City of Pasco Washington

Butterfield Water Treatment Plant Facilities Plan

CIP Update - Aquatic Plants and Cyanotoxins

FINAL / October 2023

carollo

Butterfield Water Treatment Plant Facilities Plan

CIP Update - Aquatic Plants and Cyanotoxins

FINAL / October 2023

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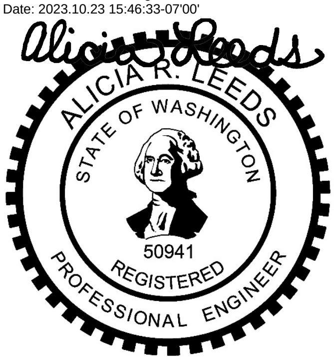

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Abbreviations

µg/L	micrograms per liter
Carollo	Carollo Engineers, Inc.
CIP	capital improvements plan
City	City of Pasco
GAC	granular activated carbon
HAB	harmful algal bloom
HAL	Health Advisory Level
hp	horsepower
MCC	motor control center
mgd	million gallons per day
O&M	operations and maintenance
PAC	powdered activated carbon
UV	ultraviolet
VFD	variable frequency drive
WTP	water treatment plant
µg/L	micrograms per liter

CIP UPDATE - AQUATIC PLANTS AND CYANOTOXINS

Carollo Engineers, Inc. (Carollo) worked with the City of Pasco (City) to develop the Butterfield Water Treatment Plant (WTP) Facilities Plan (Carollo, 2022), which defined a capital improvement strategy for addressing WTP deficiencies and encompassed a 20-year planning horizon from 2023 to 2042. The development of the plan involved a multi-year process that established performance goals for Butterfield WTP, reviewed past water quality, evaluated WTP performance and condition, evaluated alternatives for WTP processes, and developed a capital improvements plan (CIP) that included repair and replacement projects for the WTP. During the summer of 2021, while the sequencing of the identified CIP projects was being developed, the City and other utilities that utilize water from the Columbia River in this area experienced unprecedented raw water quality issues associated with record algae and aquatic plant (milfoil) growth and the presence of cyanotoxins.

As a result of this event the City asked Carollo and its subconsultant J-U-B to conduct additional data analysis and provide recommendations for remediation with respect to cyanotoxins and aquatic plants and prepare an alternate sequence of phased replacement of the Butterfield WTP that prioritizes meeting new water quality and facility operational challenges caused by climate-change. Having this information on-hand helps the City be better prepared for more frequent and greater intensity algae and aquatic plant growth as well as cyanotoxins in the Columbia River.

The analysis and recommendations to address the issues of cyanotoxins and aquatic plant growth were developed and documented in the Resiliency Plan: Cyanotoxins Technical Memorandum (Carollo, 2023) and the Butterfield Water Treatment Plant Intake Aquatic Plant Life Technical Memorandum (J-U-B, 2023). These memoranda are provided as Appendix A and B, respectively.

Cyanotoxin Mitigation and Treatment

The Resiliency Plan: Cyanotoxins Technical Memorandum analyzed data collected from the City and other nearby utilities treating Columbia River water as well as statewide and national cyanotoxin data. The analysis focused on the four most prevalent cyanotoxins: anatoxin-a, microcystin, cylindrospermopsin, and saxitoxin.

Cyanotoxins have been detected in the Columbia River and its tributaries for several years. However, significant algal toxins in the Columbia River, specifically in the Tri-Cities area, were not detected until the Summer of 2021. Samples from the Tri-Cities area water treatment facilities were collected from September through November 2021 these raw water samples focused on anatoxin-a, with 22 detects out of 96 samples ranging from 0.046 micrograms per liter (µg/L) at Butterfield WTP to 0.385 µg/L at Richland. Microcystins were below detectible limits during the 2021 WTP sampling, and saxitoxin and cylindrospermopsin were not sampled in the WTP dataset.

To better understand the cause of the 2021 harmful algal bloom (HAB), Carollo analyzed factors that favor cyanobacteria including water temperature and stream flow. Although there was no clear correlation in the dataset, it is likely that the combination of lower flows released from the Priest Rapids Dam and the hotter summer temperatures contributed to the 2021 HAB.

Utilizing the existing treatment processes and skillful operations staff, the Butterfield WTP was able to successfully remove raw water algal toxins to non-detectable levels in finished water samples throughout the 2021 HAB.

In order to provide water treatment plant resiliency for future HABs several alternative treatment methods were evaluated, with a focus on both near-term solutions, utilizing treatment tools already available at the Butterfield WTP and long-term solutions, using advanced treatment technologies.

The goals for treatment of algal toxins were established using a variety of public health reference sources, and are shown in Table 1. Design raw water concentrations and finished water goals used for this evaluation in bold.

Table 1 Raw Water Cyanotoxin Assumptions and Effluent Goals for Butterfield WTP

Toxin	Estimated Raw Water Concentration (μg/L)	Design Raw Water Concentration (μg/L)(1)	HAL (μg/L)	Finished Water Goal, (μg/L)
Anatoxin-a	14.4 (2)	**28.8**	0.3(3)	**0.20**(5)
Microcystins (total)	4.6 (4)	**9.2**	0.3	**0.24**
Cylindrospermopsin	7.0 (4)	**14.0**	0.7	**0.56**

(Estimated Raw Water → Design Raw Water: x2; HAL → Finished Water Goal: 80%)

Notes:
(1) Appendix A