radial flow turbine impellers	 1 1 Inclusive
Coagulation tank equipment • Top entering mixer • AC induction motor (10 HP) • Anti-vortex baffle set	 2 2 2
Maturation tank equipment • Top entering mixer • AC induction motor (10 HP) • TURBOMIX draft tube	 2 2 2
Settling tank equipment • Scraper drive (0.75 HP) • Scraper assembly • Lamella settler set • Lamella settler support set • Lamella tube tie-down assembly • Effluent collection trough set	 2 2 2 2 2 2
Microsand recycle circuits • Microsand recirculation pumps (20 HP) (1 duty + 1 standby per train) • Discharge pump isolation valve • Suction side pump isolation valve • flush connection valve • Microsand recirculation pump pressure transmitter isolation valve • Sand sampling valve	 4 4 4 4 4 4
Hydrocyclone recycle equipment • Hydrocyclones (1 duty + 1 standby per train) • Hydrocyclone support stand • Sand concentration sampling device	 4 2 2
Commissioning consumables • Microsand ballast (tons) • Polymer flocculant (lbs)	 20 750
ACTIFLO system control panels • NEMA 12 Panel to control ACTIFLO system based on operator setpoints • Back panel for control panel – SAGINAW • Panelview Plus 6 1000 color touchscreen operator interface w/Ethernet – ALLEN BRADLEY • Control Logix PLC processor – ALLEN BRADLEY • UPS 850VA 120VAC input/ 120VAC output – SOLA • PLC control panel I/O + 20% “LIVE” spare wired signals for additional signal interface – KRUGER • Complete set of control panel internals per Kruger standard scope – KRUGER • PLC and operator interface programming – KRUGER • PLC site start-up and testing – KRUGER	 1 1 1 1 1 1 1 1 1

ACTIFLO system instrumentation	
• HACH surface scatter 7 turbidimeter	1
• Influent pipe pH (pre-chem feed): pH sensor, mounting, and controller	1
• Settling tank turbidity (post-chem feed): NTU sensor, tank immersion mounting, and controller	2
• Settling tank pH (post-chem feed): pH sensor, mounting, and controller	2
• Sand recirculation pumps pressure indicating transmitter: ceramic diaphragm	4
• Sand recirculation pump discharge flowmeter: magnetic flowmeter and controller	4

5.6 Summary

The coagulation and clarification processes presented work in concert with conventional filters and may be appropriate for membranes in certain circumstances. If used as pretreatment for membranes, consideration should be given to carry over of coagulant, polymer and oxidizing chemicals. The purposes of these processes are to reduce the loading on the filters and prolong the filter run life or, in the case of the auto-strainer, to protect the membrane filters from debris that could damage them.

SECTION 6 – FILTRATION

The filtration alternatives described include conventional filtration, direct filtration, and membrane filtration. Other filtration options such as slow sand and diatomaceous earth are assumed to be not applicable based on the site constraints, filter performance requirements (algal loading), and professional judgment.

6.1 Regulatory Requirements

Drinking water treatment is regulated by Oregon Administrative Rules (Chapter 333, Division 61, Public Water Systems) administered by the Oregon Health Authority, Public Health Division. Surface water treatment requirements are summarized in Table 6.1. The Total Treatment Required will be provided through a combination of filtration and disinfection. Therefore, the type of filtration selected also impacts the level, cost, and potentially the type of disinfection.

Table 6.1: Log Removal Requirements for Surface Water Treatment Filtration Credits and Disinfection Requirements

Requirement or Credit	Crypto (log) (1)	Giardia (log)	Viruses (log)
Total Treatment Required	2	3	4

Notes:
1. Requirement or Credit to be met by filtration and disinfection.
2. Ashland established the Crypto 2 log TTR through their LT2ESWTR Round 1 sampling and they are currently confirming those results with their Round 2 sampling.

In addition, OHA requires that comprehensive analytical data or pilot testing be conducted to quantify the performance of any new process treating surface water. The team recommends that pilot testing be completed for any selected filtration process to satisfy this requirement.

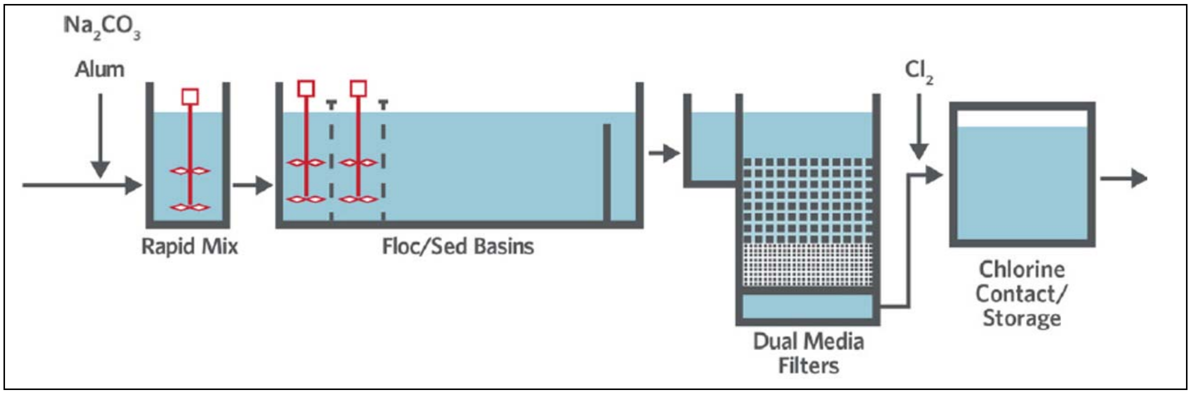
6.2 Summary of Filtration Alternatives

This section summarizes filtration alternatives used to remove particulate contaminants to make water safe to drink in combination with disinfection. Three filtration treatment approaches are discussed in the following sections; conventional, direct, and membrane.

Conventional Filtration

Conventional filtration is a treatment process that includes: coagulation-clarification (as described in the prior Chapter 5) and gravity filtration through media (such as layers of anthracite, sand, garnet, or combinations thereof, with varying thicknesses of each) resulting in substantial particulate removal. Flow through the process steps is typically by gravity the basins are open to the atmosphere (non-pressurized). Figure 6.1 is a process schematic diagram for a typical conventional filtration system in Oregon. Variations to this schematic include replacing the flocculation/sedimentation basins with one of the other processes listed in the prior chapter.

Figure 6.1: Conventional Filtration Process Schematic Diagram



Another variation is to use pressure filtration, closed steel vessels, instead of the open-air basins. This variation means everything is under pressure and eliminates the need for pumping, in the case of the Granite Low site. However, this type of system is more difficult to control and maintain as operations staff is unable to visually inspect the system and access to clean and/or repair the system is very constrained. Such systems are most commonly used for groundwater where turbidity is very low and constant. The team is unaware of any Oregon surface water plants larger than 1 MGD, let alone up to 10 MGD, that uses this process, and this type of process is specifically banned for surface water treatment in several other states (ie. Washington and Montana).

Conventional filtration is a standard surface water filtration method since it can readily treat raw waters with substantial raw water turbidity (>50 NTU), can handle rapidly changing turbidity (like when storms pass across Reeder Reservoir), and has the most resiliency in case of an upset to the upstream coagulation/clarification step. Medford Water Commission, City of Grants Pass, and Eugene Water and Electric Board's WTPs are examples of conventional WTPs.

A final variation has the filters be biologically active ("biofiltration") to adsorb more TOC. This occurs naturally if chlorine is added prior to the filters, but is greatly enhanced if ozone injection occurs before filtration. This is the variation of conventional filtration at Medford.

Downsides for a conventional filtration process are the size and corresponding cost of the clarification step. See Chapter 5 for the variations developed specifically to reduce the process footprint.

Conventional filtration receives the treatment credits and has the remaining disinfection requirements listed in Table 6.2.

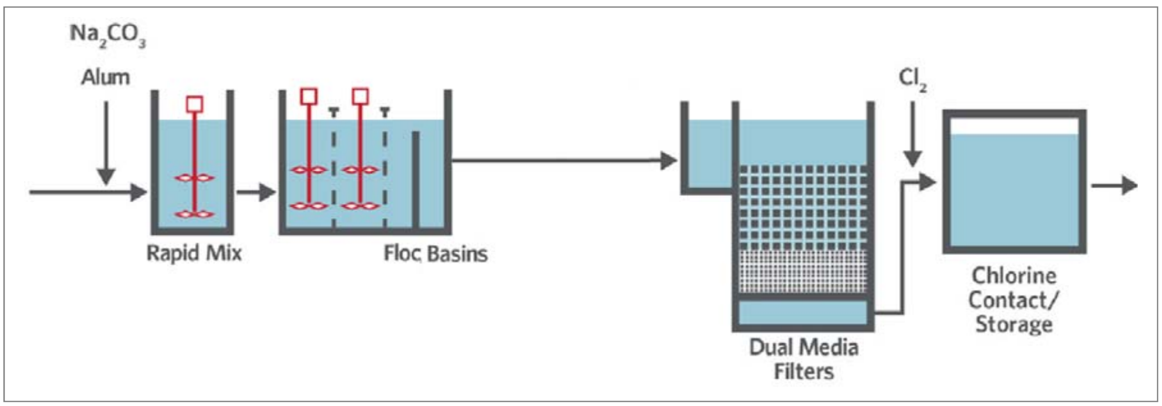
Table 6.2: Treatment Credit and Remaining Disinfection Requirement – Conventional Filtration

Requirement or Credit	Crypto (log)	Giardia (log)	Viruses (log)
Total Treatment Required	2	3	4
Credit with Conventional Filtration	2	2.5	2
Disinfection Required for Conventional Filtration	0	0.5	2

Direct Filtration

Direct Filtration is the same as conventional filtration but specifically excludes the clarification step**.** The omission means a smaller and less expensive footprint but that the solids removal is done exclusively by the filters. As a result, this type of process is meant for low turbidity (10 NTU or less) waters, such as coming from Reeder Reservoir, since the reservoir essentially acts as a very large sedimentation basin already. The existing WTP as a direct filtration facility has been in operation since the 1940's and has met current regulations. A process schematic diagram for a typical Oregon direct filtration plant is provided in Figure 6.2. The filtration step has the same variations as conventional filtration, such as varying number and thicknesses of media, pressure filtration, and the potential for biofiltration.

Figure 6.2: Direct Filtration Process Schematic Diagram



Direct filtration cannot achieve the same level of treatment as conventional filtration, is granted less treatment credit from the state, and therefore has an associated higher requirement for disinfection. Direct filtration receives the treatment credits and has the remaining disinfection requirements listed in Table 6.3.

Table 6.3: Treatment Credit and Remaining Disinfection Requirement – Direct Filtration

Requirement or Credit	Crypto (log)	Giardia (log)	Viruses (log)
Total Treatment Required	2	3	4
Credit with Direct Media Filtration	2	2	1
Disinfection Required for Direct Media Filtration	0	1	3

Membrane Filtration

Membrane filtration is direct filtration but replaces the granular media filters with low-pressure membranes.

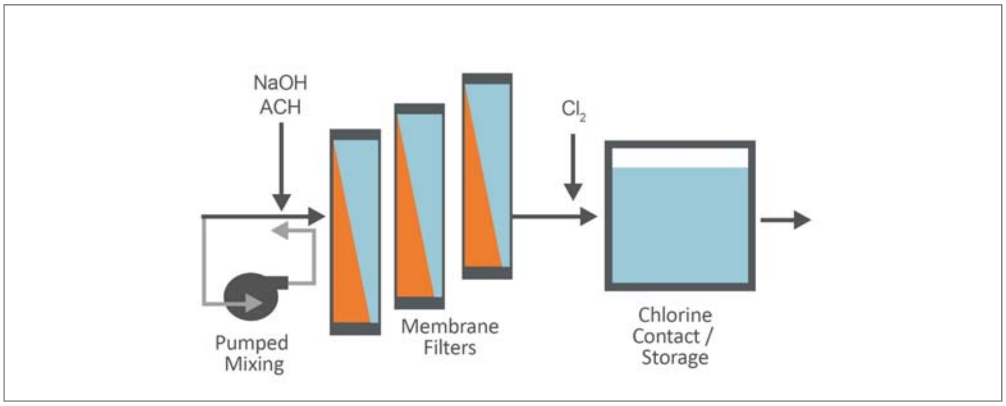
There are two types of low-pressure membrane filter material: polymeric and ceramic. Polymeric filters are manufactured from extruded polymers and generally composed of hollow fibers housed in modules. This is the most common type of membrane in Oregon and the rest of the world. Bend, Newport, and Cottage Grove, Oregon all use polymeric membranes. By definition, ceramic membrane filters are made from much harder ceramics, typically aluminum oxide. The only installations of municipal ceramic membranes in the United States are in Butte, Montana and Park City, Utah. However, ceramic membranes are the preferred municipal membrane in Japan and South Korea, and ceramic membranes are used extensively in the US for filtering wine, fruit juices, and pharmaceuticals. Many utilities across the US are evaluating ceramic membranes as a competitor or replacement to polymeric membranes.

In addition, there are two types of low-pressure orientation: pressurized and submerged. Pressurized membrane filters operate under pressure and are not open to the atmosphere. Such membranes have been installed in Oregon at Newport, Bend, Myrtle Creek, and Cottage Grove. Submerged membranes place the low-pressure membranes in large open-to-atmosphere basins. Currently, these membranes are principally used for highly turbid waters, retrofits into existing conventional or direct filtration plants, and for new facilities that are much larger than proposed for Ashland. The older submerged membrane Oregon installations include Pendleton and Oregon City.

Membrane filters require air and water supplies for backwashing along with chemical systems for cleaning. The chemical cleaning systems include Chemically Enhanced Backwashes (CEB), Clean-in-Place (CIP) using a combination of caustic soda, chlorine, and possibly acid, and cleaning solution neutralization / dechlorination (using either sodium thiosulfate, acids/ bases).

A process schematic for Membrane Filtration is provided in Figure 6.3.

Figure 6.3: Membrane Filtration Process Schematic Design



Membrane filtration is appropriate to treat Ashland's raw waters and is capable of treating greater turbidites than direct filtration. Sedimentation is not required due to the low raw water turbidity, reducing the capital investment in large concrete basins. Membranes require pressurized supply to provide the necessary force to drive water through the membranes, typically this requires pumping. The City can utilize the elevation difference between the powerhouse tailrace and the proposed treatment plant location to provide the driving force required for production. At high flows or dirty filter conditions, head may need to be added by an in-line pump station.

Membrane filtration provides a higher level of treatment than direct or conventional filtration because it provides an absolute barrier to the passage of many microorganisms including the cyanobacteria. Accordingly, it can be credited with much greater removal of *Cryptosporidium* and *Giardia*. This could become important if Ashland's water quality degrades or additional sampling identifies microbial contamination in TID raw water.

As each membrane filter is manufactured and operated differently, OHA provides individual membrane filters with varying amount of treatment credits depending on their rated performance. Table 6.4 shows the treatment credits provided by a "typical" membrane filter and the remaining disinfection requirements. Membranes are regulated by OHA and only approved membrane filters are provided credits. Membrane filters not yet approved by OHA will require documentation before filtration credits are provided.

Table 6.4: Treatment Credit and Remaining Disinfection Requirement – Membrane Filtration

Requirement or Credit	Crypto (log)	Giardia (log)	Viruses (log)
Total Treatment Required	2	3	4
Typical Credit with Membrane Filtration[1]	4	4	0
Disinfection Required for Membrane Filtration	0	0.5[2]	4

Notes:

1. Values based upon list of the OHA-approved membrane filters, updated 11 May 2017.
2. OHA requires a minimum of 0.5-log Giardia disinfection following filtration even if credit provided to membrane filtration satisfies the Total Treatment Required.

6.3 Filtration Selection Considerations

This section describes considerations in selecting the filtration process. Overall treatment footprint and needed instrumentation and control were considered in the opinion of cost analysis and the impacts they have on cost can be found in the opinions of cost in Section 11. Labor and chemical costs were evaluated as O&M costs and compared on a complete plant basis as well.

Energy Considerations

There will be a substantial amount of energy in the raw water as it arrives at the Granite Low site. This energy can be retained if a pressurized water treatment process is used. A pressurized treatment process also has the advantage of flowing by gravity all the way to the Crowson I reservoir when system headlosses are low (lower flows and clean filters). The prior text indicates that there are two types of pressurized filtration alternatives: membrane and pressure filter. Of the two, pressurized membranes provide a greater filtered water quality; is easier to inspect, troubleshoot, and clean; and has a much greater successful operational track record in Oregon and throughout the US for installations smaller to much larger than the requirements of Ashland. In comparison, pressure filters are known to provide a lesser water quality compared to membranes and are difficult to maintain. In addition, the team is unaware of where an Oregon surface water treatment plant that uses pressure filters and knows that several states outright prohibit their use.

The best non-pressurized filtration option, with regards to energy, would be conventional or direct filtration due to their known usage and history in the state. Again, pressure vessels, even in a low or non-pressurized configuration, are unknown in the state and retain all the disadvantages noted earlier.

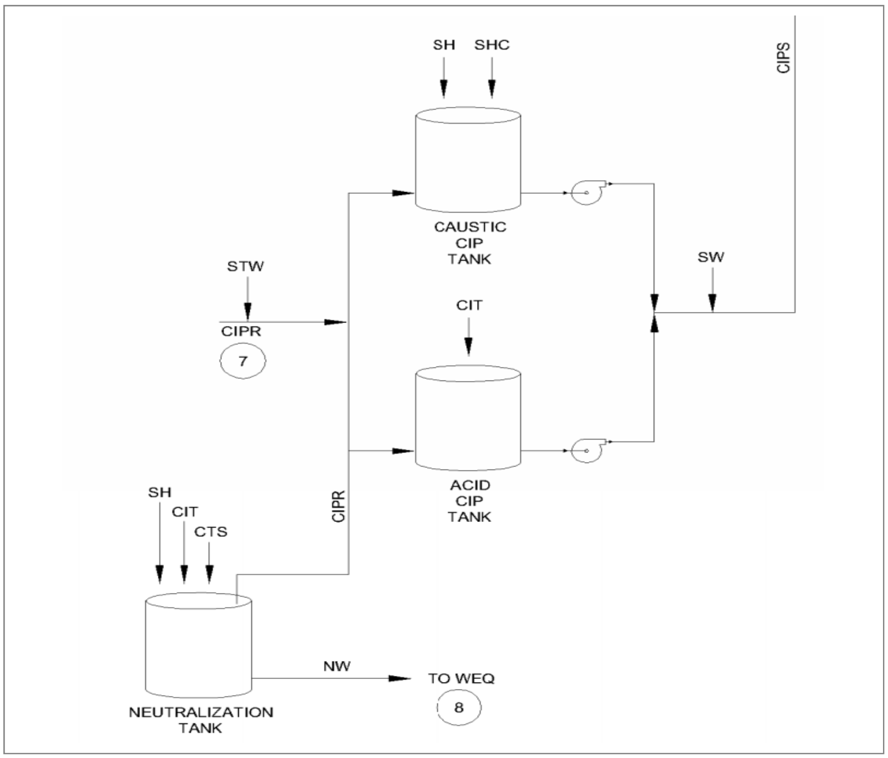
Pretreatment

The level of pretreatment between filtration options varies significantly. By definition, conventional filtration requires one of the pretreatment processes noted in Chapter 5. Given the rocky sloped site (higher construction costs) and the low turbidity raw water, this level of pretreatment is not considered cost effective. Direct filtration requires flocculation that would occur in an open basin at atmospheric pressure. This requires downstream pumping and will not take advantage of the potential gravity flow available for the Granite Low site. Membrane filtration requires the least amount of pretreatment. While chemical addition is needed, full flocculation is not required. Minimal coagulation/ flocculation can occur in-line and under pressure, preserving head and minimizing expensive large concrete structures. Such a system is used at Newport and Bend. This preserves budget for post-filtration taste and odor control and to address any potential algal toxin occurrence.

Backwashing and Cleaning

Conventional filters backwash based on differential head across the filter. The backwash cycle is designed to create a fluid velocity that can expand the media bed to release contaminants. Membrane filters would backwash about every 30 minutes and only require enough water to flush the trapped solids from the membrane modules (no media expansion). The backwash supply and waste volumes from membrane filters are generally about 30% to 50% less than granular media filters, respectively. For the City's existing direct filter plant, the annual plant wastage due to backwashing varied between 8 to 15 percent from 2010 to 2016, resulting in a recovery of 85 to 92 percent. Conventional and membrane filtration are anticipated to waste about 5% (95% recovery). In addition, it should be noted that to achieve media expansion in conventional media beds, backwash service pumps are necessary. These pumps will need to deliver velocities within the bed that will cause the filter media to expand (float) to release and flush the trapped waste material out of the bed. Membrane filtration requires pumping as well although on a smaller scale as well as specialized CIP and backwash equipment. The pumps and volumes of backwash produced by conventional filtration are anticipated to be more significant and costly than the pumping and specialized equipment required for membranes.

Figure 6.4: Typical Membrane Filtration Chemical Cleaning System

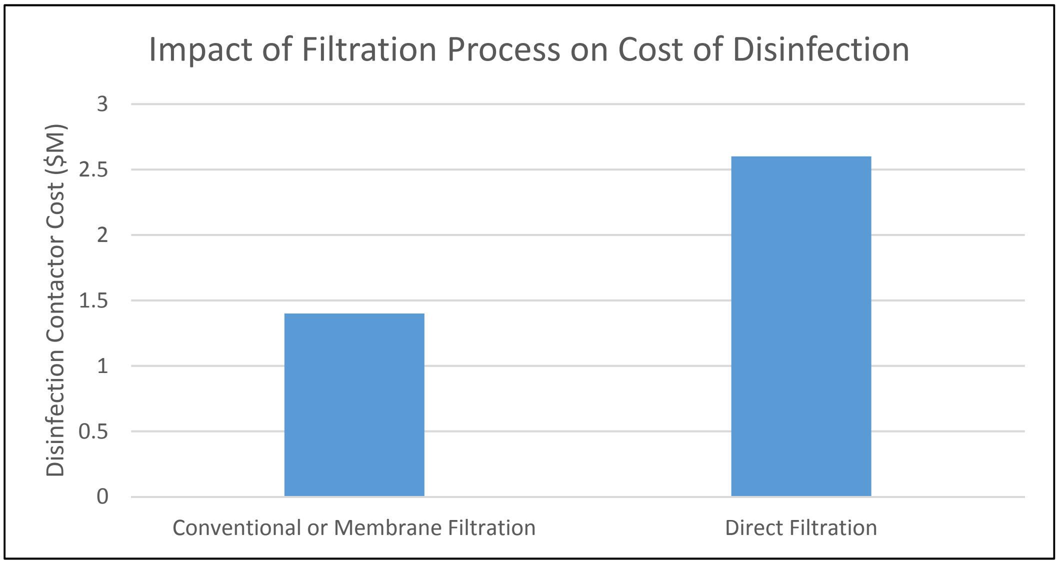


As described above, membrane filters require chemical cleaning to keep headlosses (transmembrane pressures) low, see Figure 6.4. The chemical cleaning systems include Acid Clean-in-Place (CIP), Caustic CIP, and Cleaning Solution Neutralization. Cleaning solutions can be reused for multiple membrane racks and the cleaning systems are relatively automated and specific to the membrane manufacturer.

Chlorine Disinfection

As discussed above, the filtration process selected influences the level and cost of disinfection. As shown in Figure 6.5, assuming 10 MGD production, the capital savings associated with the lower log removal requirements for disinfection after conventional and membranes, and therefore shorter CT, could be about $1.2 Million. This savings is from shorter contact requirements due to the lower disinfection requirements needed to meet the log removal and is based on planning level storage costs.

Figure 6.5: Impact of Filtration Process on the Cost of Disinfection



Summary Evaluation

A summary evaluation of filtration options is included below. Conventional and membrane filtration are compared against a base condition of the City's existing plant process, direct filtration. Conventional filtration was relatively better than direct filtration in three categories, equal to it in four, and worse in three more. In comparison, membrane filtration was better than direct filtration in eight of the categories, tied for operational history in Oregon, and was worse in one area (chemical cleaning systems).

Table 6.5: Filtration Options Summary

Criteria	Conventional Filtration	Direct Filtration	Membrane Filtration
Pre-treatment needs	-	O	+
Potential for turbidity breakthrough	+	O	+
Disinfection credits	+	O	++
Water recovery	+	O	+
Ease of expansion	-	O	+
Reduced rock excavation	-	O	+
Automation	O	O	+
Chemical cleaning systems	O	O	-
Ease of Operation	O	O	+
Operational history in Oregon	O	O	O
Overall			
Worse than base case (existing WTP)	3	Zero	1
Equal to base case	3	9 (base)	Zero
Better than base case	3	Zero	8

Legend:
O: base condition of existing WTP process
-: worse than base condition
+: better than base condition

Conclusions

1. Pressure filtration has many challenges and is not widely used (if at all) for Oregon surface waters. As a result, this option is not considered further.
2. Due to the generally low turbidity of the reservoir water source, sedimentation does not appear to be required for adequate treatment unless a very heavy dosage of PAC is required for seasonal taste-and-odor control (see Chapter 7).
3. Conventional filtration carries an additional capital cost because of its larger footprint and additional process steps.
4. Given the relatively low source water turbidities, either direct filtration or membrane filtration could effectively meet the desired treatment and production needs.
5. Membrane filtration requires chemical cleaning and neutralization systems, not required for direct and conventional filtration.
6. The higher level of treatment credit given to membrane filtration provides future protection if future sampling of Reeder Reservoir or TID raw water detects significant concentrations of *Cryptospordium* or *Giardia*.
7. The selected location for the new facility provides a gravity supply with significant pressure. Membrane filters can utilize this pressurized supply and eliminate the need for pumping prior to the filters. The pressurized membrane process will preserve enough head to significantly reduce the amount of pumping necessary to deliver finished water to the system.

8. The selected location for the new facility contains rock. Structures with larger footprints, such as those required for conventional and direct filtration, will likely require site clearing and rock excavation. The cost associated with the rock excavation could be significant.

SECTION 7 – DISSOLVED CONTAMINANTS REMOVAL

Ashland's primary source is an open reservoir. Open reservoirs will often collect material that dissolves into the water from sources like decaying plant material or the growth of algae. These dissolved contaminants are often organic based and are the contributing factors for taste and odor, toxins (such as algal toxins), and disinfection-by-product precursors (such as humic and fulvic acids).

Reeder reservoir experiences significant blue-green algae (cyanobacteria) growth during the summer months, as described in Section 3. Little water quality information is currently available on the TID water source, but is currently being collected (see Appendix B). Cyanobacteria produce algal toxins and there has been a detection of the algal toxin microcystin in Reeder Reservoir. The industry's understanding of algal toxins has grown in recent years and they have been linked to human health concerns.

Cyanobacteria also produce taste and odor-causing compounds, Geosmin and Methylisoborneol (MIB). Ashland currently experiences taste and odor complaints during the summer months. Cyanobacterial cells have been observed to be present in finished water produced by the existing water treatment plant. The primary taste and odor compound observed in Reeder Reservoir water is Geosmin. It has been measured at concentrations up to 70 nanograms/liter (ng/L) in raw water, whereas the general public odor threshold is 5 – 10 ng/L.

Cyanobacteria can also excrete organic matter that reacts with chlorine to form disinfection by-products. There are also naturally-occurring organic compounds in Reeder Reservoir from watershed runoff that react with chlorine to form disinfection byproducts (DBPs). DBPs are suspected carcinogens and are regulated by the Safe Drinking Water Act rules classified as Total TriHalogenated Methanes (TTHMs) and five regulated Haloacetic Acids (HAA5).

Cyanobacteria are prevalent in Reeder Reservoir water and the City has requested that the new WTP be designed to remove algal toxins, remove taste and odor causing compounds, and effectively control disinfection byproducts.

The existing plant uses powdered activated carbon (PAC) on a seasonal basis to attempt to remove tastes and odors. In the past, the PAC use had not been efficient enough to remove Geosmin low enough to avoid customer complaints. However, a new type of PAC, from a new supplier (Calgon WPH 1000), will be used where 2015 jar testing found it to be more effective and less expensive. See HDR's 2016 Technical Memorandum on PAC Testing Results. PAC can be difficult to manage, it is messy to handle and feed and it can create an explosive atmosphere around the feed equipment. PAC feed facilities are typically explosive hazard classified areas. For this reason, if activated carbon is selected for the new facility, it will likely be in the form of granular activated carbon (GAC). If a membrane filter is selected that is compatible with PAC, then PAC will be given further consideration.

Activated carbon media has been selected for the biofiltration process over other forms of media due to its affinity to remove dissolved organic materials while supporting biological growth. As its name suggests activated carbon (GAC or PAC) has an active surface charge, other proprietary filter medias have been developed with similar characteristics but were not considered in the concept report due to cost and availability concerns. The City has experience with this technique treating their source water and desire to continue ths approach for Taste & Odor and DBP management.

The technologies that will be considered in this section to reduce tastes and odors, algal toxins, and DBP precursors include:

- Granular Activated Carbon or Powdered Activated Carbon adsorption
- Ozone and GAC bio-stabilization or biofiltration
- UV/Peroxide and GAC bio-stabilization

With the exception of ozone followed by granular media biofiltration, the remaining treatments to destroy tastes and odors and to protect against algal toxins would be located downstream from coagulation/filtration as a polishing step. This location takes advantage of the removal of algae and a portion of the dissolved organic chemicals through the coagulation and filtration process. By removing a portion of the dissolved organics by filtration this stage of the process can be smaller and / or have reduced costs for operation. Also, by removing the algae through filtration, the oxidant demand is significantly reduced and the potential release of additional organics due to the algal cell lysing is reduced.

7.1 Granular Activated Carbon (GAC) or Powdered Activated Carbon (PAC)

Activated carbon is an adsorptive process that can remove dissolved organic compounds, typically measured as total organic carbon (TOC), such as Geosmin, algal toxins, organic acids, and other DBP and taste and odor precursors. Both GAC and PAC were given consideration. GAC is more convenient for operations and also provides effective contacting / performance and was selected to move forward with this analysis. If membrane filtration is selected and the selected system is compatible with direct feed of PAC, then PAC may be given more consideration in the future.

GAC media is contained in a flow-through contactor that is typically comprised of a pressurized steel vessel. GAC beds can be configured in downflow fixed bed, upflow fixed or moving bed, or pulsed bed configurations. All three configurations remove contaminants the same way. For the Ashland plant, a downflow fixed bed is recommended to take advantage of the raw water head available and avoid the expense of the more complex options.

As water flows through the GAC media bed, contaminants are adsorbed from the water onto the surface of the GAC media. Generally, GAC contactors must be backwashed to remove fine materials that result in increasing headloss across the contactor. Periodically, the GAC media will become exhausted (the surface of the GAC becomes saturated with contaminants) and the media loses its capability to adsorb additional contaminants. At that time, the GAC media must be replaced by the supplier.

Media replacement involves removal of the spent GAC and replacement with new activated carbon. This process would be contracted through a GAC media supplier. Most GAC suppliers provide removal and replacement services and have the necessary specialty equipment to remove and replace the media. They also have the necessary arrangements to dispose of the spent media or regenerate the media. It is anticipated that the units would be configured so that the media in one vessel would need to be replaced each year, this is based on the experience of Newport Oregon treating similar water and input from a GAC supplier. Media replacement frequency is a function of the concentration of naturally occurring organic matter in the water. Bed sizing and media life predictions are made based on the results of pilot or bench-scale testing for each application's specific condition. Total unit and media requirements will be refined during predesign and design after testing of processes and characterization of the anticipated organic loadings have been completed.

It is recommended that GAC be installed after coagulation / filtration, since the removal of natural organic matter (NOM) with coagulation and filtration will decrease the GAC usage rate. The capability to partially bypass the GAC under clean water conditions and blend the effluent is recommended to conserve the GAC.

GAC System Sizing

The GAC system is designed for a 10 MGD plant, but the quantity of vessels can scale with the plant capacity if a lower initial capacity is needed. The GAC serves to adsorb TOC (DBP precursors), T&O compounds, and algal toxins for the membrane filter/GAC plant configurations. The WTP will need to be designed with space, piping, and platforms to accommodate future water demands when more vessels are added. The major components of the GAC system are:

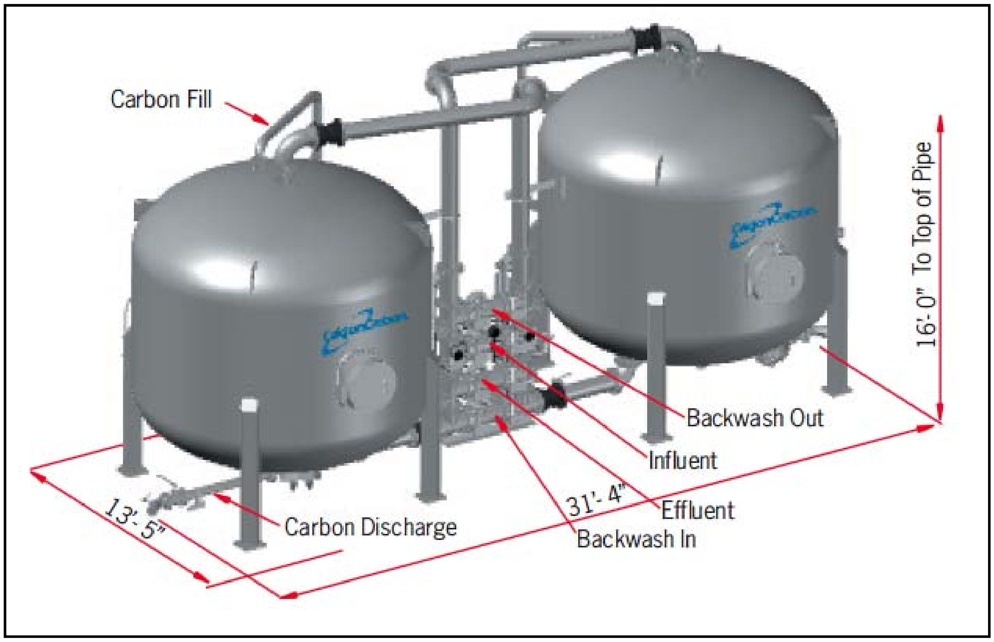
1. GAC vessels (Calgon Carbon Model 12-20 are shown in Figure 7.1)
2. Granular activated carbon
3. GAC system piping

GAC Vessels

Granular activated carbon vessels adsorb unwanted compounds and can maintain system pressure up to 125 psi. Calgon Carbon recommended the Model 12-20 vessels (Figure 7.1[1]) which have 12-foot diameters and hold 20,000 lbs of Filtrasorb 300 activated carbon.

[1] Calgon Carbon. *Model 12-40 Modular Carbon Adsorption System*. Calgon Carbon, 2012.

Figure 7.1: Model 12-20 Calgon Carbon GAC Vessels



Vessels are sized by their Empty Bed Contact Time (EBCT). Previous experience has shown an EBCT of 7-10 minutes is a good balance of performance and cost for applications in TOC, T&O, and algal toxin removal. Ten model 12-20 vessels would need to be configured in parallel for a 10 MGD plant flowrate. Alternatively, the 12-40 (12' diameter, 40,000 lbs GAC) vessels were considered, but the pressure drop through the vessels constrains the system design. An upper limit of 5 psi would limit the flow to 750 gpm per 12-40 vessel, which would require 10 of the more expensive 12-40 vessels. The model 12-20 vessels are recommended instead, where the EBCT would limit the flow to 700 gpm per vessel. A lower pressure drop (~3.4 psi) would be achieved, and the capital cost would be reduced by using the less costly model 12-20 vessels.

Granular Activated Carbon Media

Filtrasorb 300 is recommended by Calgon Carbon to reduce the pressure drops across each vessel while still achieving contaminant removal performance. The Filtrasorb 300 GAC has an effective size of 0.8-1.0 mm and an apparent density of 0.56 g/mL. Each model 12-20 vessel would be loaded with 20,000 lbs of GAC and would be changed out at an expected frequency of 2 vessels per year. Actual GAC lifespan would vary and can be estimated more accurately with small scale column testing.

Equipment List

The quantity and equipment needed for the GAC system for the established design criteria are shown in Table 7.1

Table 7.1 Granular Activated Carbon System Equipment and Quantity

Description	Number of Units (10 MGD) Design
GAC System	
• Model 12-20 Calgon Carbon GAC vessels	10
• Filtrasorb 300 (20,000 lbs per vessel)	Inclusive
• Piping, valves, and GAC skid	Inclusive

7.2 Ozone with Biostabilization or Biofiltration

Ozone is a best available technology for taste and odor destruction, as well as the destruction of algal toxins. When applied downstream from filtration, the State of Oregon allows disinfection credit with ozonation. Ozone is a strong oxidant and is used to create hydroxyl radical, an even stronger oxidant. The oxidation process destroys contaminants, but it also increases the biodegradability of residual NOM. Left unchecked, this could increase the growth of microorganisms in the distribution system which would be undesirable. To prevent this, we propose a bio-stabilization step following ozonation. If ozone is used following membrane filtration, this would be comprised of a flow through contactor with GAC media acting as a support substrate for an attached growth biofilm treatment process, consuming the readily bioavailable organic matter prior to water distribution. If ozone is use prior to granular media filtration, then the granular media filter would be operated biologically.

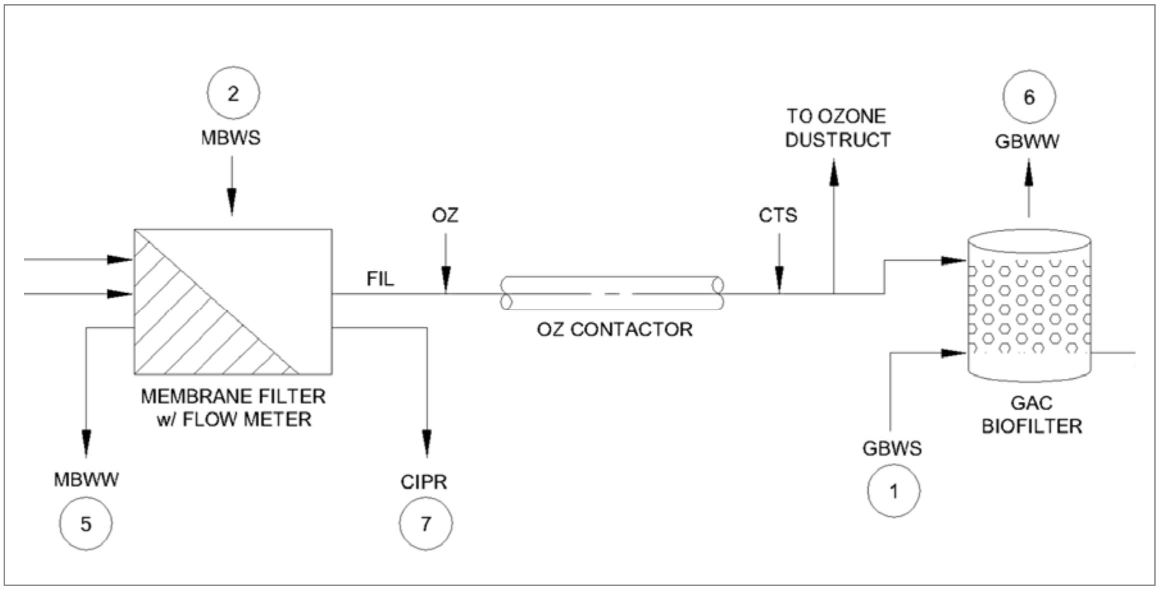
Ozone would be applied downstream from either clarification or membrane filtration. The primary reason for this is that ozone should not be applied to raw water containing cyanobacteria – doing so lyses the algal cells and releases the internal toxins. Applying ozone downstream from clarification or membrane filtration allows the algal cells to be removed prior to ozone application removing a significant portion of the potential demand before ozonation. Other reasons for applying ozone post clarification or membrane filtration are that: 1) ozone is not compatible with most membrane filtration modules and 2) ozone consumption is lower due to the organic reduction from coagulation / filtration.

Due to its high reactivity and short half-life, ozone must be generated on-site. Ozone can be generated from ambient oxygen or liquid oxygen (LOX) that is delivered to the site. LOX provides a higher efficiency, uses less equipment, and is the process most commonly used in Oregon (such as Medford, Lake Oswego, and Wilsonville). As a result, we recommend LOX for the City's new treatment facility. LOX is vaporized and fed as a gas to the ozone generators.

Ozone generators are supplied by manufacturers or chemical suppliers as packaged equipment to ensure the processes are appropriately sized and the controls and safety equipment are properly designed. Ozone is a powerful oxidant that poses life and safety concerns as does LOX. Manufacturers specializing in the production of this equipment have detailed SCADA systems to control the process in a safe and efficient manner.

In Ashland's treatment plant, ozone gas would be fed at an anticipated plant dose of 3 mg/L through a side-stream of process water using a venturi eductor. This process is similar to feeding chlorine gas which most operators are familiar with. The side-stream solution would then be mixed into the main process stream. It should be noted that side stream injection is typically sized at 10% of the process flowrate, this will become substantial as the plant grows. The necessary detention time would be provided in a plug flow, pressurized pipeline contactor. The side-stream injection / pipeline contactor method is anticipated to have lower capital costs than a bubble diffusion contacting basin at the Granite Low Site. Additionally, the pipeline contacting method can be completed under pressure, taking advantage of the hydraulics of the selected plant site. Following ozonation, any residual ozone in the water would need to be quenched using calcium thiosulfate (CTS) or sodium bisulfite. Ozone off gas would be collected and destroyed through an ozone destruct process. Figure 7.2 illustrates a typical ozone feed system with a pipeline contactor, followed by GAC bio-stabilization.

Figure 7.2: Ozone / Biostabilization Process



Ozone System Sizing

The ozone treatment system is sized for a 10 MGD plant flowrate. Side stream injection was selected based on anticipated lower capital costs and pressurized hydraulic profile. Component recommendations were provided by Mitsubishi Electric Power Products (MEPPI). There are other manufacturers that sells such equipment in the US and their input will be incorporated as the project design progresses. The major components of the ozone system are:

1. LOX feed gas to ozone generators
2. Ozone generation
3. Ozone injection system
4. Ozone pipeline contactor
5. Dissolved ozone quenching
6. Ozone destruct unit

Feed Gas to Ozone Generators

Ozone is generated on-site from oxygen due to the instability of ozone. The source of oxygen can either be from air or liquid oxygen (LOX). LOX is preferable because ozone generators can produce a higher ozone concentration with a pure oxygen feed. Pure oxygen can be supplied from vendors and stored on-site as LOX. A mixture of gaseous oxygen and 1% nitrogen are feed to the ozone generator to maintain high ozone production rates.

LOX Tank Storage Design Criteria

A method of LOX storage is needed to provide a continuous supply to the ozone generators. Cylindrical storage vessels are available in vertical or horizontal orientations and come with vaporizers and a pressure control manifold. The vessels would be installed outdoors on a concrete pad that is accessible for delivery from a vendor. If oxygen were supplied as air, the maximum ozone concentration lowers to ~3 %wt, whereas if gaseous oxygen (GOX) from LOX is supplied to the ozone generator, a concentration of 13.4 %wt is possible. For this reason LOX is the recommended source of oxygen supply.

A LOX demand of 1,970 pounds per day (210 gal/day) is needed to achieve an ozone dosage of 3.0 mg/L at the plant design flowrate of 10 MGD. A truckload of LOX will be required every month from AIRGAS to meet the demand. To store the LOX, two 6,000 gallon storage vessels will be needed with one as a redundancy.

Liquid Oxygen Vaporizers

Liquid oxygen storage is followed by vaporizers designed to produce gaseous oxygen before being feed to the generators. Typically, the vaporizers are heated by ambient air as LOX flows through finned tubes. Heat is transferred from the air to vaporize the LOX into GOX. Freezing conditions may require three vaporizers (one duty, one stand by, and one thaw). Vaporizers would be rented with LOX storage vessels from AIRGAS.

Nitrogen Boost Gas Feed System

A Primozone LOX booster system adjusts the nitrogen level to the ozone generator to 1% using dry, clean, oil-free plant air. Unoptimized nitrogen levels can cause production of nitrogen byproducts and cause a gradual decrease in the ozone production concentration.

Ozone Generation

Ozone would be generated onsite, a model GM48 2.0 Primozone generator is Illustrated in Figure 7.3[2]. Oxygen gas is ionized between two electrodes forming ozone by the combination of oxygen and an oxygen ion within the generators. The ozone generated would be dissolved into the side stream flow and combined with the plant flow for oxidation of organic compounds.

[2] Kim, Robert. *Ozone generation system budgetary proposal*. MEPPI, June 2017.

Figure 7.3: Primozone Ozone Generator

Two duty and one standby generator are needed to supply an ozone dosage of 3 mg/L at a 10 MGD plant flowrate. It is assumed that the generators are producing 13.4 %wt ozone (20 %wt maximum) with a 95% mass transfer efficiency to the raw water. The ozone demand would be 264 pounds per day.

Cooling Water Supply

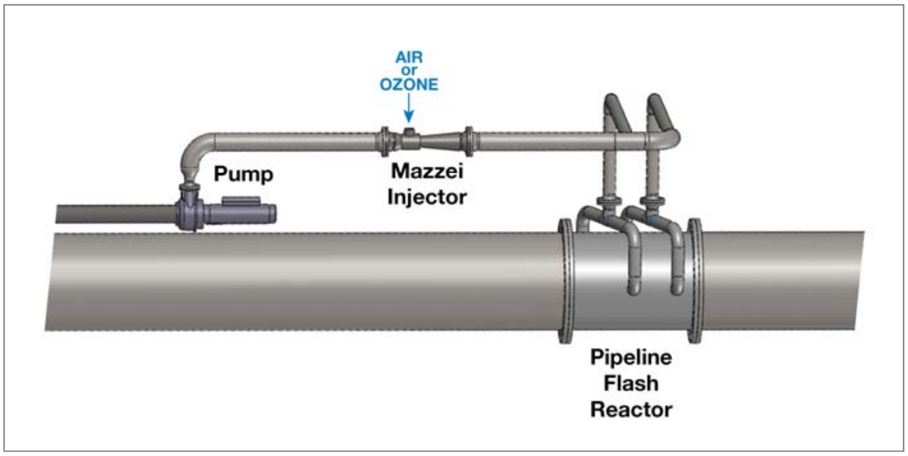
Water is pumped through a closed circle loop from a chiller into the ozone generators. Water is chilled to 50 °F, keeping the generator within a 9 °F temperature increase. Cooling water is needed because an increased ozone generator temperature results in reduced efficiency and lower production concentrations.

Ozone Dissolution and Contacting

The goal of the ozone system is to contact organics with the highly reactive ozone and hydroxyl radical molecules for oxidation and subsequent biofiltration. To dissolve the ozone, a portion of the raw water is diverted and boosted by end suction centrifugal pumps which pump the diverted water through a venture injector system. Ozone is pulled out of the venture injector and into the side-stream forming a two-phase mixture. Undissolved gas is removed from the side stream through a degas separator. The side-stream is mixed back into the main flow via a nozzle mixing system connected to an inline pipe flash reactor as pictured in Figure 7.4[3]. The flash reactor provides mixing for effective mass transfer of the ozone. Following the flash reactor would be a pipeline contactor to achieve contact time to oxidize organic compounds.

[3] *Mazzei Pipeline Flash Reactor*. Digital image. *Mazzei.net*. Mazzei, n.d. Web. 5 July 2017.

Figure 7.4: Mazzei Injector and Pipeline Flash Reactor



Dissolution of the ozone will require piping for diversion of the flow which is typically 3-15 percent of the total flow. Three 316L stainless steel Mazzei injectors and three 7.5 hp pumps will be required to inject the side stream with ozone. A Mazzei 316L stainless steel flash reactor would need to be sized to a 72-in diameter and 96-in length to provide an assumed 95% mass transfer efficiency of ozone to the raw water. The 316L stainless steel pipeline contactor would be sized for a 72-in diameter and 170-ft in length to provide a 5-minute retention time for a 1 mg/L ozone residual to achieve effective removal of microcystins. This also provides a CT value of 5 mg/L-minute which is above the CT value required for 0.5-log removal of *Giardia* (CT value of 0.48 mg/L-minute for <1° C water).

Ozone Quenching Pipeline

While ozone has a short half-life, factors such as temperature and pH can influence its lifespan, causing ozone residuals to last up to 1-2 hours. Ozone can cause issues with corrosion in downstream pipes and equipment and can pose a safety hazard if it off gases into closed facilities, ambient monitoring detects this condition and laerts operators of a hazard. To remove the residual ozone, UV radiation, chemicals, or activated carbon can be employed. Common chemicals used in municipal water treatment are hydrogen peroxide, sodium bisulfite, and calcium thiosulfate. Chemical treatment is a common way of eliminating ozone residual, and calcium thiosulfate (Captor) would be recommended for this application.

A pipeline flash mixer and contactor would be needed to provide the necessary contacting time of 60 seconds to remove residual ozone whilst maintaining system pressure. The pipeline would be constructed from 316L stainless steel with an 84-in diameter and be 25-ft in length to provide a 1 minute retention time.

Ozone Destruction

Ozone gas not transferred to the raw water needs to be removed at a destruct unit. The ozone system is assumed to transfer 95% of ozone to the raw water. The remaining gas must be collected by degas separators which separate the two phases based on their density difference. Degassed ozone is conveyed to a destruct unit which converts ozone to oxygen and releases the remaining ozone at concentrations below 0.1 ppm. The gas is preheated to prevent condensation and to increase the effectiveness of a granular catalyst. The ozone destruct skid contains a pre-heater, an ozone destruct unit, a blower, instrumentation and the necessary valves, and a control panel. MEPPI recommended one model DM50 (50 m^3/h) ozone destruct unit for a 10 MGD plant.

Equipment List

The quantity and equipment needed for an ozone system at the design criteria are shown in Table 7.2

Table 7.2: Ozone System Equipment

Description	Number of Units (10 MGD) Design
LOX System • LOX storage tank (6,000 gallons) • Vaporizers • GOX filter • LOX/GOX Instruments & Valves	 2 Inclusive Inclusive Inclusive
Ozone generators and power supply units • Primozone GM48 2.0 ozone generator • Mini-SEPT power supply unit (48 per unit)	 3 3
Supplemental Nitrogen System • Primozone LOX Booster	 1
Ozone Injection system and pipeline contactor • 72” diameter x 96” stainless steel pipeline flash reactor • 316L SS Mazzei injectors • Centrifugal 7.5 hp pump • Instrumentation, valves • 72” diameter x 170’ stainless steel pipeline contactor	1 3 3 Inclusive 1
Ozone quenching pipeline contactor • 84” diameter x 25’ long stainless-steel pipeline	 1
Closed loop cooling water system	3
DM50 Ozone destruct units	1
Instrumentation and monitors • High concentration ozone monitors • Off-gas ozone monitor • Destruct outlet ozone monitor • Ambient ozone monitor • Dissolved ozone analyzer • Ambient oxygen monitor • Dew point monitor	 2 1 1 2 2 1 1
Control Panels • Main ozone control panel • Local ozone control panel (1 per generator) • Ozone destructor local control panel	 1 3 1

Biofiltration System Sizing

The biofiltration system is contemplated to be pressurized to take advantage of the hydraulics that are unique to the site. The system would not be a deep bed GAC filter/contactor. The pressurized biofiltration system would biodegrade residual organic matter after the ozone treatment system has oxidized it. The biofiltration system is designed for a 10 MGD plant, but the quantity of vessels can scale with the plant capacity if a lower initial capacity is needed. The WTF will need to be designed with space, piping, and platforms to accommodate future water demands when more vessels are added. The major components of the biofiltration system are:

1. 12-20 GAC vessels
2. Granular activated carbon
3. System piping

GAC Vessels

To reduce the height of the vessels, Calgon Carbon recommended the 12-20 pressure vessels. Other manufacturers offer horizontal vessels that may provide cost savings. The design criteria for the biofilter pressure vessel is to maintain a loading rate of 5-6 gpm/sq ft. To achieve this value, 11 vessels will be needed and each will receive a flowrate of 630 gpm for a 10 MGD plant flowrate.

Granular Activated Carbon

Filtrasorb 300 is recommended by Calgon Carbon to reduce the pressure drops across each vessel for the biofiltration system and the GAC system. All vessels would have their GAC changed out every 10 years. The first GAC fill is included.

Equipment List

The quantity and equipment needed for a GAC biofiltration system at the design criteria are shown in Table 7.3.

Table 7.3 Granular Activated Carbon Biofiltration System Equipment and Quantity

Description	Number of Units (10 MGD) Design
GAC System	
• 12-20 Calgon Carbon GAC vessel	11
• Filtrasorb 300	Inclusive
• Piping, valves, and GAC skid	Inclusive

7.3 Ultraviolet Light (UV) – Peroxide with Bio-stabilization

Ultraviolet light (UV) coupled with hydrogen peroxide (HP) can be used to create a hydroxyl radical, similar to the ozonation process described above. However, this process is rarely used in water treatment. The UV doses required are much higher than typically used solely for disinfection. The dosing for HP is sensitive and any residual hydrogen peroxide that remains unreacted may cause process control problems with downstream chlorination systems. Bio-stabilization would also be needed, similar to ozonation. This alternative is less stable than GAC or Ozone/bio-stabilization and will require significantly more operator attention to control. The alternative is also similar in capital cost to ozone. Due to the higher long-term O&M cost and uncertainty of the process stability it is not a good fit for Ashland. A technical and budgetary memo is provided within Appendix D.

7.4 Evaluation

We recommend that UV/Peroxide be dismissed from further consideration due to limited use in drinking water applications. Ozone / biofiltration and GAC are advanced to the evaluation described in Section 11.

SECTION 8 – DISINFECTION AND DISINFECTION BYPRODUCT CONTROL

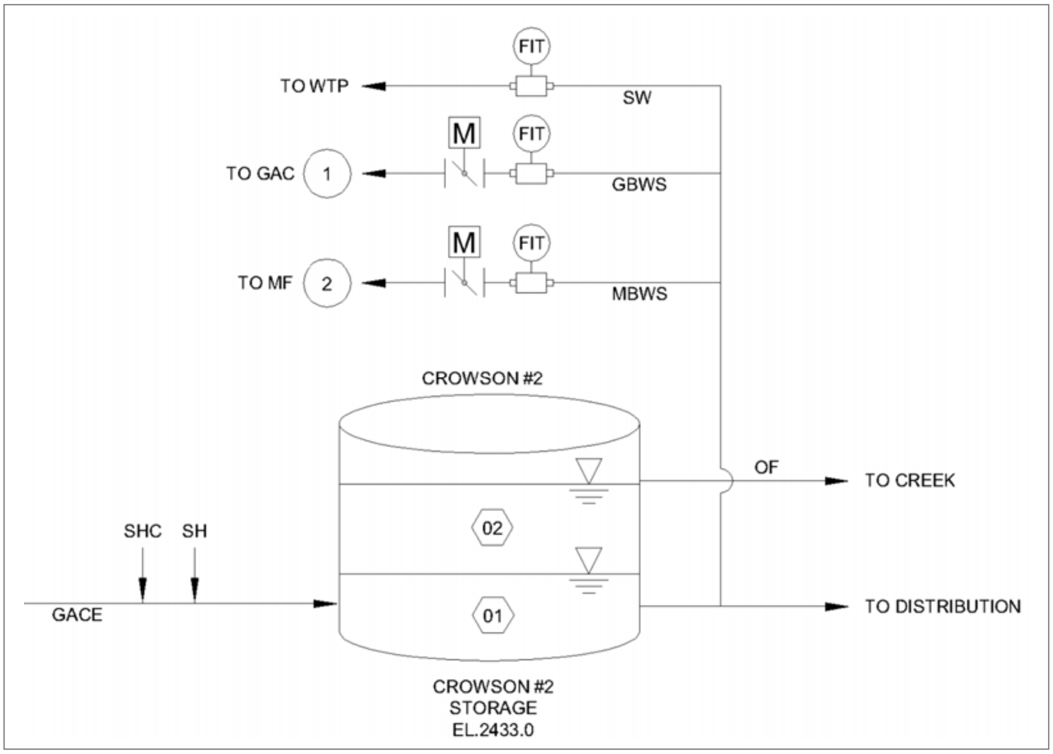
Disinfection must be achieved while simultaneously controlling the formation of disinfection byproducts. The disinfectants considered include chlorine, ultraviolet light (UV), and ozone. The evaluation considers that chlorine would have to be added to meet the residual requirements within the distribution system regardless of the primary disinfectant used. Also included in the evaluation is that finished water storage would be built at the new water treatment plant site, the Crowson II reservoir currently planned by the City.

8.1 Chlorine

The City selected sodium hypochlorite (liquid chlorine) as their preferred method for chlorination at the new WTP based on their experience with the chemical at the existing WTP. The City prefers bulk sodium hypochlorite (SHC) rather than on-site generation for their disinfection needs.

This section considers SHC as a primary disinfectant independent of the secondary disinfection needs. SHC as a primary disinfection method must meet certain contact time requirements based on CT calculations to achieve the log removal required by regulation. SHC would be fed after the last treatment step prior to the contact chamber, because SHC is being considered for primary disinfection, contact time enters this discussion. Contact time would be achieved in a chlorine contact basin located at the treatment plant. This basin could be independent of or integral to Crowson II Reservoir, as illustrated in Figure 8.1. If chlorine contact is accomplished within Crowson II Reservoir we recommend baffling the reservoir to improve contact time efficiency and to provide the City's needed useable storage volume. We are anticipating three curtain baffles and a baffling factor of 0.5. With the assumptions noted in Table 8.1, we are anticipating that a contactor volume of 0.7 to 1.3 MG would be needed, depending on the treatment selected and the associated log removal required. For comparative purposes 0.7 MG and 1.3 MG were used for the capital cost estimates.

Figure 8.1: Chlorine Disinfection System



Legend/Notes:

This symbol designates keynotes in figure above.
Keynote 01 – dedicated chlorine contact volume.
Keynote 02 – operational and emergency storage volume.

Table 8.1: Impact of Filtration on Disinfection Cost

Treatment Type	Giardia Inactivation Requirement (log)	Typical Disinfection Contactor Size (MG)
Direct Filtration	1	1.3
Conventional Filtration	0.5	0.7
Membrane Filtration	0.5	0.7
Assumptions:		
Chlorine Residual	0.6	mg/L
baffle factor	0.5	
pH	7.5	
Temperature	5	deg C
CT required for 0.5-log	29	mg/L-min
CT required for 1-log	57	mg/L-min
Capacity	10	MGD
Typical Contractor Unit Cost	2	$/MG

The assumptions made in the table above are for comparative purposes, (i.e. the temperature of 5C is warmer than the minimum experienced and the chlorine residual is lower than what is typically observed in the distribution system). The values that were selected provide an illustration of the disinfection requirements for a comparative scenario. In addition, EPA has done significant testing and benchmarking of the viability of Giardia and viruses to withstand exposure to chlorine and other disinfectants. For this table, the CT requirements for Giardia are more restrictive than for viruses. Therefore, Giardia's log removal requirements were used to calculate the cost for disinfection contact.

8.2 Ultraviolet Light

Ultraviolet light (UV) can be used to inactivate Giardia and Cryptosporidium. It is less effective at inactivating viruses at typical doses in water treatment. UV's mode of inactivation is instantaneous and therefore does not require contact time. It can be performed under pressure. Several UV disinfection facilities are in operation in Oregon including Baker, Springfield, and Canby.

UV disinfection relies on lamps with power controlled by ballasts. Flow rate, UV intensity, and water UV transmittance readings are typically incorporated into the control system.

UV has lower day-to-day risk to operations staff because it does not require the handling of strong oxidizing chemicals. However, UV does have electrical based hazard that operators must be aware of when maintaining the system. UV has higher power costs than sodium hypochlorite but is not reliant on chemical deliveries, it also has a smaller footprint than both chlorine and ozone. For the new WTP UV is a viable alternative to chlorine and ozone in a specific process approach of membranes and GAC.

8.3 Ozone

Ozone is a preferred taste and odor control technology and was evaluated for use in the new WTP for control of T&O and for disinfection. The State of Oregon rules assert that disinfection credit with ozone is only available if it is applied following filtration. Ozone is further described in Section 7. Ozone reaction chambers need to be sealed to protect equipment and personnel from the hazards of this powerful oxidant. For this report, a side-stream injection system with pipeline contactor was the preferred method for ozone contact due to the pressurized raw water feed coming into the plant.

Obtaining an accurate ozone residual sample is difficult with a pipeline contactor, particularly if buried, due to the rapid dissipation of ozone residual. Due to concerns with process control for disinfection with ozone and since chlorine and the chlorine contactor will likely be installed anyway as described above, we recommend that ozone be selected as the redundant disinfection capability, but that chlorine be relied upon as the duty primary disinfection process. If there is consideration of deferring building Crowson II until a future date, then use of ozone as the primary disinfectant in lieu of chlorine could be reconsidered. If ozone is used as the primary disinfectant and assuming the same parameters as Table 8.2 ozone would have CT value in the range of 1.9 min-mg/L.

8.4 DBP Control Strategy

Potential disinfection byproducts include bromate produced by ozone and chlorinated organics produced by chlorine.

Bromate is formed upon the ozonation of water containing natural bromide. Samples of Ashland's Ashland Creek raw water supply have not detected bromide. However, given that ozone could be selected as a taste and odor treatment technology, raw water bromide samples should continue to be collected for confirmation. If ozonation is tested at the bench- or pilot-scale, ozonated water should be tested for bromate to support that will not be an issue.

Byproducts from chlorine disinfection are formed from NOM precursor material. The strategy to control these byproducts, trihalomethanes (TTHM) and the five regulated haloacetic acids (HAA5), is to remove NOM prior to the addition of chlorine. The existing plant has always been in compliance with DBP requirements, and further optimized their compliance in 2012. Seasonal HAA5 concentrations were approaching the maximum regulatory limit, when used on an annual average basis, when operators shifted the point of chlorination from raw water to filtered water. Since the 2012 optimization, HAA5 concentrations have been much lower and well below the regulatory limit. TTHM compliance has never been an issue for the existing WTP.

For the new plant, NOM will be removed during the coagulation / filtration process. Current plans include acid addition (carbon dioxide) to be able to lower the pH to remove even more NOM. Polishing would occur including either ozone / bio-stabilization or GAC that would further remove NOM. Further, ozone transforms some recalcitrant NOM to make it bioavailable. We are anticipating removal of significant amounts of NOM through the treatment processes prior to the addition of chlorine. We believe that the resultant treated effluent water will have low NOM concentrations and result in low DBP formation after the addition of chlorine whether it is added as the primary disinfectant or only for residual in the distribution system.

SECTION 9 – RESIDUALS HANDLING/ DISPOSAL AND CHEMICAL FEED

9.1 Residuals Handling and Disposal

This section describes backwash supply, residuals handling and disposal.

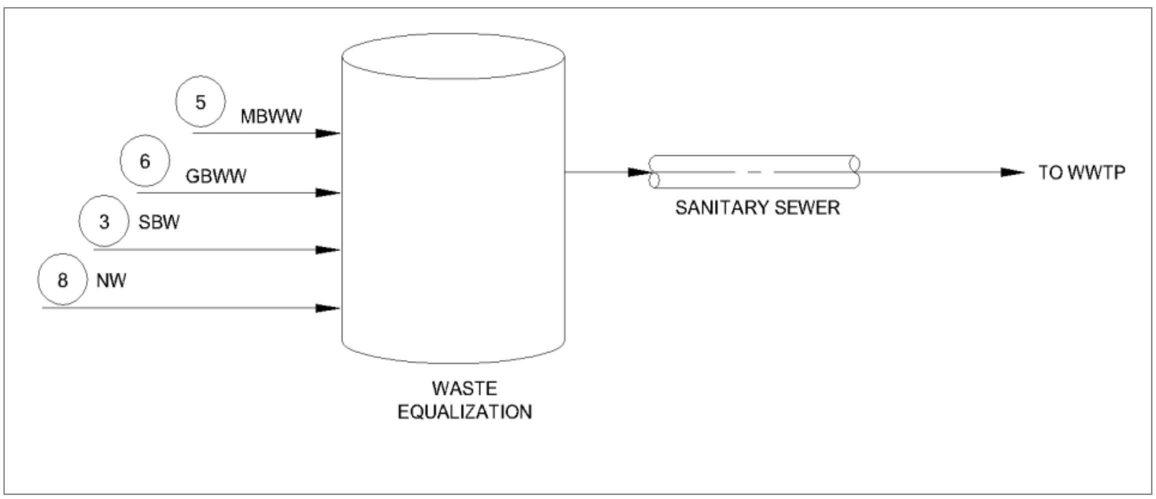
Backwash Supply

Backwash water supply will be required for the membrane or granular media filters and the GAC and biofilters. Backwash supply will be provided from the Crowson II finished water storage reservoir or from the pressurized distribution system. The reservoir will also provide potable/service water for the water treatment plant. If biofiltration is used, non-chlorinated (or chlorinated water treated with sodium bisulfite to dechlorinate) backwash supply will also be needed.

Backwash Waste and Spent Chemical Cleaning Solution

Backwash wastes from the membrane filters, GAC and biofilters, and autostrainers will discharge to a waste equalization basin (WEQ) and waste will be metered out at a uniform rate to the sanitary sewer and wastewater treatment plant, as shown in Figure 9.1. Chemical cleaning wastes will also be discharged this way, shown as neutralized waste in Figure 9.2.

Figure 9.1: Waste Equalization and Disposal



Legend:
MBWW = Membrane Backwash Waste
GBWW = GAC Backwash Waste
SBW = Strainer Backwash Waste
NW = Neutralized Waste cleaning solution

Plant Drains and Sanitary Sewer

Plant drains will also be routed to discharge to the waste equalization basin. Sanitary wastes will bypass the WEQ and drain directly to the sanitary sewer.

Spent GAC

GAC media becomes unavailable for organic adsorption over time. The spent media must be removed from the pressure vessels and replaced with new media. This process is discussed with the GAC process discussion in other sections of this report. For discussion in this chapter, it should be noted that the GAC supplier has provided information on anticipated costs to replace the media. This waste stream would be handled through a contract to remove and haul the spent GAC away for disposal or regeneration.

9.2 Increasing Plant Recovery

The estimated plant recovery for the proposed system is 95% to 97%. The plant recovery could be increased using either of the following two methods described below. . However, reprocessing backwash waste may require additional monitoring because the plant will be reintroducing removed waste back to the raw water stream. Potential dissolved and suspended contaminants will have to be removed a second time by the process, this alternative should be further explored during the pre-design of the plant.

The methods to increase plant recovery will increase capital and operating costs of the project. If it is possible to avoid these by wasting more to the sanitary sewer, then that is recommended to conserve budget. Increasing plant recovery is discussed in the master plan and an approach for this may need to be considered in the future, however, neither of these methods is recommended at this time unless sanitary sewer capacity is not sufficient for the residuals produced from the proposed facility. The other scenario that would drive a consideration to increase plant recovery would be demands that are higher than the available source water, this may not occur until the plant has reached its full buildout capacity.

Backwash Waste Recovery by Membrane Filtration

Backwash wastes from the GAC biofilters and the membrane filtration units could be captured in storage tanks and then reprocessed through a dedicated membrane filter unit. The filtrate from the backwash recovery membrane unit would be combined with the plant filtration to the clearwell. Backwash waste from the backwash recovery unit would discharge to the sanitary sewer. It is estimated that the overall recovery of the facility could be increased to 99% with this method. While technically feasible, this approach is typically only used when a WTP has limited resources for disposing of its backwash waste streams or has a limited raw water supply. In most cases backwash recovery becomes a function of economics of the particular site and backwash recovery using this method can be costly. Currently, the City does not have limiting factors on waste discharge or water supply so this approach was not included in the overall plant analysis.

Solids Recovery with Plate Sedimentation

Backwash wastes from the treatment process (other than chemical cleaning wastes) could be reprocessed through plate sedimentation. Settled water would discharge to the head of the plant and underflow solids would be discharged to the sanitary sewer. It is estimated that the recovery of the facility could be increased to 97% with this method. Similar to the membrane recovery approach, this approach requires the construction and operation of a secondary settling basin process. This process, depending on the preferred alternative, may not be similar to the other processes being operated at the

WTP adding an extra layer of complexity to the facility. This approach was not considered further. If backwash waste disposal or source water become concerns in the future then this concept can be explored further for its appropriateness.

9.3 Chemical Options, Storage, and Feed Systems

The following chemical feed systems were considered for the new plant with their respective processes. Not all chemicals are applicable to all process configurations. Refer to the previous sections or Section 11 to determine which chemicals match each treatment scenario.

Chemical Feed Systems at the Existing Plant

- If chemical feed is performed at the existing plant, chemicals will have to be fed at the Terrace Street Pump Station when TID water is used as a source.
- Sodium hydroxide (NaOH) delivered in totes. (need to discuss with operations the potential to use the existing soda ash feed system)
- Sodium permanganate (SPM) delivered in totes

Chemical Feed Systems at the New Plant

- Carbon dioxide (CO2) delivered as a compressed gas, vaporized, dissolved in a side-stream for injection, used for pH decrease in coagulation
- Aluminum chlorohydrate (ACH) delivered in bulk, fed neat, used as coagulant to remove NOM
- Liquid oxygen (LOX) delivered in bulk, vaporized, used to generate ozone gas, dissolved in a side-stream for injection into a pipeline contactor, used to destroy tastes and odors and algal toxins
- Calcium thiosulfate (CTS) delivered in tote containers, used for quenching ozone residual and dechlorination
- Sodium hypochlorite (SHC) delivered in bulk and fed neat, used for disinfection (including distribution system residual) and to make caustic clean-in-place (CIP) solution and for chemically enhanced back washes
- Sodium hydroxide (NaOH) delivered in tote containers. Used for pH increase, to make caustic clean-in-place solution, for chemically enhanced back washes, and for cleaning solution neutralization
- Citric acid (CA) delivered in totes and used to make acid CIP solution
- Salt, delivered in bags on pallets and used for water softening

SECTION 10 – PERMITTING

The following permits / reviews are anticipated to be required.

Table 10.1: Permitting

Permit / Review	Governing Agency	Process Time	Contact Information
Plan Review	Oregon State Department of Human Services – Drinking Water Program	Approx. 2 weeks	DHS Drinking Water Program 2860 State Street Medford, OR 97504 Phone: 541.776.6222
Construction Activities Permit (NPDES #1200-C)	Oregon State Department of Environmental Quality	2-3 weeks	DEQ Western Region 750 Front St. NE, Suite 120 Salem, OR 97301-1039 Phone: 541.378.8240
Conditional Use Permit	City of Ashland Community Development Department	8-13 weeks	Community Development / Planning Division 20 East Main St. Ashland, OR 97520 Phone: 541.488.5305
Physical and Environmental Constraints Permit	City of Ashland Community Development Department	8-13 weeks	Community Development / Planning Division 20 East Main St. Ashland, OR 97520 Phone: 541.488.5305
Building Permit	City of Ashland Community Development Department	4-6 weeks	Community Development / Planning Division 20 East Main St. Ashland, OR 97520 Phone: 541.488.5305
Excavation Permit	City of Ashland Public Works Department	N/A	Public Works Department 20 East Main St. Ashland, OR 97520 Phone: 541.488.5587
	Oregon Department of Fish and Wildlife (ODFW)		ODFW Rogue District 1495 East Gregory Road Central Point OR 97502 541-826-8774
In-Conduit Exemption	Federal Energy Regulatory Commission (FERC)		City of Ashland Water Resources Technician Ciara Marshall ciara.marshall@ashland.or.us (All communication with FERC shall be through the City of Ashland)

If there is work in a waterway or wetlands, then the US Army Corps of Engineers, Oregon Department of State Lands (ODSL), and Oregon Department of Fish and Wildlife (ODFW) would need to be consulted.

If there is work on the Penstock or Powerhouse, then the Federal Energy Regulatory Commission (FERC) would need to be consulted.

If there may be new facilities to create hydropower, then the following would likely need to be consulted: FERC, ODFW, Oregon Water Resources Department (OWRD).

In addition to the permits above, a variety of permits (i.e. plumbing, electrical) are anticipated to be required by the Contractor during construction.

SECTION 11 – RECOMMENDED TREATMENT PROCESS

Using the previous discussion on potential treatment processes, individual unit processes were assembled to create four logical treatment trains to meet the overall treatment objectives. The treatment trains were then evaluated based on cost (capital and operations), expandability, and ability to meet future regulations as well as other site and operations specific criteria to select a preferred treatment train for Ashland.

The City currently is evaluating whether to build the new Crowson II Reservoir. For this analysis, it is assumed that the Crowson II Reservoir will not be built and each treatment train must provide its own disinfection process independently without relying on the reservoir to achieve the necessary contact time. For the purpose of this report, processes that require contact time included a volume for contact that did not include additional cost associated with the reservoir. By using this method it allows the costs to be independent of the Crowson II Reservoir construction costs and schedule and balances the cost comparisons.

The treatment processes used to build the treatment trains are:

CL – Clarification
OZ – Ozone
BF – Biofiltration
MF – Membrane Filtration
GAC – Granular Activated Carbon
CL2 – Chlorination
UV – Ultraviolet light disinfection

11.1 Alternative Treatment Trains

Four alternative treatment trains were developed for evaluation. The treatment trains are shown schematically in the process flow diagrams placed at the end of this section. Table 11.1 summarizes each major treatment step and their respective purposes.

Table 11.1: Summary of Alternatives and Major Treatment Processes

Alt.	Pre-Treatment	Filtration	Post-Filtration	Final Treatment
1	Coagulant feed to co-precipitate organics and color. Carbon dioxide addition to stabilize diurnal water pH swings	Membrane filtration for turbidity, *Cryptosporidium*, and *Giardia* removal	GAC for removal of Geosmin (primary purpose) and potential algal toxins (secondary)	Chlorination for distribution system disinfection, and *Giardia* and virus destruction
2	Same as Alt. 1	Same as Alt. 1	GAC for removal of Geosmin (primary purpose) and potential algal toxins (secondary). UV for *Giardia* inactivation	Same as Alt. 1 but process is smaller since *Giardia* inactivation is met by membranes and UV.
3	Same as Alt. 1	Same as Alt. 1	Ozonation for Geosmin, *Giardia*, virus and algal toxin destruction. Biofiltration to absorb ozonated nutrients and TOC to stabilize treated water.	Same as Alt.2 but even smaller process as *Giardia* inactivation met by membranes and ozone and water has a lower chlorine demand due to ozonation.
4	Coagulant feed to co-precipitate organics, color, and fine particles/colloids. Carbon dioxide addition to stabilize diurnal water pH swings. Clarification (CL) to remove coagulated solids. Ozonation for Geosmin and algal toxin destruction	Biofiltration to remove turbidity, *Giardia*, and *Cryptosporidium*, and to absorb ozonated nutrients and TOC.	None	Same as Alt. 1

Alternative 1: MF – GAC – CL2

- ✓ Allows for future ozone addition
- ✓ PAC could be substituted for GAC depending on membrane selection

Alternative 1 is the simplest with regards to the number of treatment processes. The membrane system would be used to address Surface Water Treatment Rule requirements while the GAC system would be used to address the City's existing seasonal Geosmin issues and any potential algal toxin releases. Chlorine disinfection would be added for the same purpose as the current water treatment plant's chlorine usage, namely *Giardia* and virus disinfection and to maintain a secondary disinfectant (chlorine residual) throughout the distribution system.

This alternative would be a completely pressurized hydraulic profile. It would flow completely by gravity approximately 60% of the time. However, the clearwell for chlorine disinfection would have to be located at about elevation 2405, increasing disinfection costs.

Alternative 2: MF – GAC – UV – CL2

- ✓ Allows for future ozone addition
- ✓ PAC could be substituted for GAC depending on membrane selection

This alternative is similar to Alternative 1 but adds UV disinfection. The purpose of this system is to provide *Giardia* inactivation, thus greatly reducing the chlorine concentration x time (CxT) requirements and allows a considerable smaller clearwell/reservoir. As with Alternative 1, this alternative would be a completely pressurized hydraulic profile and would flow by gravity approximately 60% of the time.

Alternative 3: MF – OZ – BF – CL2

Alternative 3 provides an even higher level of treatment than Alternatives 1 and 2 by replacing the use of UV with ozonation. Ozonation is an extremely strong oxidant that destroys many pathogens and Geosmin. The biofiltration step utilizes GAC contactors like in Alternatives 1 and 2. The key difference is that the GAC is used as a substrate to support biofiltration, which then allows for additional nutrient and TOC removal and to stabilize the treated water. (Ozonated water transforms TOC into simple sugars that can cause biofilm growth in distribution systems, even in the presence of free chlorine. Stabilization means that the potential for this growth is greatly reduced, thus is biologically “stable”). This alternative would again be a completely pressurized hydraulic profile and flow by gravity approximately 60% of the time.

Alternative 4: CL – OZ – BF – CL2

The prior alternatives were based on membrane filtration, the current state-of-the-industry for filtration throughout Oregon and the rest of US, and a process that provides considerably cleaner (i.e. less turbid) water than the current direct filtration water treatment plant. Alternative 4 was developed to follow a similar process as the current plant but provides additional treatment processes to overcome existing deficiencies. Those deficiencies include:

1. Lack of a clarification step to remove coagulated solids prior to filtration, thus limiting filter run times and reducing operational reliability during storm-driven turbidity events.
2. Difficulty in removing Geosmin, resulting in taste-and-odor issues throughout the distribution system.
3. Limited ability to remove algal toxins if they are found in significant concentrations.

Addressing these deficiencies involves adding a clarification step and ozonation, and having the filters become biologically active. This alternative would break head and treat water in basins open to atmospheric pressure. All water processed through the WTP would need to be pumped up to elevation 2425. As noted in Chapter 8, ozonation is not yet granted credit for disinfection when used ahead of filtration in Oregon. For this reason, the chlorine disinfection contactor could be quite expensive because 1-log Giardia inactivation would be required if the state classifies this as a direct filtration WTP.

11.2 Evaluation Criteria

Through multiple workshops with City staff, the following evaluation criteria and weighting were established. The remainder of this section will evaluate the four alternative treatment trains against the criteria presented below, with each criterion weighted as shown in Table 11.2.

Table 11.2. Evaluation Criteria and Weightings

Criteria	Weighting (%)
Affordability (capital cost)	20
Life-Cycle Cost (O&M)	20
Treatment Performance	10
Automation	10
Maximizing Capacity	10
Compact Footprint	10
Ease of Expansion	10
Sustainability	10
Total	100

Each alternative are qualitatively ranked against each other. A score of 1 is given to the best alternative for the particular criteria and a score of 4 is provided for the worst alternative. Intermediate alternatives are given a score of 2 or 3.

11.3 Cost Considerations

Cost considerations include initial capital cost along with 20-year life cycle operations and maintenance (O&M) costs.

Initial Project Cost

The initial project cost is impacted by how scalable treatment processes are. This initial analysis assumes that the following site development / treatment processes are not scalable and initial plant costs assume that they are constructed to handle the full 10 mgd future plant capacity:

- Site work and retaining walls
- Yard piping
- Ozone contact pipeline

- Chlorine contact tank

Instead, these items would be constructed for the full 10 MGD build-out as the marginal construction cost between an initial 2.5 MGD and a full build-out 10 MGD system is small. This assumption will be revisited as the design advances.

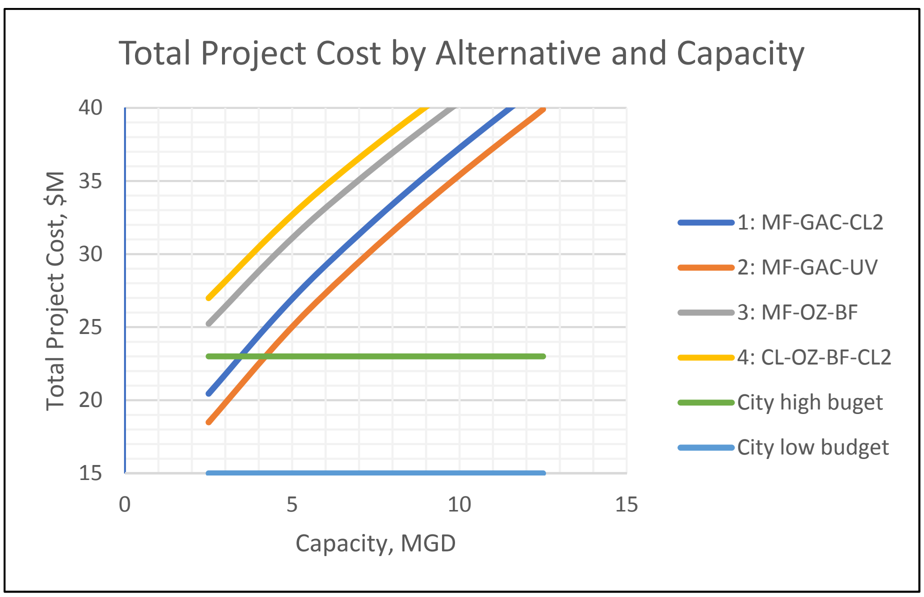
Due to greenfield development, topography, geology, and existing infrastructure, it is anticipated that this project will have relatively high initial site development costs. Initial project cost is a key evaluation criterion. The City is budgeting between $15M and $23M for Phase 1 project cost. There is a large amount of uncertainty in the site development costs because geotechnical investigations have not yet been completed. Targeted geotechnical investigation is required to reduce site development cost uncertainties prior to detailed design starting.

Initial project costs include:

- 35% Contingency
- 23% Engineering and Construction Services
- 21.5% Contractor profit, bonds / insurance, general conditions work, and mobilization
- Escalation to mid-point of construction assuming 2.5 years at 3% per year.

Figure 11.1 shows total project costs as a function of process and capacity. Based on review of the figure, only Alternatives 1 and 2 are within the City's Phase 1 budget.

Figure 11.1: Total Project Costs by Alternative and Capacity



The alternatives are ranked as follows (lower the number, the better the performance):

Table 11.3: Affordability Alternative Rating

Criteria		Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Affordability (capital cost)		20%	2	1 (lowest cost, best score)	3	4 (highest cost, worst score)

Lifecycle Life-Cycle Cost O&M Cost (20-yrs)

O&M costs were evaluated and aggregated to a 20-year present worth cost. The cost evaluation assumes that inflation is similar to interest so 0% net interest is used for the evaluation. Details of the cost evaluation are included at the end of this section. The cost components evaluated for O&M include those items listed below, which are felt to capture the bulk of O&M costs and replacement costs for short-lived assets.

- Labor
- Power
- Chemicals
- Replacements

Figure 11.2 presents the results of the evaluation.

Figure 11.2: Life Cycle O&M Cost (20 years)

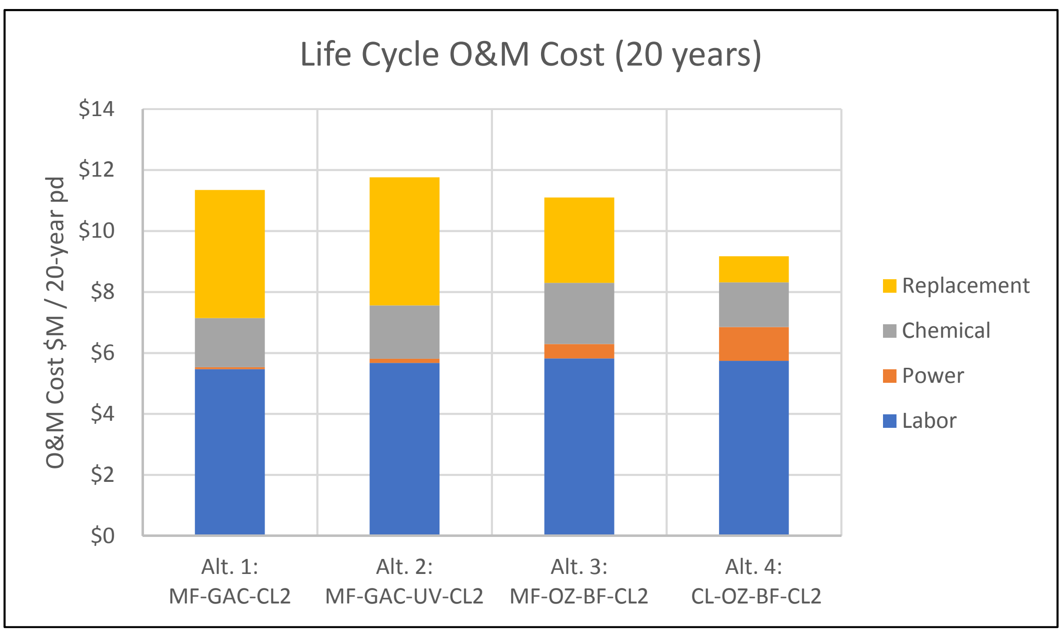


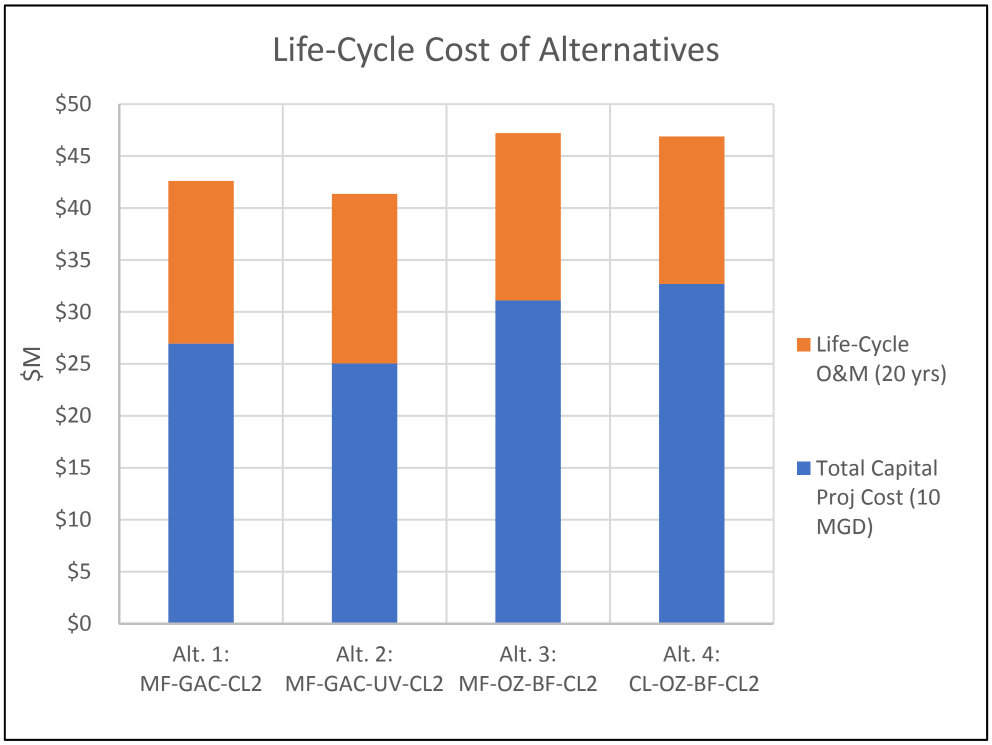
Table 11.4: Life-Cycle O&M Cost Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Life -Cycle O&M Cost	20%	2	1	4	3

Life-Cycle Cost of Alternatives (Capital + O&M)

The total lifel-cycle cost of the alternatives is evaluated based on the addition of Life-Cycle O&M to the Total Capital Project cost. The Total Life-Cycle Cost of the Alternatives are presented in Figure 11.3. This cost represents the total cost of ownership of the plant at the nd of 20 years normalized to todays dollars.

Figure 11.3:Life-Cycle Cost of Alternatives (O&M + Capital)



11.4 Treatment Performance

Each of the four alternatives was established to meet treatment criteria and will perform well for the City. However, there are significant differences in treatment capabilities between the alternatives. For example, membrane filtration provides considerably greater particle removal than granular filters, meaning lower turbidities (a key surrogate for pathogens) as well as finished waters with lower chlorine demands and greater chlorine stability. In addition, membrane filtration provides considerably greater removals of *Cryptosporidium* and *Giardia* oocysts than conventional or biological filtration.

For this reason, Alternatives 1 through 3 with membrane filtration are ranked higher than Alterative 4 with granular media filters.Ozone is a best available technology for destroying Geosmin and algal toxins and is judged to be slightly superior to GAC for this initial analysis. For this reason, alternatives including ozone (3 and 4) are ranked higher than alternatives without (1 and 2). On the basis of treatment performance, the alternatives are ranked as follows:

Table 11.5: Treatment Performance Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Treatment Performance	10%	2	2	1	3

Alternative 3 had the best (lowest) score because it used the best filtration process (membranes) combined with ozone/biofiltration for the best Geosmin and algal toxin removal. In addition, the finished water would be expected to have the lowest chlorine demand and most stable chlorine residuals, which would then mean less chlorine use and lower DBP formation.

Conversely, Alternative 4 was qualitatively selected to have the lowest treatment performance, principally because of the lack of membrane filtration results in relatively more turbid water (though still fully compliant with all regulatory requirements and equal to the current plant performance). In addition, the system is not as capable as membrane filtration in removing *Cryptosporidium*. The use of ozone provides no benefit for this pathogen as its ability to destroy *Cryptosporidium* oocysts is greatly hindered in wintertime water temperatures.

Alternatives 1 and 2 were assigned the intermediate scores, It should be noted that Alternative 2 may be better because the UV process provides additional *Cryptosporidium* treatment even though it was not required, and requires a lower CxT that should result in lower potential DBP concentrations.

11.5 Automation

Automation is important to the City to prevent an excessive amount of labor to operate and maintain the new WTP. City staff have worked diligently to automate their existing WTP. With the new plant, there may be a prolonged period when the City is operating two water treatment plants. For this reason, having an automated new facility would benefit the City.

Options with membrane filtration are ranked higher than options with granular media filtration. Although automated, it is anticipated that ozone will require more operator attention than GAC, UV or CL2. For this reason, options with ozone are ranked lower on the basis of automation. Rankings based on automation are:

Table 11.6: Automation Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Automation	10%	1	1	2	2

11.6 Maximizing Capacity

The City's goal is to maximize capacity for the available budget while meeting treatment goals. Therefore, systems that are modular are preferred. It is also preferred that adjustments on the number of treatment units can be made efficiently while proceeding into construction in the event of favorable bids. MF, GAC, and UV are all considered modular and are preferred for maximizing capacity within the fixed budget. Concrete basin granular media filters, chlorine / ozone contact chambers are judged to be less modular and more difficult to phase. On the basis of maximizing capacity, the alternatives are ranked as follows:

Table 11.7: Maximum Capacity Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Maximing Capacity	10%	3	1	2	3

11.7 Compact Footprint

Some of the sites that were under consideration by the City were steeply sloped. Therefore, a compact footprint was desired to minimize earthwork and rock excavation. A compact footprint will still be valuable at the Granite Low site in helping to control capital costs of the project and obtaining more treatment capacity for the City within the given budget. Primary disinfection with chlorine requires the largest footprint and options with CL2 as their primary disinfectant (excluding chlorine residual for distribution maintenance) are ranked the worst. Membrane filtration is anticipated to have a more compact footprint than clarification / granular media filters. On the basis of compact footprint, the alternatives are ranked as follows:

Table 11.8: Compact Footprint Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Compact Footprint	10%	2	1	1	3

11.8 Ease of Expansion

The City may be in a position to need to expand the new plant relatively soon, so ease of expansion will be a benefit to the City. Alternatives that can be installed with little to no interference to existing operations, minimal changes to already built structures, and be implemented quickly are preferred to those processes that have significant plant disruptions, would cause newly built structures to be reworked, and takes considerable amounts of time. As a result, alternatives with the MF system would score lower than granular media filters. GAC and UV systems can be installed quickly with minor disruptions but more equipment means more disruptions and longer implementation times. The ozone system is considered to be readily expandable as the major intensive construction, the ozone contactor, was assumed to be already built-out to 10 MGD per the initial capital cost criteria.

Table 11.9: Ease of Expansion Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Ease of Expansion	10%	3	1	2	3

11.9 Sustainability

All of the options considered are judged to be relatively similar with respect to sustainability. The membrane filtration options are pressurized and are anticipated to save about 650,000 kilowatt hours (kWh) per year in energy consumption. GAC has low energy costs but requires a significant amount of coal mining, transport, and must be burned in a furnace (by the supplier) for regeneration. Ozone has significant energy costs (420,000 kWh/year) and also requires the production and delivery of liquid oxygen (by the supplier). UV requires only about 20% of the energy used by ozone, but it relies on lamps filled with mercury that require recycling / disposal. All of the options have benefits and drawbacks related to sustainability and are ranked as follows:

Table 11.10: Sustainability Alternative Rating

Criteria	Weight	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Sustainability	10%	2	2	2	2

11.10 Summary

The alternative, their individual scoring, and their final weighted score are summarized in Table 11.3 and shown graphically in Figure 11.4. Given the methodology used, an “ideal” alternative with zero costs, perfect performance, complete automation, and no environmental impacts would be given a total weighted score of 1.0 while the the “worst” alternative with infinite costs and still not provide regulatory-compliant drinking water would be assigned a total weighted score of 4.0.

Overall, Alternative 2: MF-GAC-UV-CL2 is ranked lowest (best) by a fairly wide margin. Alternative 2 has the lowest initial project cost, maximizes the plant capacity, and has the most compact footprint. In addition, it was ranked second best with regards to treatment performance, automation, and ease in expansion. The one area where it performed poorly was lifecycle cost where it was tied with Alternative 1. The high lifecycle O&M cost was due to the assumed replacement cycle for the GAC. This cost should be evaluated and reconsidered with pilot testing and as the design advances.

Table 11.11: Alternative Scores

Criteria	Weighting (%)	Alternative 1: MF-GAC-CL2	Alternative 2: MF-GAC-UV-CL2	Alternative 3: MF-OZ-BF-CL2	Alternative 4: CL-OZ-BF-CL2
Initial project cost	20%	2	1	3	4
Lifecycle O&M costs	20%	2	1	3	4
Treatment performance	10%	2	2	1	3
Automation	10%	1	1	2	2
Maximizing capacity	10%	3	1	2	3
Compact footprint	10%	2	1	1	3
Ease of expansion	10%	3	1	2	3
Sustainability	10%	2	2	2	2
Weighted Score	-	2.1	1.2	2.2	3.2

Figure 11.4 presents the scoring of the alternatives in a reverse weighted format for easier understanding. By doing this the top ranked alternative is the tallest bar and the lowest is the shortest bar.

Figure 11.4: Reverse Weighted Scoring of Treatment Alternatives

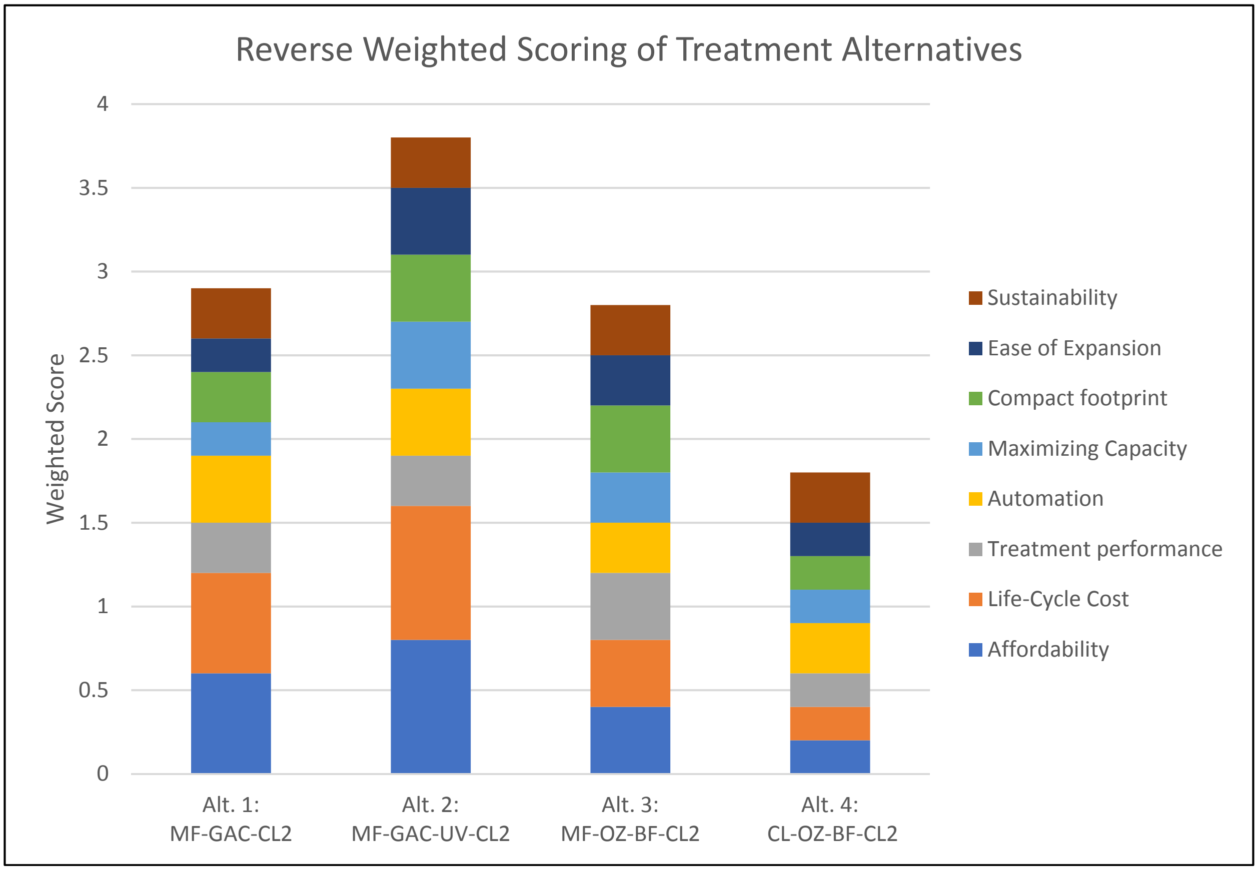


Figure 11.5: Alternative 1 Opinion of Cost

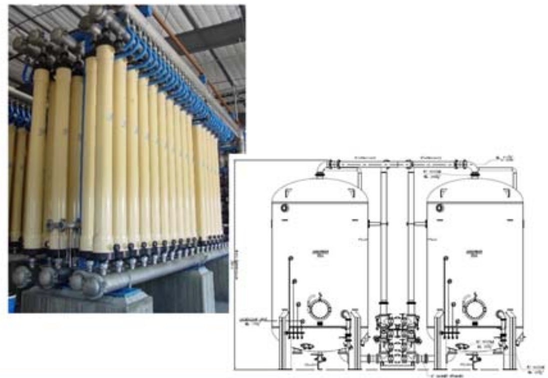
City of Ashland, OR
10MGD Membrane Water Treatment Plant

Project Identifier: Alt. 1 - Membrane + GAC + Cl2

Objective: New 10 MGD Treatment

Potential Issues:

:Project Location
Granite Low Location



General Line Items	Unit	Unit Price	Estimated Quantity	Cost (2017 dollars)
Treatment				
Raw Water Chemical Feed				
Carbon Dioxide (CO2)				
Aluminum Chlorohydrate (ACH)	LS	$ 23,000	1	$ 23,000
Mixing Pump	LS	$ 45,000	1	$ 45,000
Membrane Filtration	LS	$ 3,505,000	1	$ 3,505,000
5X2 MGD Membrane units (10MGD capacity)				
4 Feed Strainers				
2 Reveerse Filtratin Pumps				
Air System (2 compressors, 1 reciever)				
MCP				
System Commissioning/Training				
Waste Neutralization System				
Computers and Programming	LS	$ 75,000	1	$ 75,000
GAC Beds	LS	$ 2,102,962	1	$ 2,103,000
Concrete Pad	CY	$ 300	114	$ 34,000
Booster Pump Station	LS	$ 723,000	1	$ 723,000
Finished Water Chemical Feed				
Sodium Hypochlorite (SHC)	LS	$ 23,000	1	$ 23,000
Sodium Hydroxide (SH)	LS	$ 15,000	1	$ 15,000
Mixing Pump	LS	$ 20,000	1	$ 20,000
Chlorine Contact Basin	GAL	$ 2	700000	$ 1,400,000
Waste Handling	LS	$ 20,000	1	$ 20,000
Building	SF	$ 300	10000	$ 3,000,000
Office/Operations				
Treatment and Pumping Area				
Chemical Feed				
Carbon Dioxide - outside				
Aluminum Chlorohydrate				
Sodium Hypochlorite				
Sodium Hydroxide				
Site Work & Yard Piping	LS	$ 100,000	1	$ 100,000
Emergency Power, diesel with weather enclosure and silencer	EA	$ 150,000	1	$ 150,000
Subtotal				***$ 11,236,000***
Electrical Construction, 7.5%	LS			$ 843,000
Subtotal				***$ 12,079,000***
Mobilization, O&P - Percent of Item Cost Sum		21.5%		$ 2,596,985
Contingency - % of construction costs		35%		$ 5,136,595
Total Construction Costs				***$ 19,812,580***
Engineering and CMS - % of construction costs		23%		$ 4,556,893
Total Project Cost (rounded)		***$24,370,000***		
2019 Project Cost, i=3%, N=2.5		***$26,240,000***		

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our opinion of probable costs at this time and is subject to change as the project design matures. Keller Associates has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding or market conditions, practices or bidding strategies. Keller Associates cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the cost presented .herein

Figure 11.6: Alternative 2 Opinion of Cost

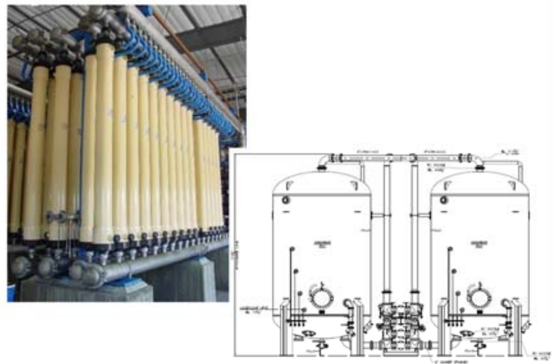
City of Ashland, OR
10MGD Membrane Water Treatment Plant

Project Identifier: Alt. 2 - Membrane + GAC + UV

Objective: New 10 MGD Treatment

Potential Issues:

Project Location:
Granite Low Location



General Line Items	Unit	Unit Price	Estimated Quantity	Cost (2017 dollars)
Treatment				
Raw Water Chemical Feed				
Carbon Dioxide (CO2)				
Aluminum Chlorohydrate (ACH)	LS	$ 23,000	1	$ 23,000
Mixing Pump	LS	$ 45,000	1	$ 45,000
Membrane Filtration	LS	$ 3,505,000	1	$ 3,505,000
5X2 MGD Membrane units (10MGD capacity)				
4 Feed Strainers				
2 Reveerse Filtratin Pumps				
Air System (2 compressors, 1 reciever)				
MCP				
System Commissioning/Training				
Waste Neutralization System				
Computers and Programming	LS	$ 75,000	1	$ 75,000
GAC Beds	LS	$ 2,102,962	1	$ 2,103,000
Concrete Pad	CY	$ 300	114	$ 34,000
Booster Pump Station	LS	$ 723,000	1	$ 723,000
Finished Water Chemical Feed				
Sodium Hypochlorite (SHC)	LS	$ 23,000	1	$ 23,000
Sodium Hydroxide (SH)	LS	$ 15,000	1	$ 15,000
Mixing Pump	LS	$ 20,000	1	$ 20,000
UV (pressurized)	LS	$ 546,377	1	$ 547,000
Waste Handling	LS	$ 20,000	1	$ 20,000
Building	SF	$ 300	10200	$ 3,060,000
Office/Operations				
Treatment and Pumping Area				
Chemical Feed				
Carbon Dioxide - outside				
Aluminum Chlorohydrate				
Sodium Hypochlorite				
Sodium Hydroxide				
UV				
Site Work & Yard Piping	LS	$ 100,000	1	$ 100,000
Emergency Power, diesel with weather enclosure and silencer	EA	$ 150,000	1.0	$ 150,000
Subtotal				***$ 10,443,000***
Electrical Construction, 7.5%	LS			$ 783,000
Subtotal				***$ 11,226,000***
Mobilization, O&P - Percent of Item Cost Sum		21.5%		$ 2,413,590
Contingency - % of construction costs		35%		$ 4,773,857
Total Construction Costs				***$ 18,413,447***
Engineering and CMS - % of construction costs		23%		$ 4,235,093
Total Project Cost (rounded)			***$22,649,000***	
2019 Project Cost, i=3%, N=2.5			***$24,390,000***	

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our opinion of probable costs at this time and is subject to change as the project design matures. Keller Associates has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding or market conditions, practices or bidding strategies. Keller Associates cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the cost presented herein.

Figure 11.7: Alternative 3 Opinion of Cost

City of Ashland, OR
10MGD Membrane Water Treatment Plant

Project Identifier: Alt. 3 - Membrane + O3/Biofilter

Objective: New 10 MGD Treatment

Potential Issues:

Project Location:
Granite Low Location

General Line Items	Unit	Unit Price	Estimated Quantity	Cost (2017 dollars)
Treatment				
Raw Water Chemical Feed				
Carbon Dioxide (CO2)				
Aluminum Chlorohydrate (ACH)	LS	$ 23,000	1	$ 23,000
Mixing Pump	LS	$ 45,000	1	$ 45,000
Membrane Filtration	LS	$ 3,505,000	1	$ 3,505,000
5X2 MGD Membrane units (10MGD capacity)				
4 Feed Strainers				
2 Reveerse Filtratin Pumps				
Air System (2 compressors, 1 reciever)				
MCP				
System Commissioning/Training				
Waste Neutralization System				
Computers and Programming	LS	$ 75,000	1	$ 75,000
Ozone and GAC Biofilter w LOX feed	LS	$ 4,845,650	1	$ 4,846,000
Concrete Pad	CY	$ 300	131	$ 39,000
Booster Pump Station	LS	$ 723,000	1	$ 723,000
Finished Water Chemical Feed				
Sodium Hypochlorite (SHC)	LS	$ 23,000	1	$ 23,000
Sodium Hydroxide (SH)	LS	$ 15,000	1	$ 15,000
Mixing Pump	LS	$ 20,000	1	$ 20,000
Waste Handling	LS	$ 20,000	1	$ 20,000
Building	SF	$ 300	10000	$ 3,000,000
Office/Operations				
Treatment and Pumping Area				
Chemical Feed				
Carbon Dioxide - outside				
Aluminum Chlorohydrate				
Liquid Oxygen - outside				
Sodium Hypochlorite				
Sodium Hydroxide				
Site Work & Yard Piping	LS	$ 100,000	1	$ 100,000
Emergency Power, diesel with weather enclosure and silencer	EA	$ 150,000	1	$ 150,000
Subtotal				***$ 12,584,000***
Electrical Construction, 7.5%	LS			$ 944,000
Subtotal				***$ 13,528,000***
Mobilization, O&P - Percent of Item Cost Sum		21.5%		$ 2,908,520
Contingency - % of construction costs		35%		$ 5,752,782
Total Construction Costs				***$ 22,189,302***
Engineering and CMS - % of construction costs		23%		$ 5,103,539
Total Project Cost (rounded)		***$27,293,000***		
2019 Project Cost, i=3%, N=2.5		***$29,390,000***		

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our opinion of probable costs at this time and is subject to change as the project design matures. Keller Associates has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding or market conditions, practices or bidding strategies. Keller Associates cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the cost presented herein.

Figure 11.8: Alternative 4 Opinion of Cost

City of Ashland, OR
10MGD Conventional Treatment Plant

Project Identifier: Alt. 4 - Dissolved Air Flotation/ Filtration

Objective: New 10 MGD Treatment

Potential Issues:

Project Location:
Granite Low Location

General Line Items	Unit	Unit Price	Estimated Quantity	Cost (2017 dollars)
Treatment				
Raw Water Chemical Feed				
Carbon Dioxide (CO2)				
Aluminum Chlorohydrate (ACH)	LS	$ 23,000	1	$ 23,000
Mixing Pump	LS	$ 45,000	1	$ 45,000
DAF - Leopold	LS	$ 1,527,500	1	$ 1,527,500
Basins Concrete	LS	$ 396,000	1	$ 396,000
Basins Excavation	LS	$ 80,000	1	$ 80,000
Ozone w LOX feed	LS	$ 2,542,688	1	$ 2,543,000
Dual Media Filtration (anthracite over sand) - Equipment	LS	$ 1,200,000	1	$ 1,200,000
Basins Concrete	EA	$ 47,250	6	$ 283,500
Basins Excavation	EA	$ 10,000	6	$ 60,000
Blowers/Compressors	LS	$ 100,000	1	$ 100,000
Computers and Programming	LS	$ 75,000	1	$ 75,000
Finished Water Chemical Feed				
Sodium Hypochlorite (SHC)	LS	$ 23,000	1	$ 23,000
Sodium Hydroxide (SH)	LS	$ 15,000	1	$ 15,000
Mixing Pump	LS	$ 20,000	1	$ 20,000
Clearwell / Chlorine Contact Basin	GAL	$ 2	700000	$ 1,400,000
Booster Pump Station	LS	$ 938,000	1	$ 938,000
Building	SF	$ 300	13000	$ 3,900,000
Office/Operations				
Treatment and Pumping Area				
Clarification Area = 5,000 ft2				
Filter Area = 4,000 ft2				
Chemical Feed				
Carbon Dioxide - outside				
Aluminum Chlorohydrate				
Sodium Hypochlorite				
Sodium Hydroxide				
Site Work & Yard Piping	LS	$ 100,000	1	$ 100,000
Emergency Power, diesel with weather enclosure and silencer	EA	$ 450,000	1	$ 450,000
Subtotal				***$ 13,156,000***
Electrical Construction, 7.5%	LS			$ 987,000
Subtotal				***$ 14,143,000***
Mobilization, O&P - Percent of Item Cost Sum		21.5%		$ 3,040,745
Contingency - % of construction costs		35%		$ 6,014,311
Total Construction Costs				***$ 23,198,056***
Engineering and CMS - % of construction costs		23%		$ 5,335,552.82
Total Project Cost (rounded)		***$28,534,000***		
2019 Project Cost, i=3%, N=2.5		***$30,720,000***		

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our opinion of probable costs at this time and is subject to change as the project design matures. Keller Associates has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding or market conditions, practices or bidding strategies. Keller Associates cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the cost presented herein.

SECTION 12 – CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions made throughout this report. It then provides recommendations based on the information and conclusions presented.

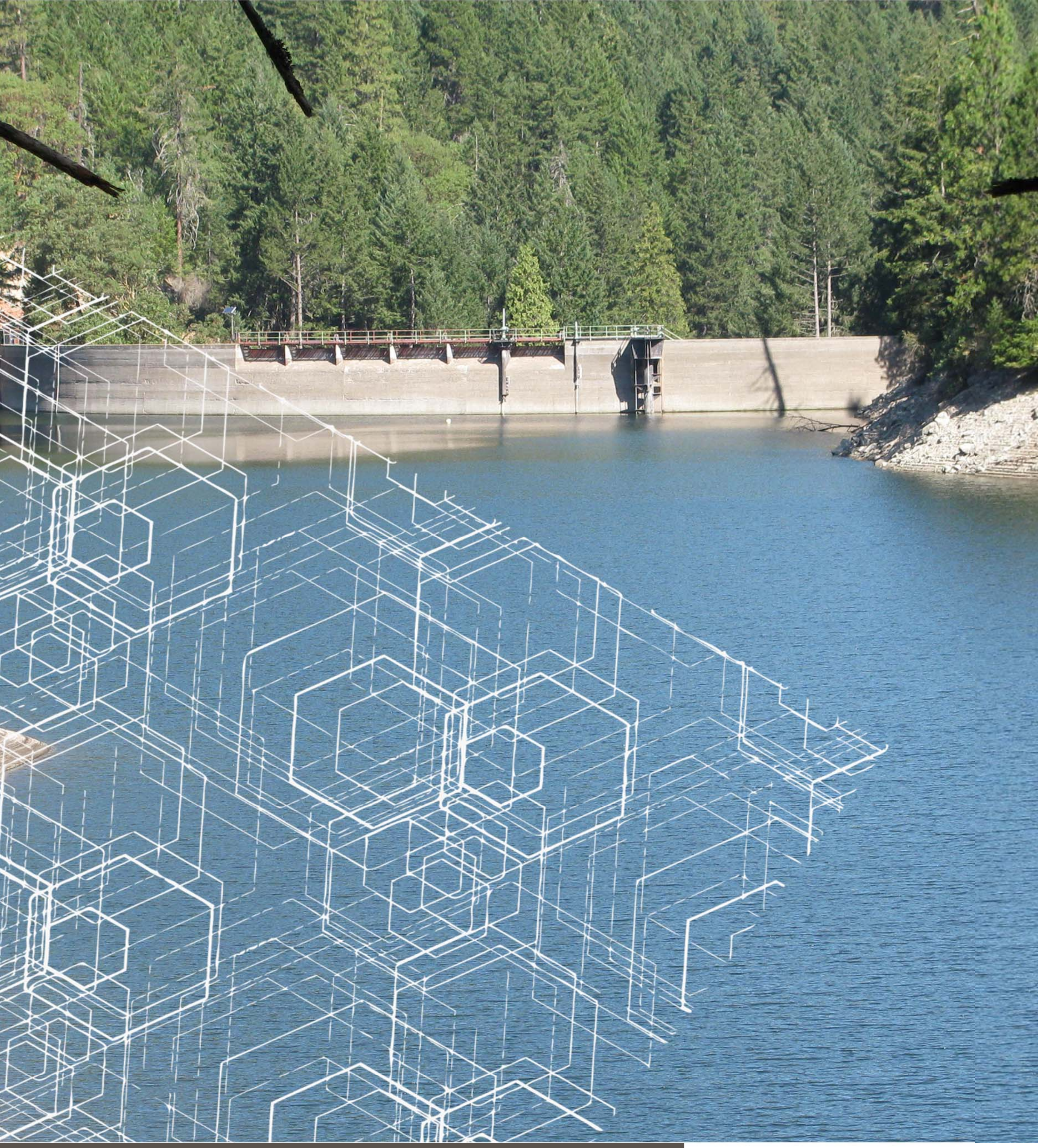
12.1 Conclusions

1. There is cyanobacteria (blue-green algae) present in the Reeder Reservoir raw water supply during late summer. Problems associated with cyanobacteria include the development of seasonal taste and odor issues in most years and the potential formation of algal toxins.
2. Reeder Reservoir stratifies heavily in late summer causing anoxic conditions to develop in the hypolimnion. There is a relative lack of data for what occurs in Reeder Reservoir but sampling at many other lakes in Oregon and throughout the US find that such conditions can release phosphorus, iron, and manganese from the sediments into the water.
3. The quality of the TID raw water supply is currently not well characterized but a sampling program has been initiated to address this data gap.
4. The siting study recommended the Granite Low site and raw water connection to the tailrace through the existing TID pipeline.
5. Due to the early stage of the project, there is a substantial amount of uncertainty in the opinions of probable construction cost, particularly with site development.
6. Option 2: MF-GAC-UV has the lowest initial cost, the lowest 20-year life-cycle cost, and is the preferred option on the basis of the eight criteria used in this evaluation.
7. Ozone may provide improved water quality and operational benefits, but does not appear to be affordable currently based on the City's budget. Omission of it now does not negatively affect future water quality relative to the current water quality produced by the existing plant.
8. Depending on the membrane filter that is selected, there may be an opportunity to replace GAC with PAC (powdered activated carbon) to obtain more capacity within the fixed budget.

12.2 Recommendations

1. Continue to use the variable level intake to avoid the greatest densities of cyanobacteria.
2. Implement membrane filtration for the new plant.
3. Continue efforts to characterize TID raw water supply and use the information for the next stage of project development.
4. Perform focused geotechnical investigation to better understand site development and costs.
5. Provide treatment for the known issues of:
    a. Color
    b. Turbidity
    c. Taste-and-odor (Geosmin)

   d. Primary disinfection for *Cryptosporidium*, *Giardia*, and viruses
   e. Secondary disinfection in the distribution system.
   f. Distribution system corrosion control
6. Provide additional treatment for the potential issues of:
   a. Iron and manganese
   b. Algal toxin occurrence
   c. Disinfection byproducts
7. Move forward with preliminary design and permitting of the recommended project:
   a. Locate the plant at the Granite Low site.
   b. Supply the new plant with raw water from the powerhouse tailrace through the existing TID pipeline.
   c. Proceed with treatment Alternative 2: membrane filtration followed by GAC, ultraviolet disinfection, and chlorination (MF-GAC-UV-CL2).
   d. Keep ozone in the plant design. As cost certainty improves, it may be possible to install ozone initially or to install ozone in a future project expansion / upgrade.
8. Move forward with pilot-testing of membrane filter suppliers.



Appendix A
Water Quality Summary and Review

Get there!
KELLER associates

Technical Memorandum

Date:	Friday, April 21, 2017
Project:	Ashland Water Treatment Plant
To:	James Bledsoe, Bryan Black – Keller Associates
From:	Kelsey Harpham, Pierre Kwan
Subject:	Water Quality Data Summary and Review

Introduction

The City of Ashland, Oregon (City) has retained Keller/HDR to investigate the replacement of the City's existing Ashland Water Treatment Plant (WTP) with a new facility. This memorandum documents the City's available historical data for the raw water qualities and finished water qualities. The purpose of this memorandum is to identify potential water quality parameters that could affect the subsequent treatment process evaluation and selection for the new WTP.

Water Supply Description

The WTP is primarily supplied surface water from Ashland Creek that flows through and is stored in Reeder Reservoir prior to entering the WTP. The City also purchases water from the Talent Irrigation District (TID) to provide additional supply. The TID supply is used during periods when the Reeder Reservoir supply is low, which is typically during summer. When needed, TID water is pumped out of the Ashland Canal to the WTP, where it blends with the Reeder Reservoir supply prior to entering the WTP. See Figure 1 for the annual water supply by source to the City.

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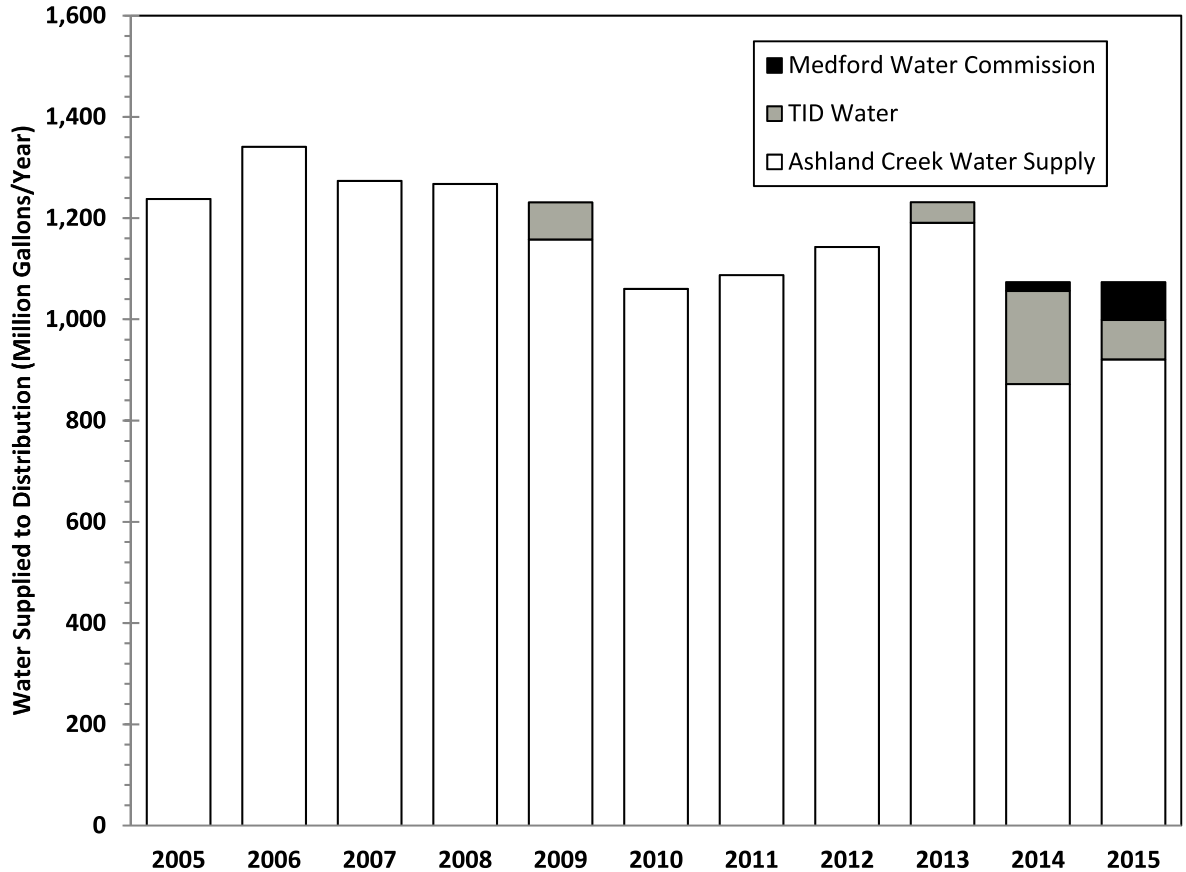

Figure 1. Annual Water Volume Supplied to City Distribution System

The years 2014 and 2015 were droughts and the City's water supply was supplemented with both TID water and MWC water. The MWC line was first operational in 2014 and thus it was not a source in previous years. Prior to 2014, the years of 2001, 2009 and 2013 were also considered drought years, and the City had to purchase TID water to supplement the Reeder Reservoir supply.

Reeder Reservoir water quality was evaluated in 2007 as described in a report entitled, "Reeder Reservoir (Ashland Oregon) Water Quality and Sediment Assessment". The report shows significant thermal stratification occurring during summer months. The thermocline appears to develop about 30-feet below the water surface. The stratification dramatically impacts water quality. Dissolved oxygen was completely depleted in the hypolimnion (lower reservoir). This is problematic because under these reducing conditions, contaminants dissolve from the sediments into the water. Contaminants that behave in this way typically include iron, manganese, and phosphorus. Currently, the reservoir outlet (WTP intake) is configured to accept reservoir water from about 30-feet deep below the full water surface.

For this memorandum, the raw water quality analysis generally focuses on samples collected from the plant, which is after the point where Ashland Creek/Reeder Reservoir and TID water are blended together. Since the TID water usage varies month-by-month and year-to-year, there was no way to distinguish the water quality results of Ashland Creek/Reeder Reservoir versus TID within this data. However, the water supply for most months is only from Reeder Reservoir, while the summer months may consist of a Reeder Reservoir / TID blend.

The City is also supplied potable water by the Medford Water Commission (MWC) and conveyed to the City through the Talent-Ashland Pipeline (TAP). The TAP discharges the MWC potable water directly into the City distribution system. This memorandum does not cover the MWC potable water since the existing WTP does not affect the MWC potable water quality. A study of any impacts of MWC potable water blending with current and future City potable water in the distribution system may be conducted in a subsequent phase of this project.

Ashland Creek/Reeder Reservoir Water Quality

The data presented in this section were provided by the City or found on the Oregon Health Authority's Public Drinking Water System webpage. The data evaluated include:

- Turbidity
- Total Organic Carbon (TOC)
- pH
- Alkalinity
- Hardness
- Iron and Manganese
- Temperature
- Pathogens (*Cryptosporidium* and *Giardia*)
- Cyanotoxins
- Inorganic compounds (IOCs)
- Volatile and synthetic organic compounds (VOCs and SOCs)
- Algae and cyanotoxins
- Taste-and-odor (T&O) compounds (2-methylisoborneol [MIB] and Geosmin)
- Color

Turbidity

Turbidity tracking and removal is a required parameter for surface water treatment, as waters with higher levels of turbidity have been positively correlated with having greater levels of pathogenic organisms that could induce water-borne illnesses if consumed. Additionally, higher turbidity levels results in increased headloss in filtration systems as filters clog from these materials being removed. Figure 2 shows the average monthly raw turbidity values recorded at the WTP from 2004 to 2016. Overall turbidity results are relatively very low for surface water supplies. Such results are expected as any variable turbidities in Ashland Creek are both attenuated when the water is discharged into Reeder Reservoir and settle out as the creek water spends several days to weeks in storage prior to withdrawal to the WTP. Most months' average turbidity levels are below 1 NTU, with some spikes occurring early in the year (January-February) and in the late summer (July-September).

Higher levels of turbidity were detected in the late summer months of 2014 and 2015, which was also the time of higher levels of alkalinity and hardness. The data from 2014 and 2015 differs from other years as 2014 was considered a very severe drought year and 2015 was the worst drought ever experienced by the City. As a result, storage within Reeder Reservoir was quite low, which means less storage and settling, compared to other years.

The average monthly turbidity provides a good description of long-term turbidity trends but misses the potential short-term turbidity increases associated with storms. Figure 3 displays the maximum daily turbidity for each day of 2016. Whereas the January 2016 average monthly turbidity is 2.9 NTU, the daily data shows that the month consisted of half a month of 1 – 2 NTU and the storm-induced peak of 7.1 NTU on January 18, 2016. Turbidity remains very low (<1 NTU) throughout the drier summer months of May-October, and then spikes again with storm events in late October.

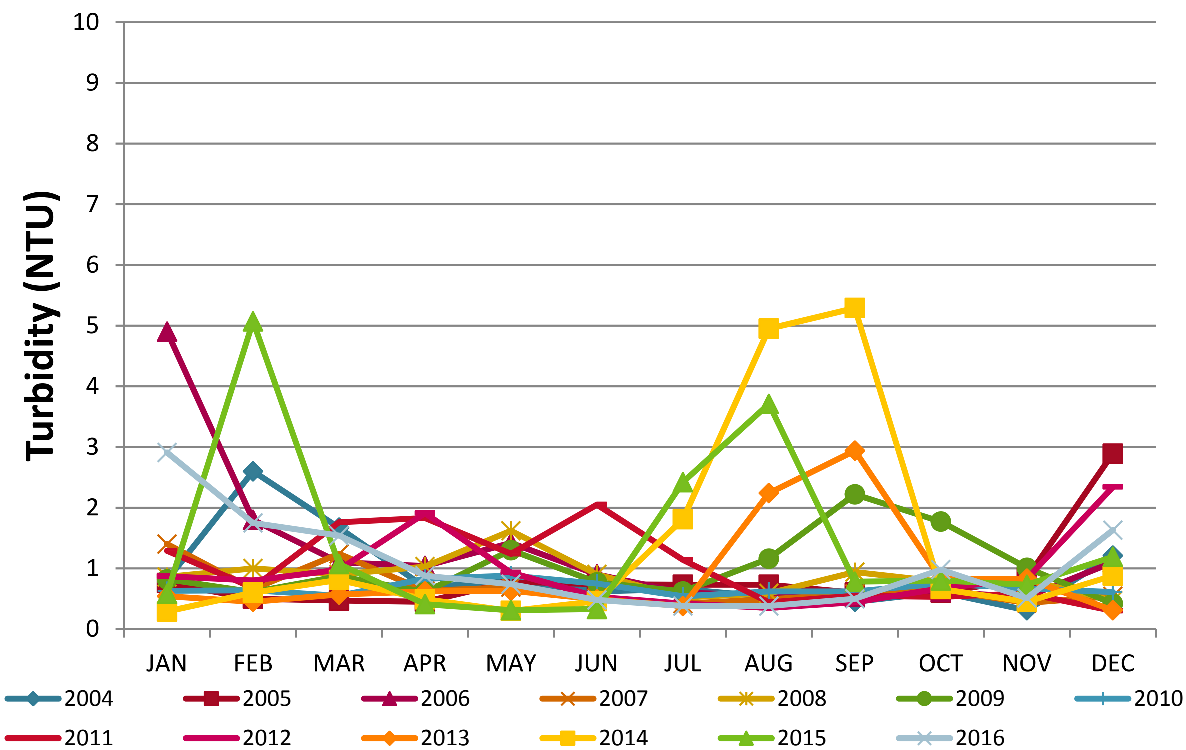

Figure 2: Average Monthly Turbidity Recorded at WTP Entry

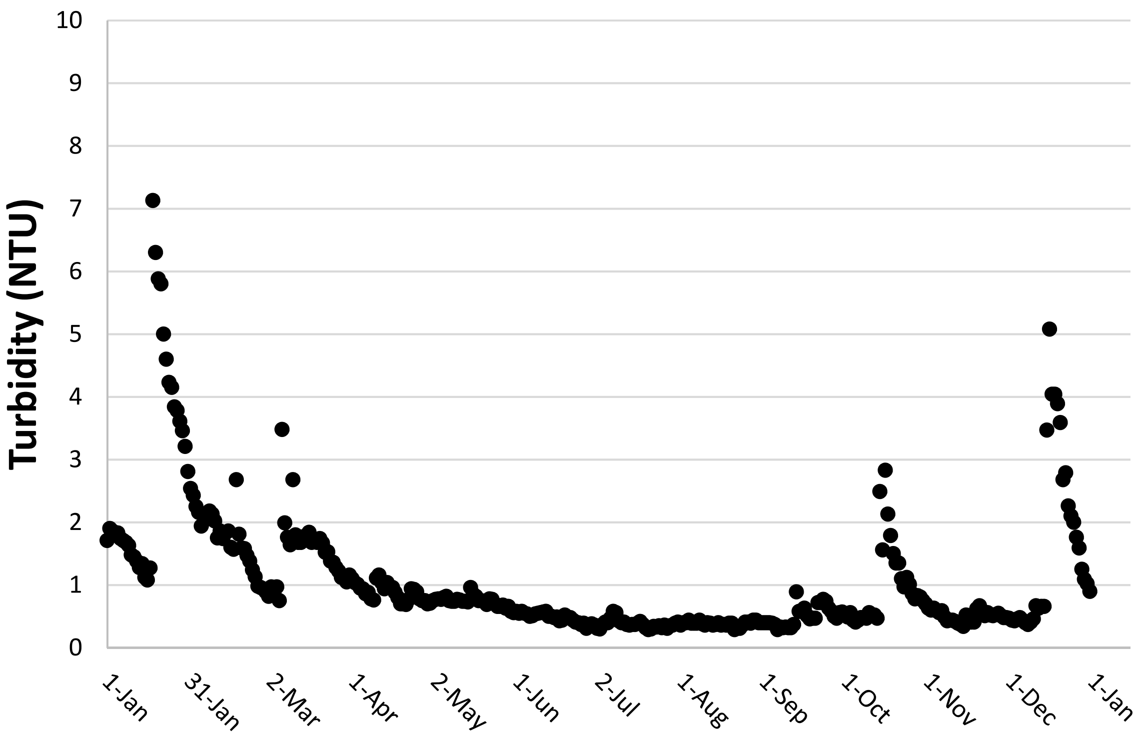

Figure 3: 2016 Maximum Daily Turbidity Recorded at WTP Entry

Total Organic Carbon (TOC)

TOC is a key precursor of the formation of disinfection byproducts (DBPs) that are regulated under the Federal Stage 2 Disinfection/Disinfection Byproducts Rule so removing TOC will reduce the DBP formation potential of the water. In addition, TOC removal also helps with minimizing the water's chlorine demand, improving chlorine maintenance in the distribution system, and reducing the potential for biofilm growth in the distribution system. For filtration systems, TOC is also a key parameter for having sand filters become biologically active and for organic fouling in membrane systems.

TOC samples are taken from raw water as it enters the WTP. Monthly values are reported from December 2010 to March 2017 and plotted in Figure 4. Three additional samples are also reported in 2004, and these values are within the range of the more recent data reported. Raw water TOC at the WTP ranges from 1.29 mg/L to 10.8 mg/L, with an average of 2.9 mg/L. TOC levels trend higher in winter months (November-March), and higher in summer months (July-September). April demonstrates the highest average level of TOC, however 2016 had some anomaly high values in January and February, while 2012 had the highest recorded TOC value of 10.8 mg/L in December. The City staff suspect that that this very high value is associated with a grab sample was collected at the same time as a large storm was stirring the water up in Reeder Reservoir.

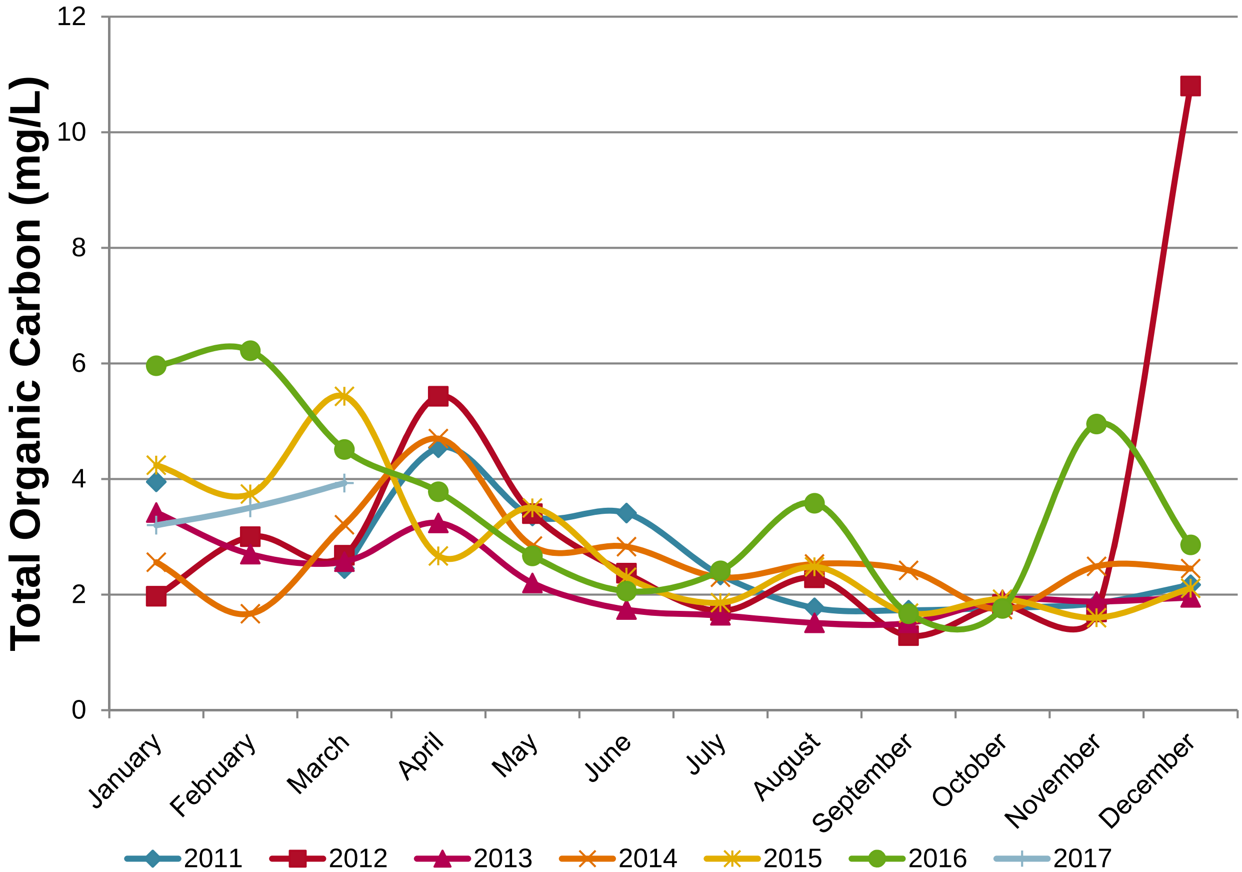

Figure 4: Monthly Grab Samples of Total Organic Carbon at WTP Entry

pH

pH is a water quality parameter that impacts coagulation and disinfection efficiency, as well as other chemical reactions. Finished water pH is important for the City to manage compliance with the Lead and Copper Rule. The monthly average pH of the Ashland raw water ranges from 6.8 to 7.9 as it enters the water treatment plant, with an overall average of approximately pH 7.3 – 7.5 for the entire year (see Figure 5). Such a range is fairly typical for Oregon surface waters and does not pose a challenge to a treatment process selection.

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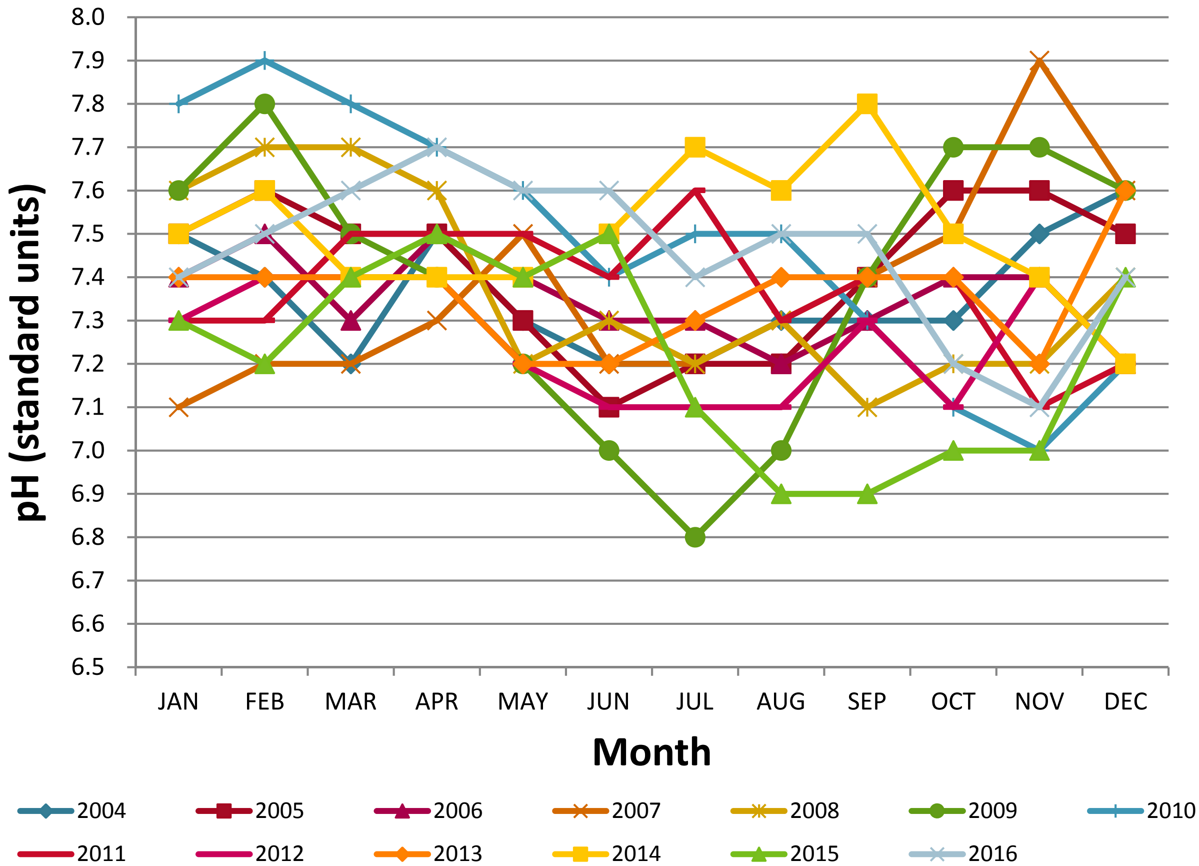

Figure 5. Monthly Average pH Recorded at WTP Entry

Alkalinity and Hardness

Alkalinity and hardness are water quality parameters that affect several key treatment and water quality processes. Alkalinity is a key factor for chemical coagulation and maintaining a stable pH in the distribution system while hardness is associated potential precipitation and scaling issues in distribution piping and customer plumbing, taste complaints, and the effectiveness of soap and detergent usage by businesses and individuals.

Alkalinity and hardness measurements were obtained monthly. From 2004 to 2016, monthly average alkalinity ranges from 22 mg/L to 61 mg/L as $CaCO_3$, and hardness ranges from 13 mg/L to 38 mg/L as $CaCO_3$. Figure 6 and Figure 7 show the average monthly values of alkalinity and hardness in the raw water entering the WTP.

The monthly average alkalinity and hardness values in 2014 and 2015 show results in the late summer months (June-September) that were consistently higher than other years recorded. As noted earlier in the pH section, this difference is likely related to the fact that 2014 and 2015 were drought years, and thus snowpack feeding the reservoir was extremely low. In years prior to 2014, snowmelt, which is free of most minerals, dilutes the alkalinity and hardness present in Ashland Creek, resulting in the observed decrease in Alkalinity and Hardness from May through August, when snowmelt runoff is most prevalent. Considerations for future reduced snowpack and drought-related water quality impacts need to be included in the treatment process selection.

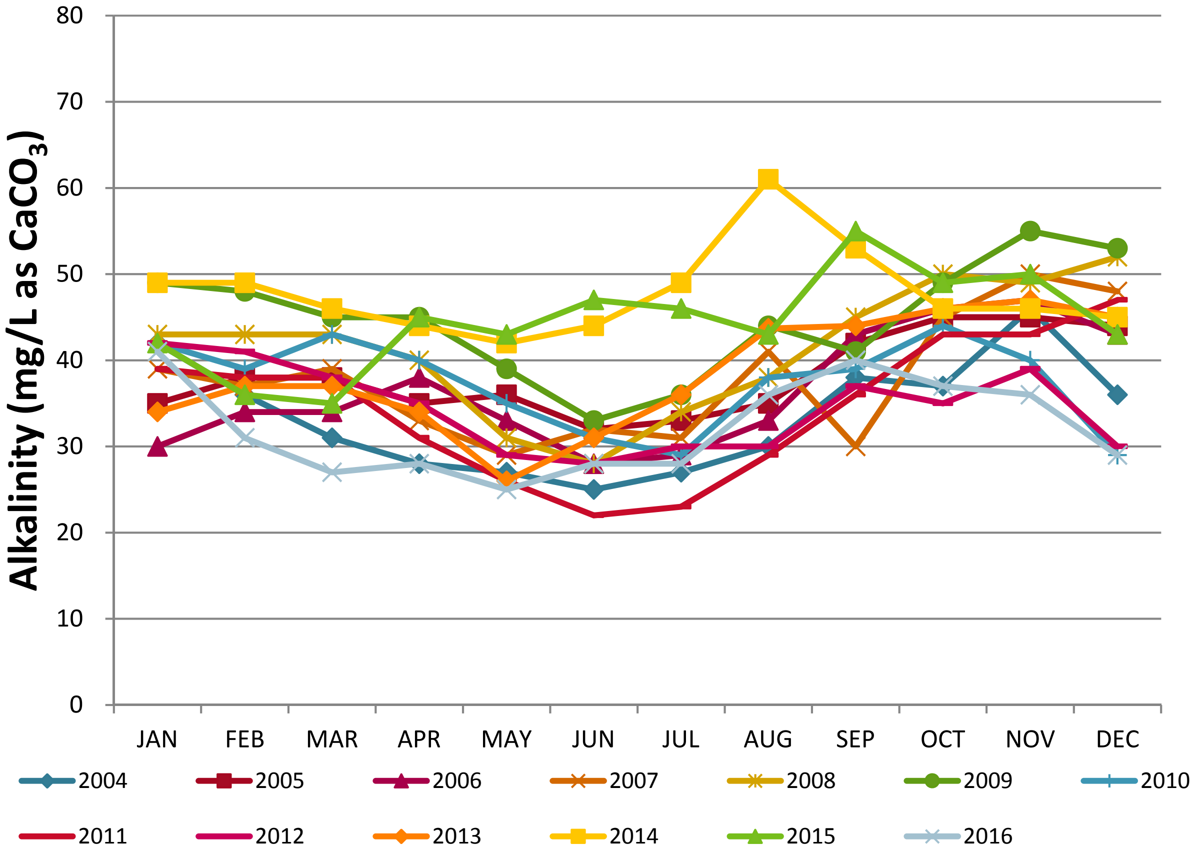

Figure 6: Monthly Average Alkalinity Recorded at WTP Entry

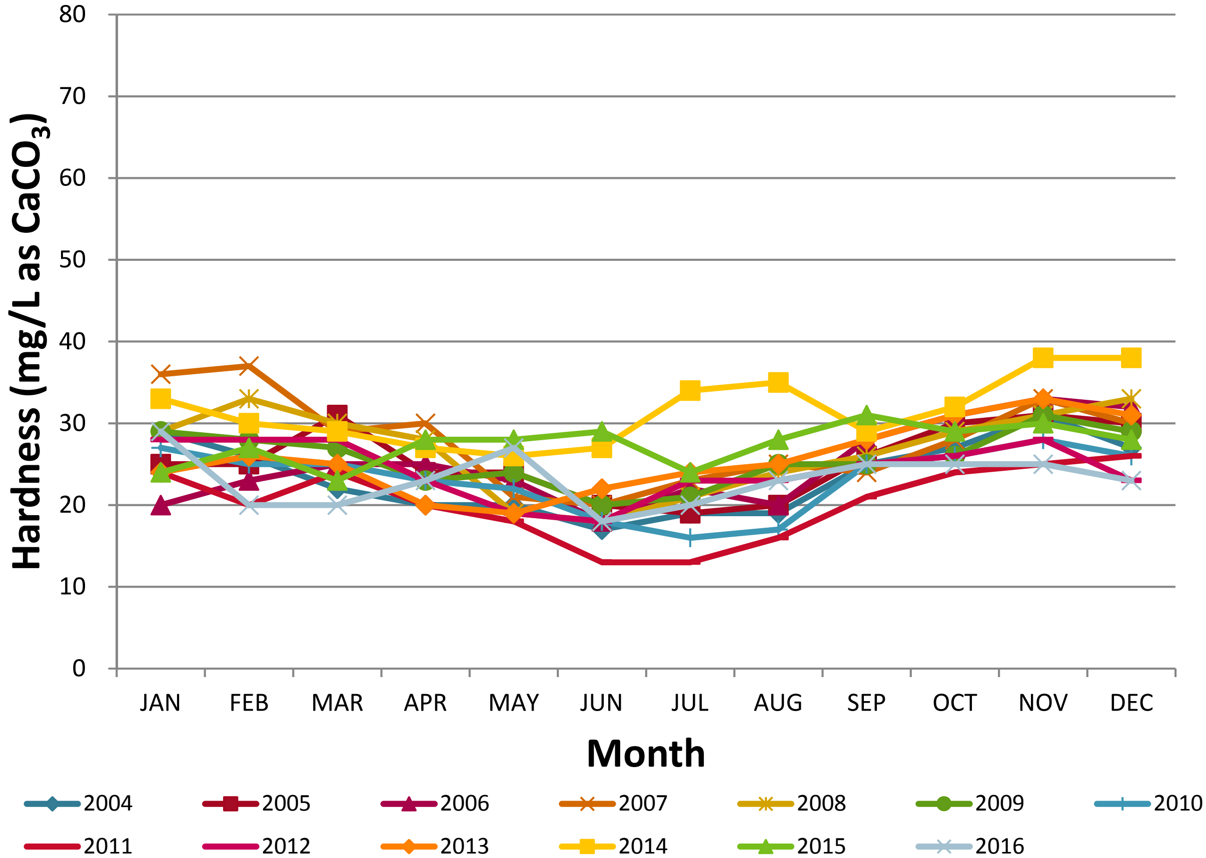

Figure 7: Monthly Average Hardness Recorded at WTP Entry

Iron and Manganese

Iron and manganese have not been found in notable quantities in raw water samples at the WTP. In 2012, testing demonstrated that both iron and manganese was not present in detectable levels. Previous testing from 1988, 1990 and 1999 did have positive samples for both elements, with the highest values reported in 1988 at 0.74 mg/L for iron and 0.07 mg/L for manganese.

Conversations with the WTP and water quality staff indicate that this historical data is not indicative of current water quality conditions. Iron and manganese are not issues with the raw water. A grab sample of the raw water found non-detectable concentrations of iron (<0.015 mg/L) and manganese (<0.005 mg/L).

Temperature

Water temperature is important as it has a direct impact on coagulation, filtration, and disinfection processes. Figure 8 shows the average temperature of raw water entering the WTP by month. Temperature ranges from 3 °C (37 °F) to 20 °C (68 °F), with clear warming and cooling periods associated with the changing seasons. The years of 2014 and 2015 had consistently higher water temperatures then other years, with a greater difference in temperature seen June through August.

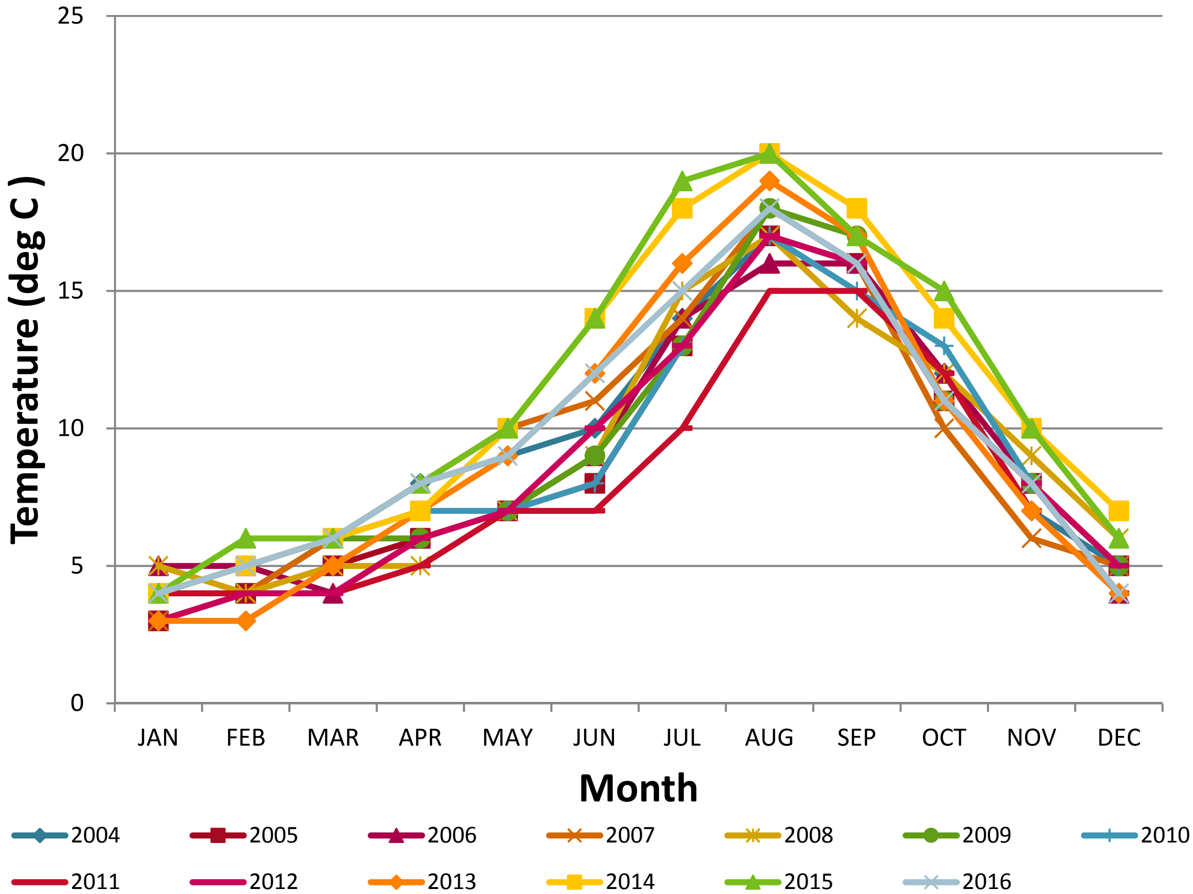

Figure 8: Monthly Average Temperature Recorded at the WTP Entry

Pathogens

The main purpose of surface water treatment is the removal of the pathogens that can potentially cause water-borne illnesses. The principal pathogens of concern are *Cryptosporidium*, *Giardia,* and viruses. The City has already completed Round 1 *Cryptosporidium* sampling and analysis per the requirements of the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWR). Based upon these results, the Oregon Drinking Water Program informed the City in September 2010 that the highest mean *Cryptosporidium* concentration was only 0.004 oocysts/L. This is a low value and places the City in Bin 1 (least additional treatment needed) of the LT2ESWTR treatment requirements.

The City has started Round 2 LT2ESWTR sampling in October 2016 and sampling and testing is ongoing. To date, one positive result for Cryptosporidium was detected on January 24, 2017, with a result of 0.093 oocysts/L. Discussions with the City indicate that the Round 2 sampling and analysis are anticipated to have similar results with Round 1 and the City should remain in LT2ESWTR Bin 1.

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Similarly, the presence, and therefore pathogenic risk, of *Giardia* is also anticipated to be low. *Giardia* was detected only once in monthly testing taking place from April 2008 to March 2010. 21 out of 22 samples reported no oocysts detected.

Inorganic Compounds

A review of the posted water quality data on the OHA website from 1986 to 2017 found only nitrate as the only IOC at concentrations above each compounds' respective detection limits. However, nitrate concentrations were always below 1 mg/L, less than one-tenth of its 10 mg/L regulatory limit. In addition, communication with the City indicated that regulated IOCs have never been a raw water quality issue. A complete list of NPDWS regulated IOCs and their Maximum Contaminant Limits is located in Appendices A, B, and C.

In addition to the regulated IOCs, the City conducted sampling and analysis in 2013 for the Unregulated Contaminant Monitoring Rule 3 (UCMR3). The City detected chromium-6, chlorate, strontium, and vanadium in the raw water. Table 1 lists the detected concentrations for these analytes. There are no USEPA or OHA regulatory limits for these analytes at this time; there is no timeline for when, or if, these analytes will have limits established. However, the table does include limits other states or the AWWA have proposed. Each analyte is well below these limits.

Table 1: 2013 Analysis of UCMR3 Analytes

Analyte	Detected Range (mg/L)	Average (mg/L)	Examples Limits (mg/L)
Chromium-6	0.0 – 0.091	0.044	10 – California
Chlorate	79 – 190	123	700 – AWWA
Strontium	80 – 110	96	1,000 – 4,000 – AWWA
Vanadium	0.49 – 0.66	0.56	15 -50 - California

Volatile and Synthetic Organic Compounds (VOC and SOC)

The VOC and SOC analyses obtained from the OHA website from 1986 to 2017 did not find any VOCs or SOCs at concentrations above each compounds respective detection limits. In addition, communication with the City indicated that the watershed is completely forested, with none of the commercial or industrial activities that are the common sources for VOC or SOC pollution. Barring some unusual man-made contamination, VOCs or SOCs should not be an issue for the existing or future WTP.

Algae and Cyanotoxins

Algae are known sources of Taste-and-Odor (T&O) compounds and cyanotoxins. Reeder Reservoir sampling in 2007 reported blue-green algal species within the reservoir, including the potentially toxic *Anabaena flos-aquae,* reaching an extremely high cell count of 31,570,000 cells/mL at the reservoir surface. The 2007 study also noted that the Reeder Reservoir water quality and physical characteristics make it prone to algal blooms and the results from 2007 are likely typical algae conditions for most years. However, one grab sample of reservoir water in

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an area of dense algal growth had non-detectable concentrations of microcystin (<0.05 µg/L) and anatoxin-a (<0.15 µg/L).

Testing for cyanotoxins, based on species, has been preformed regularly since 2010. In October 2012, microcystin-LR was reported in initial and confirmation sampling at the Reeder Reservoir intake tower and WTP tailrace raw water. Repeated sampling of the WTP finished water at this time found no cyanotoxin, indicating that the existing WTP process was providing complete removal of microcystin. This is the only positive result ever in the raw water as no samples prior to or after this event has found any microcystin, anatoxin-a, cylindrospermospin, or saxitoxin in the raw water. However, the ongoing and high presence of *Anabaena* means that the potential cyanotoxin generation exists and should be considered in selecting treatment processes for the future WTP.

Taste-and-Odor Compounds (T&O)

The City conducted a study into T&O compounds in 2015 to identify raw water concentrations and the effectiveness of the existing WTP processes to remove the compounds prior to discharging to the distribution system. The study found that all of the T&O issues were caused by Geosmin; no MIB was ever detected in any sample.

Per conversations with the City, T&O issues only occur in the later part of summer prior to the beginning of fall, when Reeder Reservoir is warmest and has fully stratified. Thus, the City only conducted T&O sampling in the later half of 2015 (see Table 2). The results found that the raw and finished water were several times higher than the general public odor threshold concentration (OTC) of 5 – 10 ng/L, with a maximum value of 73.3 ng/L detected in Reeder Reservoir and 28.9 ng/L as the Power House Tailrace immediately prior to the WTP (an OTC is when 50 percent of a population reports detecting an odor). Conversations with City staff indicate that 2015 was a particularly severe T&O episode though some T&O complaints have been received by the City every late summer to early fall. The result is that T&O removal should be considered in selecting treatment processes for the future WTP.

Table 2: Detected Geosmin Concentrations

Sampling Date	Geosmin (ng/L [ppt]) at:		
	Reeder Reservoir, 2 meters below the surface	Raw Water at Power House Tailrace	Finished Water at WTP Lab
Sept. 28, 2015	73.3	28.9	16.1
Oct. 6, 2015	49.8	24.5	(lost sample)
Oct. 22, 2015	27.4	20.7	9.5
Nov. 2, 2015	23.2	18.0	14.7
Nov. 18, 2015	12.5	10.5	7.8
Note: General public odor threshold concentration is 5 – 10 ng/L (Source: WRF Report: A Decision Tool for Earthy/Musty Taste and Odor Control [Project #3032])			

Color

Color is an aesthetic parameter that is regulated with a secondary maximum contaminant level (SMCL) of 15 platinum-cobalt units (PCU). The raw water apparent color at the WTP from 2004 to 2010 ranges from a monthly average of 20 PCU to 35 PCU (see Figure 9). Apparent color values tend to be higher in spring (March-June) and generally highest in April. The high level of raw water color means the treatment process selection for the future WTP needs to consider color removal as a criteria.

Color is typically the result of iron, manganese, and/or organic matter in the water. As indicated earlier, the City staff have not found iron or manganese in the raw water. They suspect the color is all attributable to organic matter.

As with turbidity, the average monthly values tend to mask the full range of daily color episodes. Daily maximum values for 2016 are shown in Figure 10. In 2016, it shows that color constantly declined from approximately 45 PCU in January to October, and increased substantially in October and December, correlating to increased winter precipitation. Daily color values for 2016 corroborate this evidence, showing high spikes in color from storm events October through May, and lower values with no spikes during summer months. The color is suspected to have occurred as rainfall both washed debris into Reeder Reservoir and mixed the reservoir after a long summer stratification period.

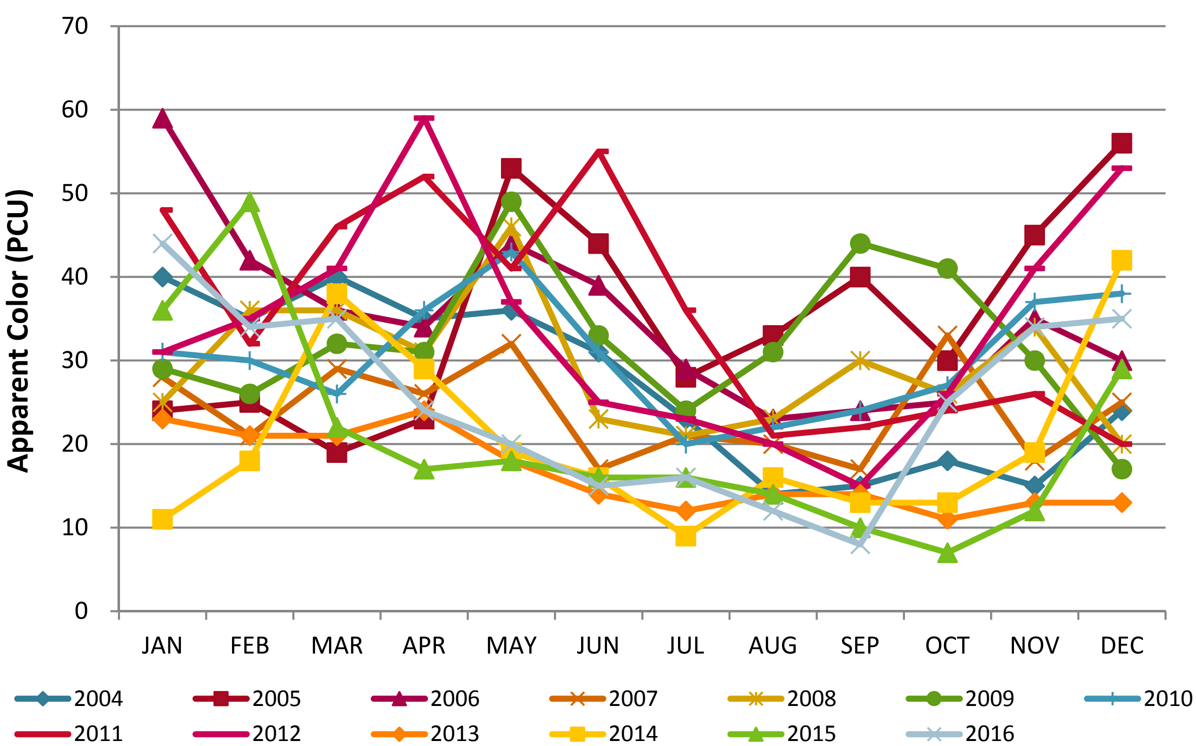

Figure 9: Monthly Average Apparent Color Recorded at the WTP Entry

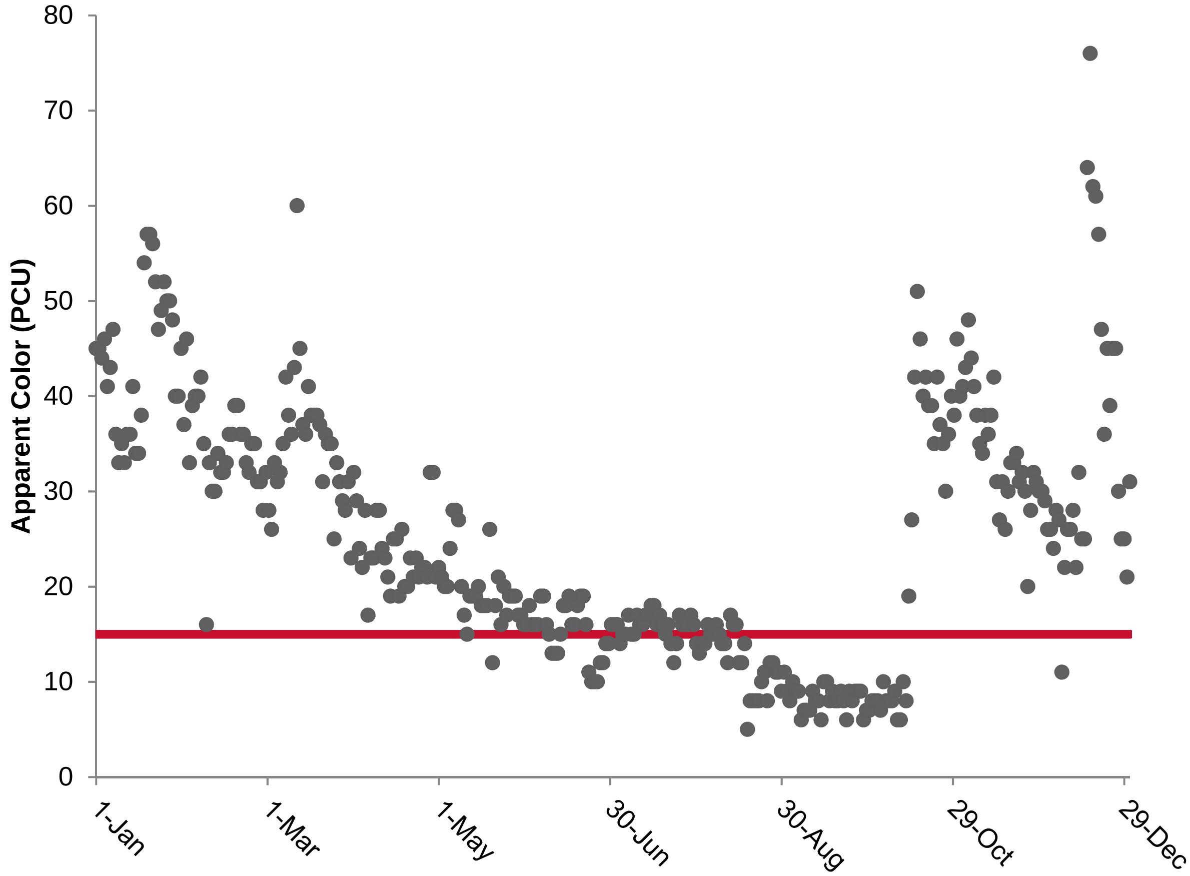

Figure 10: Maximum Daily Color Recorded at the WTP Entry, 2016

Talent Irrigation District Water Quality

Comprehensive water quality data for the TID water is limited to a grab sample collected on August 20, 2009. This sample was taken at the WTP intake and consists of TID water blended with Ashland Creek water, and thus the presented results are not representative of TID alone. A summary of the grab sample analytical results and how the results compare to the lengthy historical records for Reeder Reservoir is shown in Table 3. Those parameters which are the same as or in the mid-range of Reeder Reservoir suggest that the TID water quality is similar to that of Reeder Reservoir, as the addition of TID water to the intake does not significantly impact the overall quality of raw water.

Table 3. Summary of Blended Talent Irrigation Data Grab Sample Results and Comparison

Water Quality Parameter	2009 Grab Sample Results	Comparison to Reeder Reservoir Results
Turbidity	3.2 NTU	Mid-range of Reeder Res.
Total Organic Carbon (TOC)	2.9 mg/L	Mid-range of Reeder Res.
pH	Sample exceeded hold time for accurate measurement	-
Alkalinity	37 mg/L as $CaCO_3$	Mid-range of Reeder Res.
Hardness	Not reported but calculated to be 33 mg/L as $CaCO_3$	High end of Reeder Res.
Temperature	Not analyzed	-
Pathogens	Zero for *Cryptosporidium* and *Giardia*	Same as Reeder Res.
IOCs	Non-detect for nitrate, sulfate, fluoride. No data for all other regulated IOCs or for UCMR3 analytes.	Mid-range of Reeder Res.
VOCs and SOCs	Non-detect for all compounds.	Same as Reeder Res.
Algae and cyanotoxins	99 counts/mL	Low end of Reeder Res., though sample could have been obtained prior to peak algae growth.
T&O Compounds	Non-detect for both MIB and Geosmin. 1 TON for odor.	Better than Reeder Res., though sample could have been obtained prior to T&O issues forming.
Color	20 PCU	Mid-range of Reeder Res.
Other		
Ammonia	Non-detect	No data for Reeder Res.
Dissolved organic carbon	2.7 mg/L	No data for Reeder Res.
Dissolved UV-254 absorb.	0.050/cm	No data for Reeder Res.
Specific conductance	78 umhos/cm	No data for Reeder Res.

In addition to the single grab sample, the City's 2013 and 2014 annual consumer confidence reports (CCRs) lists TOC concentrations when TID water was purchased and blended with the Ashland Creek water prior to entering the WTP. This information is summarized below in Table 4 and compared against similarly reported values for Ashland Creek/Reeder Reservoir. The CCRs prior to and after 2013 and 2014 did not include a breakdown of TID TOC information. The CCRs did not list any other TID water quality data.

Table 4. Reported Talent Irrigation District and Ashland Creek Total Organic Carbon

Consumer Confidence Report	Reported Total Organic Carbon Data (mg/L) for:	
	Blend of Talent Irrigation District and Ashland Creek Water	Ashland Creek/ Reeder Reservoir
2013	Average: 1.5 No range reported	Average: 2.2 Range: 1.5 – 3.4
2014	Average: 2.42 Range: 2.30 – 2.53	Average: 2.66 Range: 1.67 – 4.70

In general, the 2009 grab sample and the limited 2013-2014 TOC data would appear to indicate that the TID water is possibly comparable to the City's main water supply. However, further water quality sampling is recommended as the TID water quality dataset is quite limited and more data should be gathered analyzed prior to drawing any more conclusions. A separate memorandum has been prepared to further discuss the additional sampling requirements.

Finished Water Quality

Water quality testing of the potable water at the WTP is conducted for temperature, hardness, pH, and alkalinity. There are no meaningful differences in the potable water temperature and hardness from the WTP as compared to the raw water reported in the prior section. This can be attributed to the fact that the existing WTP does not hold the water for long periods of time exposed to direct sunlight and does not perform hardness adjustments.

The existing WTP uses soda ash to replace the alkalinity consumed by the alum coagulation process and to allow that process to operate better. In general, the finished water alkalinity does not meaningfully differ from the raw water alkalinity as soda ash is controlled to replace, but not further boost, the alkalinity through the WTP.

Alum coagulation also depresses the water pH while consuming alkalinity, while soda ash addition also boosts pH in a small way. As a result, the potable water pH is slightly lower than the raw water. The WTP processes also helps smooth out the variances in the raw water pH, making the potable water pH have less variability than the water entering the WTP. The monthly average WTP pH is shown in Figure 11.

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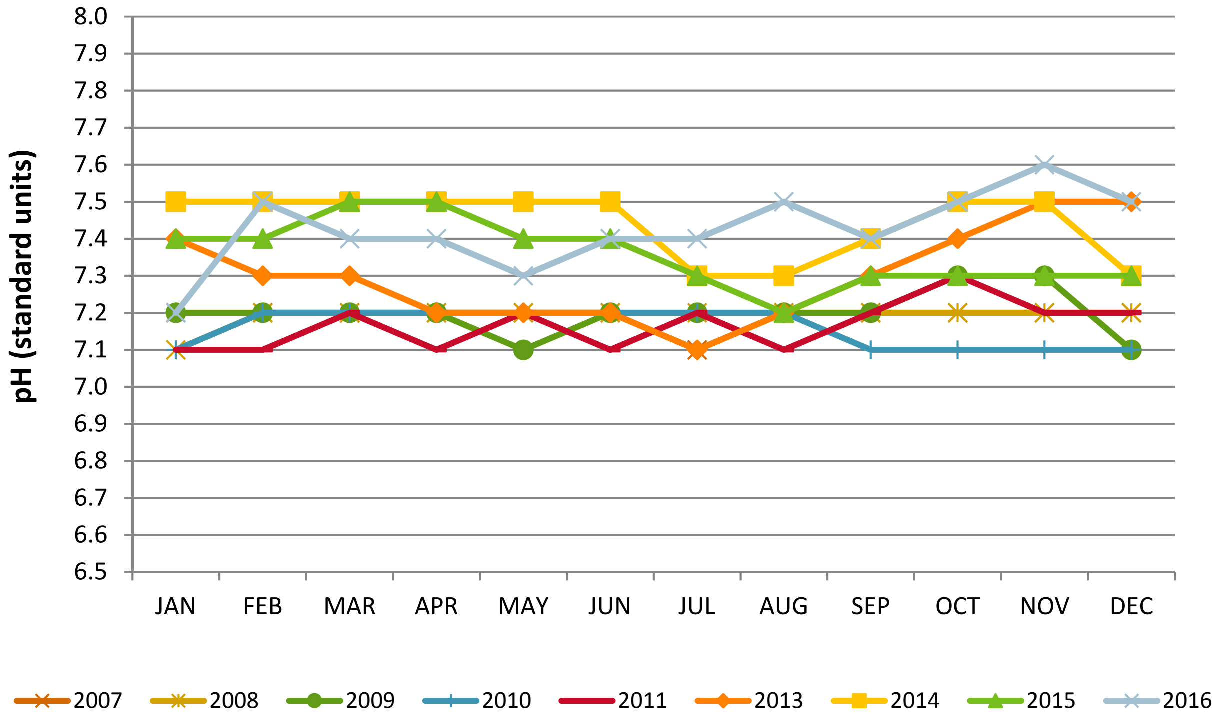

Figure 11. Average Monthly Potable Water pH Entering the Distribution System

Turbidity data shows that the WTP has been very successful in removing turbidity. The vast majority of time, the existing WTP produced potable water with turbidities less than 0.1 NTU. From January 2009 to February 2017, the plant had only four episodes in which the potable water turbidity exceeded 0.3 NTU, and only one instance (January 8, 2015) where the maximum daily turbidity exceeded 1.0 NTU. These four observed spikes were directly linked to disturbances in the WTP clearwell that caused settled debris deposits to get mixed into the water. OHA investigated the events, accepted the City's explanation, and did not cite the City for any water quality violations.

The WTP has also been successful in removing color, with the monthly average potable water color being zero, with occasionally 1 PCU recorded. While the color removal has been successful, the City has had color complaints in the distribution system. The City staff has stated that these complaints are from manganese, which is added as potassium permanganate in the existing WTP's pre-treatment system. Reducing the use of potassium permanganate in the future WTP will reduce the color complaints.

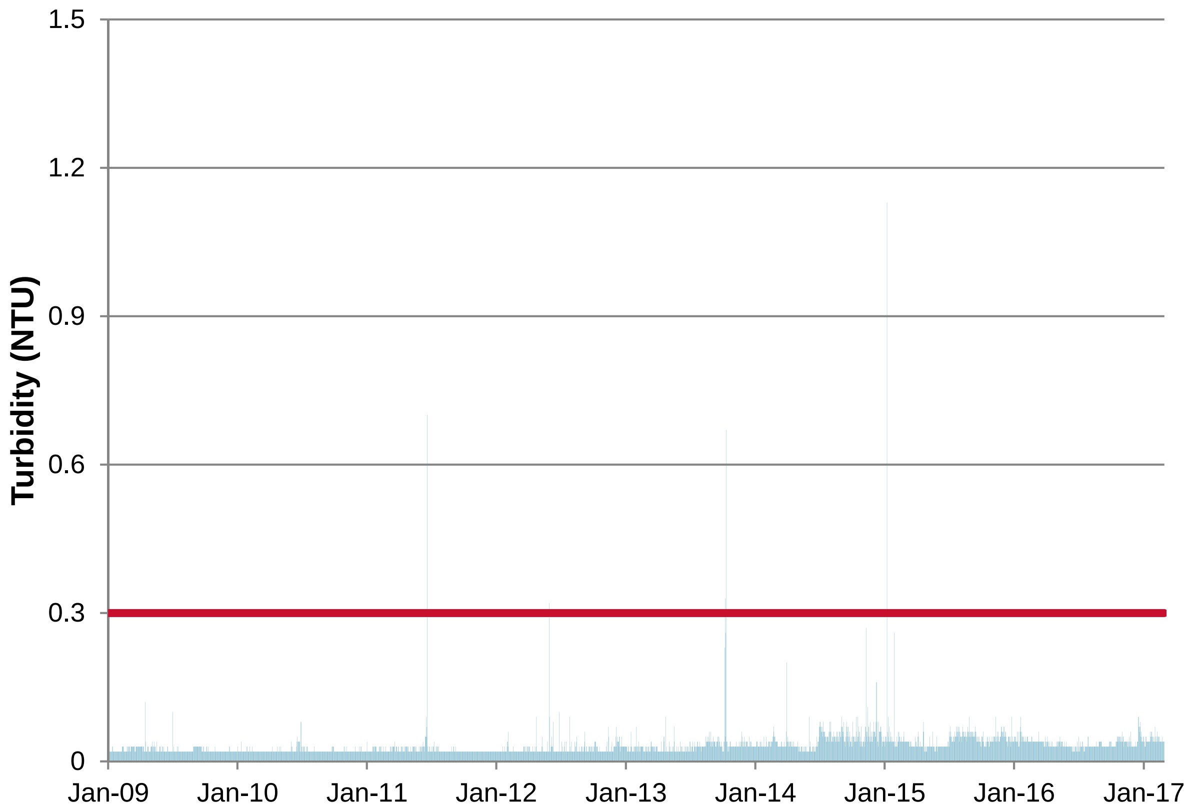

Figure 12: Daily Maximum Turbidity in Potable Water Entering Distribution System

Disinfection Byproducts

Disinfection byproducts (DBPs) are potentially carcinogenic compounds formed as organic materials in the water react with the disinfectants, chlorine and chloramine. There are two regulated categories of DBPs: four trihalomethanes grouped together as Total Trihalomethanes (TTHM) and five haloacetics acids grouped as Haloacetic Acids (HAA5). TTHM and HAA5 testing is done quarterly in the distribution system. In the previous ten years, the City has had only three HAA5 sampling rounds with any results above 0.060 mg/L. These were recorded in February and May of 2010, and February 2012. The City maintained full compliance despite these high detected concentrations as compliance is determined by annual running averages, not individual results. In this same time period, no TTHM results have been above 0.08 mg/L MCL.

The high HAA5 results were determined to be the result of past WTP practice of prechlorination. The WTP abandoned this practice in 2013 and the highest HAA5 result since then has only been 0.041 mg/L, nearly one-third below the regulatory limit.

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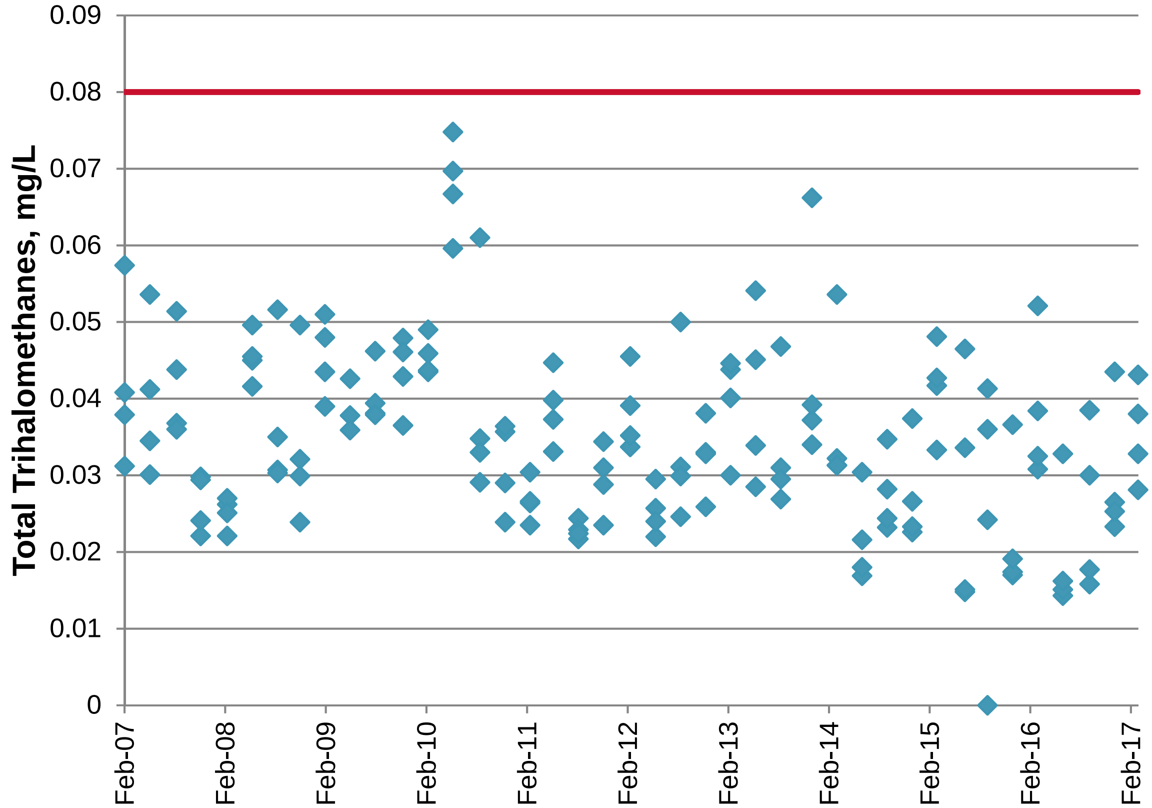

Figure 13: Total Trihalomethanes

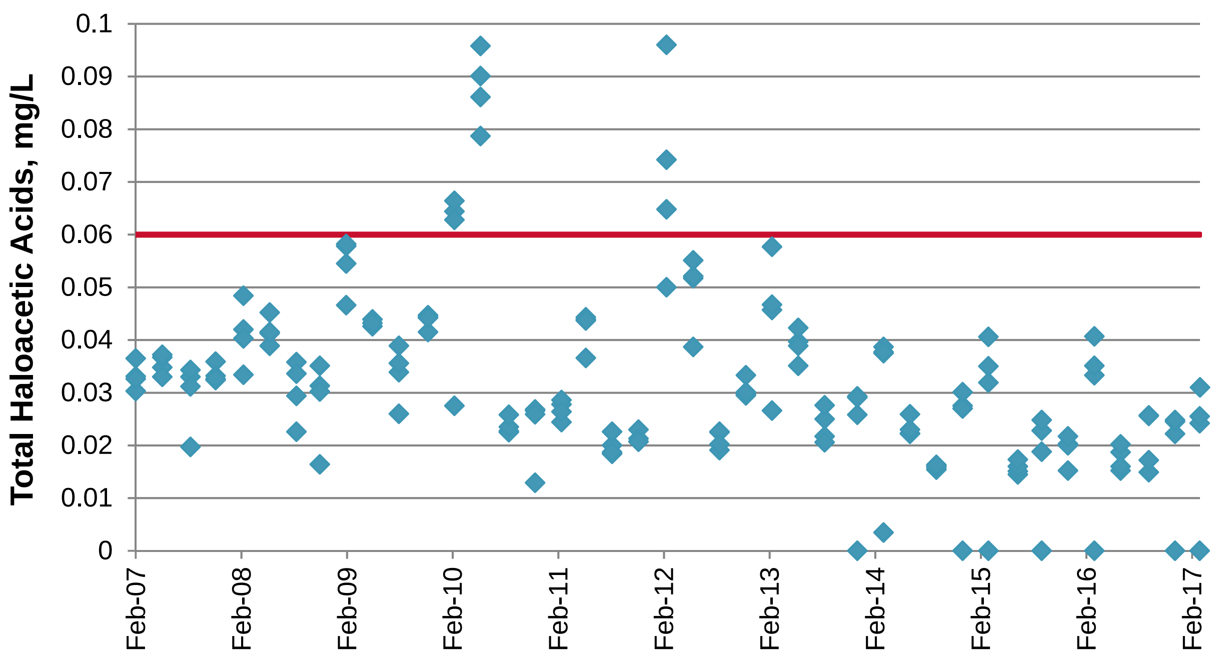

Figure 14: Total Haloacetic Acids

Summary

The Ashland Creek/Reeder Reservoir raw water and existing WTP performance can be summarized as follows:

- Generally low turbidities are found in the surface water supply due to the presence of Reeder Reservoir acting as a large sedimentation basin. Occasional heavy storms can increase raw water turbidities but even then, maximum values are low. Despite these regular storm-driven increases, the existing WTP has been very successful in removing turbidity. The future WTP needs to at least match current turbidity removal performance.
- The raw water contains organic carbon that can be precursor to biological activity in media filters, organic fouling in membranes, and cause distribution system water quality issues. The TOC is higher and most variable at the start of the year and declines from there.
- The raw water pH is variable but in the range that does not unduly affect a treatment process selection.
- Alkalinity and hardness values are comparable to other raw water sources in Oregon and exhibit seasonal depression in the summer. Careful attention should be made to prevent consuming too much alkalinity if metal salt coagulation is used or providing a method to supplement alkalinity. The existing WTP uses soda ash to counteract this issue.
- Ashland's climate exhibits all four seasons so the monthly average raw water temperature can fall to 3 deg C during winter and go as high as 20 deg C during summer. Water temperature needs to be considered in the evaluation of any treatment process. The existing WTP performance is not heavily influenced by water temperature, though the future WTP might be affected depending on the treatment process selected.
- The City is blessed with having a water supply that has little to no *Cryptosporidium* or *Giardia*, which means it is not necessarily forced to having multiple and/or advanced filtration and disinfection processes for pathogen destruction.
- The existing and future WTPs do not need to consider IOC, VOC, or SOC removal in the treatment process, though the use of potassium permanganate needs to be carefully considered to minimize distribution system color issues.
- Reeder Reservoir can contain quite high populations of algae, especially algae that can produce cyanotoxins. This issue must be considered during the future WTP treatment process selection.
- The algae are also the source for the seasonal T&O issues that the City currently experiences and which the existing WTP has had only partial success in treating. The future WTP needs to also consider T&O control measures.

- Finally, water from Reeder Reservoir contains considerable amounts of color that needs to be removed. The current WTP processes have very good success in removing color, a level of performance the future WTP should match.

Compared to the extensive raw water quality available from Ashland Creek/Reeder Reservoir, specific TID water quality is limited to one grab sample and some intermittent TOC sampling. The limited data suggests TID water is similar to Reeder Reservoir but further water quality sampling is recommended before more conclusions can be made.

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Appendix A:

Inorganic Contaminants Regulated by the EPA

Contaminant	MCLG (mg/L)	MCL or TT (mg/L)
Antimony	0.006	0.006
Arsenic	0	0.010 as of 01/23/06
Asbestos (fiber > 10 micrometers)	7 million fibers per liter (MFL)	7 MFL
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium (total)	0.1	0.1
Copper	1.3	TT; Action Level=1.3
Cyanide (as free cyanide)	0.2	0.2
Fluoride	4	4
Lead	zero	TT; Action Level=0.015
Mercury (inorganic)	0.002	0.002
Nitrate (measured as Nitrogen)	10	10
Nitrite (measured as Nitrogen)	1	1
Selenium	0.05	0.05
Thallium	0.0005	0.002

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Appendix B:

Volatile Organic Contaminants Regulated by the EPA

Contaminant	MCLG (mg/L)	MCL or TT (mg/L)
Acrylamide	zero	TT
Benzene	zero	0.005
Carbon Tetrachloride	zero	0.005
Chlorobenzene	0.1	0.1
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	zero	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	zero	0.005
1,2-Dichloropropane	zero	0.005
Epichlorohydrin	zero	TT
Ethylbenzene	0.7	0.7
Styrene	0.1	0.1
Tetrachloroethylene	zero	0.005
Toluene	1	1
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.003	0.005
Trichloroethylene	zero	0.005
Vinyl Chloride	zero	0.002
Xylenes (Total)	10	10

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Appendix C:

Synthetic Organic Contaminants Regulated by the EPA

Contaminant	MCLG (mg/L)	MCL or TT (mg/L)
Alachlor	zero	0.002
Atrazine	0.003	0.003
Benzo(a)pyrene	zero	0.0002
Carbofuran	0.04	0.04
Chlordane	zero	0.002
2,4-D	0.07	0.07
Dalapon	0.2	0.2
1,2-dibromo-3-chloropropane	zero	0.0002
Di(2-ethylhexyl)-adipate	0.4	0.4
Di(2-ethylhexyl)-phthalate	zero	0.006
Dinoseb	0.007	0.007
Dioxin (2,3,7,8-TCDD)	zero	0.00000003
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Ethylene Dibromide (EDB)	zero	0.00005
Glyphosate	0.7	0.7
Heptachlor	zero	0.0004
Heptachlor epoxide	zero	0.0002
Hexachlorobenzene	zero	0.001
Hexachlorocyclopentadiene	0.05	0.05
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Oxymal (Vydate)	0.2	0.2
Pentachlorophenol	zero	0.001
Picloram	0.5	0.5
Polychlorinated byphenyls (PCBs)	zero	0.0005
Simazine	0.004	0.004
Toxaphene	zero	0.003
2,4,5-TP (Silvex)	0.05	0.05

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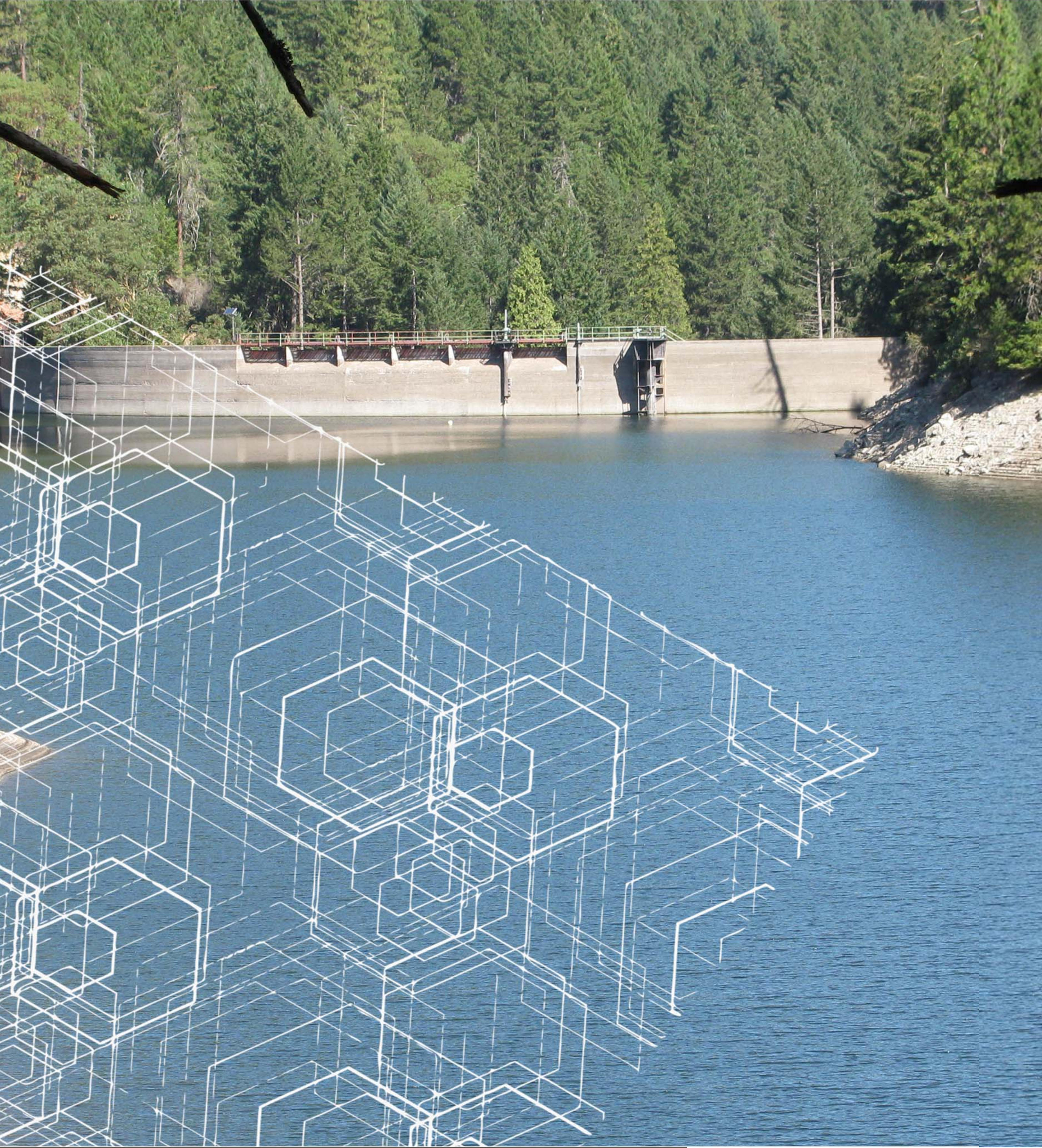

Appendix B
Regulatory Review and Treated QA Goals

Get there!
KELLER associates

Technical Memorandum

Date: Thursday, May 04, 2017

Project: Ashland Water Treatment Plant

To: James Bledsoe, Bryan Black – Keller Associates

From: Kelsey Harpham, Pierre Kwan

Subject: Regulatory Review and Treated QA Goals

Introduction

The City of Ashland, Oregon (City) has retained Keller/HDR to investigate the replacement of the City's existing water treatment plant (WTP) with a new facility. This memorandum first documents the existing and proposed water treatment regulations that the existing and future water treatment plants (WTP) must meet. Afterwards, based on the regulatory review, this document then identifies the treated water quality goals that the new WTP should be designed to meet.

Current Regulations and Compliance

Drinking water quality is regulated by the United States Environmental Protection Agency (EPA) at the national level, with the State of Oregon designating the Oregon Health Authority (OHA) as primacy agency for monitoring and enforcing these regulations at the state level.

The 1974 Safe Drinking Water Act (SDWA), and its 1986 and 1996 amendments, established specific legislation for the regulation of public water systems by federal and state governments. The EPA was required to establish primary regulations for the control of contaminants that affect public health and secondary regulations for compounds that affect the taste, odor or aesthetics of drinking water. Over the past 42 years, several new and modified regulations have been promulgated by EPA and additional regulations or modifications to current regulations are currently under development. The federal regulations are codified and enforced at the state level through the Oregon Drinking Water Quality Act of 1981, which authorized OHA to adopt state-level drinking water rules. These rules are covered under Oregon Administrative Rule (OAR) Chapter 333, Division 061.

The quality of the drinking water provided by the City must meet all existing and proposed State and Federal regulations. The following section is a summary of the current regulations that are applicable to the City and organized in the following categories:

1. Surface water treatment
2. Chemical contaminants
3. Distribution systems

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Current Surface Water Treatment Regulations

Table 1 provides a summary of the five current regulations related specifically to surface water treatment; four being the Surface Water Treatment Rule and its modifications and the Filter Backwash Rule. These rules focus on the monitoring and removal of pathogenic organisms, namely *Giardia*, *Cryptosporidium* and viruses. Turbidity is monitored and removed because it is a surrogate for these organisms.

Table 1. Current Drinking Water Regulations Specific to Surface Water Treatment

Regulation	Provisions
Surface Water Treatment Rule (SWTR)	1. Treatment must achieve 3.0-log (99.9%) or more removal/inactivation for Giardia lamblia. 2. Treatment must achieve a 4.0-log (99.99%) or more removal/inactivation for viruses. 3. Turbidity monitoring continuously or by grab samples every four hours. 4. Establishes chemical disinfection credit based upon the C x T value (disinfection residual concentration "C" multiplied by the disinfection contact time "T").
Interim Enhanced Surface Water Treatment Rule (IESWTR)	1. Reduced turbidity requirements to the following: combined filtered water turbidity less than or equal to 0.3 Nephelometric Turbidity Units (NTU) in at least 95% of monthly samples and combined filtered water turbidity never to exceed 1 NTU.
Long Term 1 ESWTR (LT1ESWTR)	1. Establishes Maximum Contaminant Level Goal (MCLG) for Cryptosporidium at zero. 2. Filtered systems must provide 2.0 log (99%) Cryptosporidium removal. 3. Establishes combined filtered water turbidity standards of < 0.3 NTU in 95% of samples for conventional filters, alternative technologies performance established by the State. 4. Requires systems to develop a disinfection profile and benchmark.
Long Term 2 ESWTR (LT2ESWTR)	1. Requires systems to collect and analyze two rounds of surface water sources for Cryptosporidium and turbidity, with each round consisting of 24 samples. 2. Monitoring results dictate if treatment of Cryptosporidium based upon the running annual average concentration from the collected samples. The average concentration indicates which "Bin" the source water is classified. 3. Treatment requires 2.0 or more log-removal of Cryptosporidium depending on the bin and the treatment technology. 4. Established a toolbox of processes that can be used to meet the additional removal requirements.
Filter Backwash Recycling Rule	1. Rule limits the amount of pathogens contained in filter backwash from returning back to the plant. 2. Designates that all recycled streams in the WTP are returned to the front of the plant such that the recycled water is treated through all plant processes. 3. Recycled streams can be no more than ten percent of the total plant raw

Regulation	Provisions
	water flowrate.

The City already implemented steps to comply with all the requirements of the SWTR, IESWTR, and LT1ESWTR. The City has also already completed the first round of sampling for LT2ESWTR and is currently in the middle of the second sampling round. The sampling has indicated the City does not need any additional treatment for *Cryptosporidium* beyond that already required for LT1ESWTR.

An important aspect of the Surface Water Treatment Rules is the removal of pathogens using the microbial "toolbox". In summary, the future WTP needs to remove the following pathogens:

- 2.0-log (99%) or more removal/inactivation for *Cryptosporidium*.
- 3.0-log (99.9%) or more removal/inactivation for *Giardia*.
- 4.0-log (99.99%) or more removal/inactivation for viruses.

The rules provide different log credits for these pathogens depending on the filtration technology selected. Table 2 summarizes the credits provided for direct, conventional, and membrane filtration. Direct filtration, which the existing WTP uses, satisfies all the requirements for *Cryptosporidium* but relies upon chlorination to fully comply with *Giardia* and virus removal requirements. Conventional filtration is considered to provide a higher level of treatment so minimizes, but does not eliminate, the need for chlorine to satisfy the surface water treatment rule requirements.

Table 2. Pathogen Removal and Credits for Different Filtration Technologies

Filtration Technology	Removal Requirements and Credit for (logs)		
	Cryptosporidium **(Need 2.0)**	***Giardia*** **(Need 3.0)**	**Viruses (Need 4.0)**
Direct	2.0 (none)	2.0 (1.0)	1.0 (3.0)
Conventional	2.0 (none)	2.5 (0.5)	2.0 (2.0)
Membrane	>2.0 (none)	>3.0 (0.5)	None (4.0)
First value is credit provided. (Second value) is log deficit to be made up using chlorination or another disinfectant.			

Membranes provide the highest level of filtration and have the highest provided credit for *Cryptosporidium* and *Giardia.* While membranes would fully satisfy *Giardia* removal requirements, OHA mandates that membrane WTPs still provide 0.5-log *Giardia* inactivation using chlorine or another disinfectant. Conversely, membranes have no credit for virus removal and needs to meet all 4.0-log removal using chlorine. However, the disinfection "concentration

× contact time" (CT) requirement for 0.5-log *Giardia* removal is nearly three times that for 4.0 log virus removal (CT of 35 mg-min/L for *Giardia* versus 12 mg-min/L for viruses).

The Filter Backwash Rule is not currently applicable as the existing WTP does not recycle backwash water. If filter backwash recycling is implemented for the future WTP, the rule requires additional monitoring on the recycle line and limiting the recycle rate to no more than ten percent of the raw water flowrate prior to recycle water introduction.

Current Chemical Contaminants Regulations and Compliance

Drinking water is strictly regulated for chemical content, with maximum contaminant levels established for a number of inorganic chemicals, volatile organic compounds, and synthetic organic compounds. Table 3 lists these regulations. The Ashland Creek/Reeder Reservoir supply is of such high quality that City is fully compliant for all of these requirements even prior to treatment.

Table 3. Current Drinking Water Regulations Specific to Chemical Contaminants

Regulation	Provisions
National Primary Drinking Water Regulations (NPDWR)	1. Establishes maximum contaminant levels (MCLs) and MCLGs for 11 inorganic chemicals (IOCs), 32 synthetic organic chemicals (SOCs), 21 volatile organic compounds (VOCs), and asbestos. 2. Establishes sampling frequencies every three years, with waivers available for three and six-year ongoing durations.
Radionuclides Rule	1. Established MCL for uranium of 30 µg/L and retains MCLs for gross alpha particles, beta/proton emitters, and radium 226/228. 2. Initially requires four quarterly samples at entry points to distribution system to determine compliance with rule and to set continued monitoring schedule. 3. Management techniques or treatment will be necessary if uranium MCL is exceeded.
Arsenic Rule	1. Lowered the total arsenic MCL to 10 µg/L in drinking water. 2. Arsenic MCL compliance is calculated as running annual average of quarterly sampling at each distribution system point of entry.

In addition to these regulations, the EPA has published the National Secondary Drinking Water Standards, which are guidelines for regulating contaminants that may cause cosmetic or aesthetic effects in drinking water. OHA has adopted these guidelines are requirements for Oregon public water systems. The secondary standards cover aluminum, chloride, color, copper, corrosivity, fluoride, foaming agents, iron, manganese, odor, pH, silver, sulfate, total dissolved solids, and zinc. Each of these parameters has an established secondary MCL (SMCL) that the City must attempt to meet at all times.

The existing WTP has to deal with color and odor. The Ashland Creek/Reeder Reservoir water has high color (monthly average values as high as 59 Platinum-Cobalt Units [PCU]) but the existing WTP reduces it to 0 – 1 PCU prior to discharge to the distribution system. The

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aesthetic SCML is 15 PCU. As a result, the City is fully compliant with water color requirements.

Current Distribution System Regulations and Compliance

Table 4 lists the current regulations that the City needs to meet in the distribution system. The review of the City-provided water quality data in the water quality memorandum indicates that the City is fully compliant with Stages 1 and 2 D/DBPRs. Similarly, review of the City's historical consumer confidence reports indicate that there are no compliance issues with the Revised Total Coliform Rule RTCR and Lead and Copper Rule (LCR).

Table 4. Current Drinking Water Regulations Specific to Distribution Systems

Regulation	Provisions
Stage 1 Disinfectants/ Disinfection Byproduct Rule (Stage 1 D/DBPR)	1. Set total organic carbon (TOC) removal requirement percentages dependent upon the source water alkalinity and TOC concentration. 2. Established Disinfection Byproduct (DBP) MCLs as follows: TTHM - 80 µg/L; HAA - 60 µg/L; bromate - 10 µg/L; and chlorite - 1.0 mg/L. 3. Required monitoring in the distribution system to verify compliance with the DBP MCLs. 4. Establishes MRDLs for chlorine and chloramines.
Stage 2 Disinfectants/ Disinfection Byproduct Rule (Stage 2 D/DBR)	1. Revises compliance based upon a locational running annual average (LRAA) at the highest concentration areas in the distribution system.
Revised Total Coliform Rule (RTCR)	1. Requires monthly sampling for total coliforms at designated sampling locations in the distribution system. Samples must be absent of total coliforms in 95 percent of all samples in the month or system in violation. Positive samples must be verified by testing E. Coli which must be absent. 2. The plant must be designed to fully disinfect ambient fecal matter coliforms so it does not enter the distribution system, resulting in RTCR violations.
Lead and Copper Rule (LCR)	1. Requires periodic monitoring of designated locations in the distribution system for concentrations of copper and lead. 2. Action levels for lead and copper is exceeded if the concentration in more than 10 percent of samples collected is greater than 0.015 mg/L and 1.3 mg/L, respectively. 3. Systems exceeding action levels are required to implement treatment to prevent corrosion, lead service line replacement, public education, and additional monitoring.

Proposed Federal Regulations

Given that the future WTP is expected to last for many decades into the future, both existing and proposed future regulations must be considered during evaluation and design. Table 5 lists the known future federal rules, the expected date for the draft and final versions of the rule, and the impacts that rules would have on the existing and future WTPs.

Table 5. Proposed Federal Regulations and Impact to City Existing and Future WTPs

Future Rules or Contaminants	Expected Date of Draft and Final Rule	Affect on City's Existing and Future WTP
Radon Rule	1999 Uncertain for final	No impact
Prohibition on Use of Lead Pipes, Solder, and Flux	2016 (Draft) 2017 (Final)	No impact
Lead and Copper Rule Long-Term Revisions (LCR-LTR)	2016 (draft) 2017-2018 (final)	No impact
Strontium	2018 (draft) 2019 (final)	No impact
Perchlorate Rule	2018 (draft) Uncertain for final	No impact
Carcinogenic Volatile Organic Compound (cVOC) Rule	2018 (draft) Uncertain for final	No impact
Hexavalent Chromium	2018 (draft) Uncertain for final	No impact
Final Fourth Unregulated Contaminant Monitoring Rule (UCMR 4)	2018	To be determined
Cyanotoxins	Draft no earlier than 2023	To be determined
Nitrosamines	Uncertain	No impact
Chlorate	Uncertain	No impact
Perfluorinated Compounds	Uncertain	Potential impact

The City's existing WTP is not impacted by most of the new rules because mainly because the contaminants are not present (radon, perchlorate, cVOCs, nitrosamines), found at concentrations well below currently suggested limits (strontium, hexavalent chromium, chlorate), or distribution system-specific rules that has little impact on WTP operations (prohibition of lead pipes, LCR-LTR).

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The impact of the UCMR4 is unknown because the list of potential contaminants on it has not been prepared at this time. In addition, the vast majority of potential contaminants that were on previous UCMR rounds were never carried forward for regulation.

A federal cyanotoxins rule is at least six years in the future so it is difficult to predict what the rule will contain. In addition, OHA has already established recommended exposure limits for the four most common cyanotoxins (microcystin, anatoxin, cylindrospermospin, and saxitoxin) so there is uncertainty if the federal rule will be more or less stringent than the OHA recommendations. The City has found very little algal toxin in the source water, and these isolated detections have also corresponded with complete removal with the City's existing WTP so there may be little to impact.

The final potential federal rule is perfluorinated compounds (PFCs). PFCs are a category of man-made carcinogenic compounds. The principal exposure risk to the City would be the dumping of old (pre-2015) fire-fighting chemical foams in the watershed to combat a fire, with the foam then washing into Ashland Creek and/or Reeder Reservoir. The formal rule making process for PFCs at the federal level is uncertain. However, the EPA has published public health advisory levels in 2016 that set stringent drinking water limits for PFC in that has forced multiple utilities around the United States to implement treatment. In addition, ten states have already formally regulated PFCs in drinking water. OHA strongly recommends utilities consider treating for PFCs if detected.

Future WTP Treated Water Quality Goals

Treated water quality goals for the future WTP must meet all applicable federal, state, and local drinking water regulations as well as provide a finished water quality that is at least equal to the existing WTP. Table 6 is a summary of the recommended treatment goals for the future WTP.

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Table 6. Recommended Treatment Goals for Future WTP

Parameter	Criteria / Goal
Pathogen Removal	At least match existing WTP performance of: ▪ ≥2.0-log *Cryptosporidium* removal using filtration only. ▪ ≥3.0-log Giardia removal using a combination of filtration and chlorination ▪ ≥4.0-log virus removal/inactivation using a combination of filtration and chlorination
Inorganic Chemicals, Synthetic Organic Compounds, and Volatile Organic Compounds	At least match existing WTP performance of: ▪ Turbidity: <0.15 NTU filtered all the time. ▪ All other primary regulated contaminants below regulatory limits ▪ Total Iron ≤ 0.05 mg/L ▪ Total Manganese ≤ 0.01 mg/L ▪ Total Aluminum ≤ 0.05 mg/L
Aesthetic Issues	At least match existing WTP performance of: ▪ Finished water color: No more than 1 platinum-cobalt units (PCU). Improve existing WTP performance of: ▪ Taste-and-odor: Reduce Geosmin concentrations to ≤5 ng/L. ▪ Distribution water color: Minimize the use of permanganate.
Secondary Disinfection and DBP Control	At least match existing WTP performance of: ▪ THMs < 60 µg/L at all points in distribution system (75% of MCL) ▪ HAAs < 45 µg/L at all points in distribution system (75% of MCL) ▪ TOC at entry point ≤ 3.0 mg/L
Corrosion Control	▪ pH at entry point 7.8 +/- 0.2 ▪ Alkalinity at entry point ≥ 25 mg/L
Cyanotoxins	At least match existing WTP performance for cyanotoxin removal and consider additional removal if future raw water concentrations are higher than prior detections.
Perfluorinated Compounds	Consider how new treatment systems can affect PFCs if they are ever released into the watershed.

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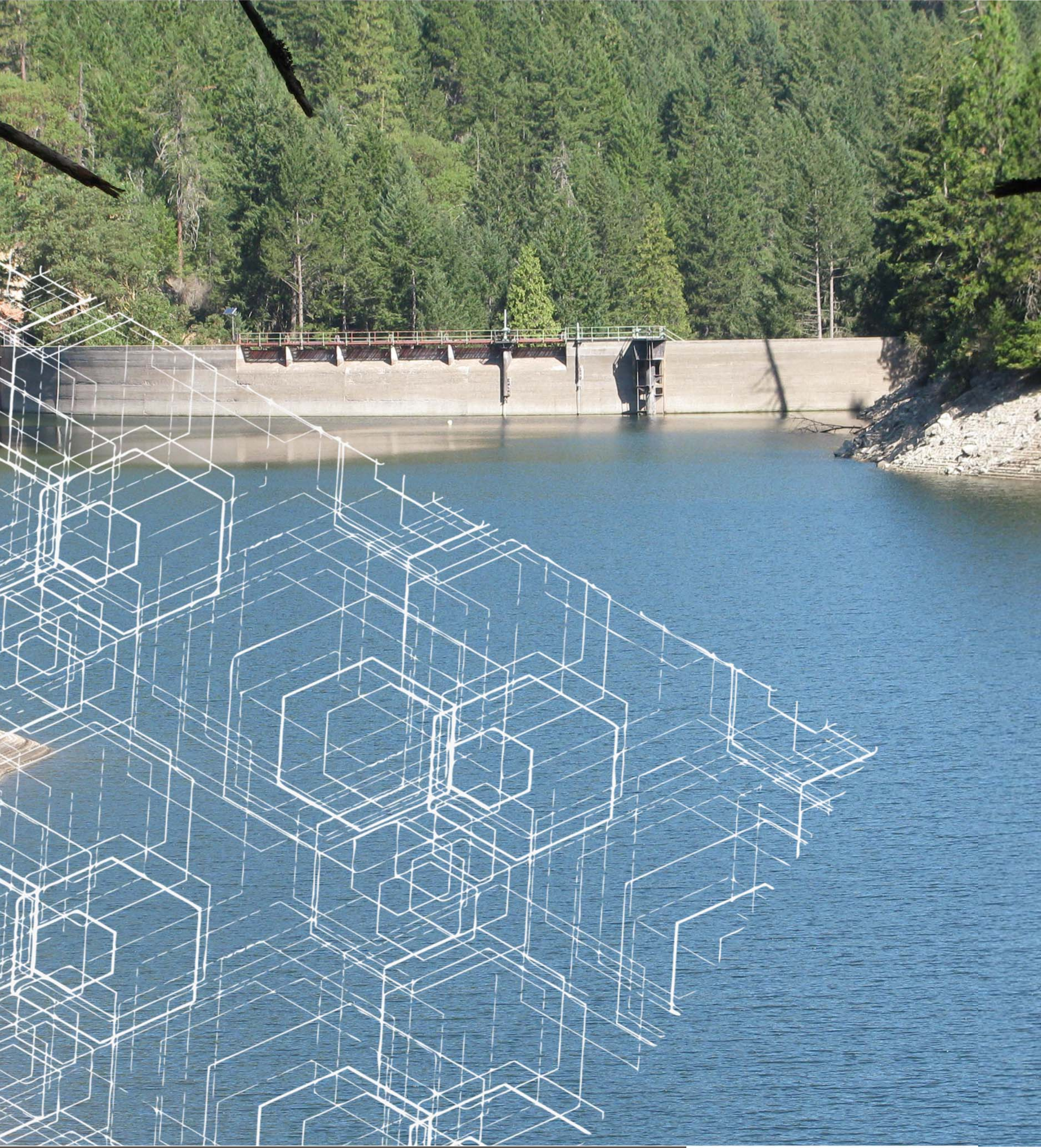

Appendix C
Additional Water Quality Data Gaps and Sampling

Get there!
KELLER associates

Technical Memorandum

Date:	Thursday, April 27, 2017
Project:	Ashland Water Treatment Plant
To:	James Bledsoe, Keller Associates
From:	Pierre Kwan, HDR
Subject:	Additional Water Quality Data Gaps and Sampling

Introduction

The City of Ashland (City) provided a considerable amount of data for the Keller/HDR team to analyze and establish the existing water quality. However, there are several gaps in the provided data set that need to be addressed prior to fully quantifying the existing water quality, which is the first step in designing and selecting the treatment process for the City's new water treatment plant. This memorandum summarizes the data gaps and provides a sampling schedule to address the gaps.

Ashland Creek/Reeder Reservoir

The City-provided water quality information for Ashland Creek/Reeder Reservoir does not include up to date results for iron, manganese or phosphorus. Iron and manganese are important factors because they are membrane fouling compounds, and membrane design will be impacted by the iron and manganese content in raw water. Phosphorus is a nutrient for biologically active direct filters and contributes to distribution system biofilms. We recommend that water samples be taken from June to October, the months where Reeder Reservoir is mostly like to experience stratification. The analytes for the samples are listed in the following Table 1. Water samples should be taken twice monthly and tested for iron, manganese and phosphorus.

Table 1. List of Field-Analyzed Analytes or Suite of Analytes for Reeder Reservoir Water

Analyte or Suite of Analytes	Frequency	Duration
Iron, Total	Twice per month	July through October
Manganese, Total	Twice per month	July through October
Phosphorus, Total	Twice per month	July through October

Talent Irrigation District

The City-provided water quality information for the Talent Irrigation District (TID) water supply consists of a single grab sample collected on August 20, 2009, with laboratory data reported on

September 11, 2009. While this single data point provides a good starting point for the conceptual planning effort, more data is required for preliminary and final design of the new Ashland Water Treatment Plant (WTP).

The following tables are requested for Keller/HDR to complete the Task 5 (Water Quality Analysis and Treatment Process Selection). For those analytes or suites of analytes collected daily, automated data collection will occur on a daily basis, with all data downloaded weekly.

Table 2. List of Field-Analyzed Analytes or Suite of Analytes for TID Water

Analyte or Suite of Analytes	Frequency	Duration
pH	Daily when algae is visible Weekly when algae is not visible	Duration of irrigation season
Temperature	Daily	Duration of irrigation season
Dissolved oxygen	Daily	Duration of irrigation season
Turbidity	Daily	Duration of irrigation season
Oxidation/reduction potential	Daily	Duration of irrigation season
Conductivity	Daily	Duration of irrigation season

Table 3. List of Laboratory-Analyzed Analytes or Suite of Analytes for TID Water

Analyte or Suite of Analytes	Frequency	Duration
Alkalinity	Monthly	Duration of irrigation season
Hardness	Monthly	Duration of irrigation season
UV-254 absorbance	Monthly	Duration of irrigation season
Total organic carbon	Monthly	Duration of irrigation season
Dissolved organic carbon	Monthly	Duration of irrigation season
Calcium	Monthly	Duration of irrigation season
Magnesium	Monthly	Duration of irrigation season
Apparent color	Monthly	Duration of irrigation season
True color	Monthly	Duration of irrigation season
Algae counts and enumeration	Monthly	Duration of irrigation season
Iron, Total	Monthly	Duration of irrigation season
Manganese, Total	Monthly	Duration of irrigation season
Strontium	Once	Duration of irrigation season

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Analyte or Suite of Analytes	Frequency	Duration
Chromium, Hexavalent	Once	Duration of irrigation season
Chromium, Total	Once	Duration of irrigation season
Silica	Once	Duration of irrigation season
Regulated Primary Inorganic Compounds	Quarterly	Duration of irrigation season or at least two samples.
All Regulated Synthetic Organic Carbon Compounds	Once	Once
All Regulated Volatile Organic Carbon Compounds	Once	Once
Aluminum	Once	Once
Chloride	Once	Once
Copper	Once	Once
Silver	Once	Once
Sulfate	Once	Once
Total Dissolved Solids	Once	Once
Zinc	Once	Once
Ammonia	Twice	Two sampling events
Phosphorus, Total	Twice	Two sampling events
Sulfide, Total	Twice	Two sampling events
Cryptosporidium	Monthly	Duration of 2018 irrigation season
Giardia	Monthly	Duration of 2018 irrigation season

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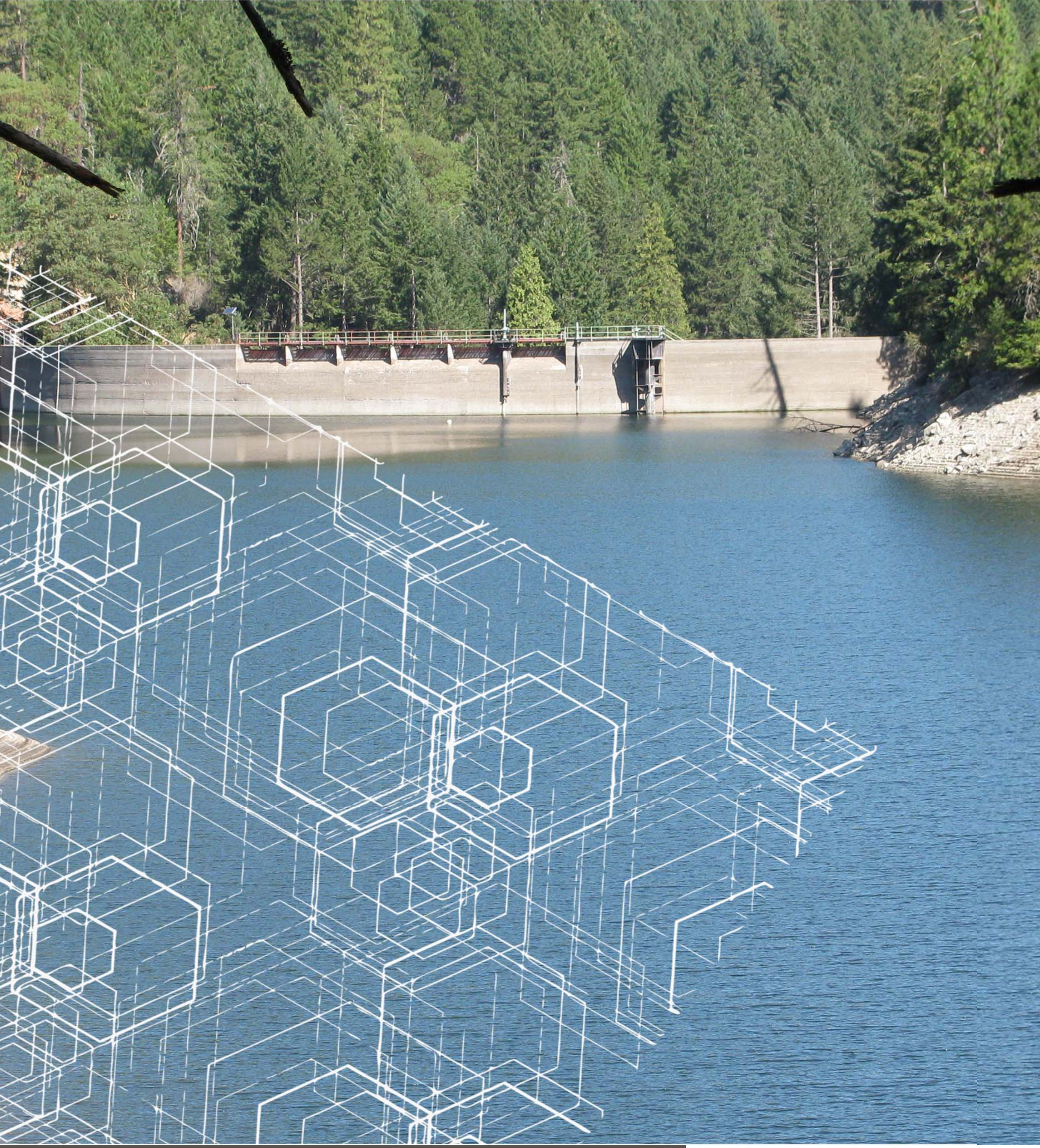

Appendix D
UV Peroxide Technology Review

Get there!
KELLER associates

Technical Memo

TO: Keller Associates Design Team

FROM: Conor M. Zoebelein

DATE: 5-12-2017

SUBJECT: UV Peroxide Technology Review

GOAL: UV-hydrogen peroxide treatment investigation for organic removal (DBP-precursors) using Reeder Reservoir as a source water. The treatment goals of the technology are to address the following:

1. 0.5-log removal of Giardia for disinfection credit
2. Treat T&O issues caused by geosmin produced by algal blooms in summer months
3. Provide AOP for treatment of cyanotoxins produced by blue/green algae

SUMMARY: The UV/peroxide system can offer 1-log removal of geosmin, 2-log removal of microcystin LR, and >0.5-log removal of *Giardia*. The UV/peroxide systems would operate with two units in parallel in two seasonal modes of operation. In winter, one unit would take all flow allowing the second unit to be removed from service for maintenance. Winter mode would run power at 8.75 kW (12.75 kW for 10 MGD) at 30% full power for disinfection alone and would not require peroxide. In summer, two units would receive ½ of the total flow each with one standby redundancy. Summer mode would require peroxide addition followed by chlorine addition for quenching of peroxide residual.

Option 1: 5 MGD flow UV/peroxide treatment with two (2) units and one standby
Option 2: 10 MGD flow UV/peroxide treatment with two (2) units and one standby

Figure 1. TrojanUV Swift ECT system. Uses UV-hydrogen peroxide to target contaminants on municipal scaled applications.

BACKGROUND

The Advanced Oxidation Process (AOP) UV-H2O2 functions by the production of hydroxyl radicals from hydrogen peroxide with exposure to UV light. Hydroxyl radicals react with organic matter, turning them into less harmful products or fully mineralizes them into CO_2 and H_2O. An example of this is outlined in equations 1 and 2, where equation 1 shows the formation of hydroxyl radicals from H2O2 and equation 2 shows the overall reaction with methanol as an example.

$$H_2O_2 + UV \rightarrow 2\dot{O}H \qquad \text{[Eq. 1]}$$

$$2CH_3OH + O_2 + UV \rightarrow 2CH_2O + 2H_2O \qquad \text{[Eq. 2]}$$

Equation 2 demonstrates that no H2O2 is consumed in the overall reaction for oxidation of methanol. While this is true, other side reactions can occur that scavenge hydroxyl radicals and consume H2O2.

UV/PEROXIDE SYSTEM

Option 1: Features for 5 MGD system for 12-week T&O event

- Uses 3x of SwiftECT 8L24
- Feed of 9 ppm peroxide (9026 gal/yr)
- Residual peroxide needs to be quenched with chlorine
- Disinfection (winter operation) requires operation of one 8L24 unit at 30% (8.75 kW)
- Dosing/injection system with 3000 gallon double walled storage tank
- Performance guarantee with supplied water sample
- Seasonal Operation Available
  - Winter operation is recommended with one unit treating the total raw water flow with two standby redundancies
    - Winter operation has no AOP and no peroxide addition
  - Summer operation is recommended with two units each taking ½ of total flow with one standby redundancy
    - Summer operation has AOP with peroxide and chlorine for quenching peroxide

Option 2: Features of 10 MGD system for 12-week T&O event

- Uses 3x of SwiftECT 16L30
- Feed of 7 ppm peroxide (14,591 gal/yr)
- Residual peroxide needs to be quenched with chlorine
- Disinfection requires operation of one 16L30 unit at 30% (12.75 kW)
- Master Control Panel (MCP) dosage control, monitoring, and shutoff of H2O2
- Control Power Panel (CPP) for UV control and system controls with PLC and SCADA systems
- Optiview system for monitoring UVT
- Dosing/injection system with 7800 gallon double walled storage tank
- Seasonal Operation Available (Same as Option 1)

EQUIPMENT & PRICING

The quantity and equipment needed for UV/peroxide system at the design criteria are shown in Table 7.2.

Table 7.2 UV/peroxide system equipment

General Line Items	Unit	Unit Price	Estimated Quantity	Cost (2017 dollars)
Capital Costs				
UV/peroxide System				$ 1,300,000
SwiftECT 16L30 (2 duty, 1 standby)	EA	-	3	Inclusive
Dosing/injection system	EA	-	1	Inclusive
ActicleanTM cleaning system	EA	-	1	Inclusive
Ballasts (1 per lamp)	EA	-	48	Inclusive
Control panels				
Control Power Panel (CPP)	EA	-	1	Inclusive
Master Control Panel (MCP)	EA	-	1	Inclusive
Optiview	EA	-	1	Inclusive
Hydrogen peroxide system				
7800 gallon storage tank	EA	-	1	Inclusive
Subtotal				***$ 1,300,000***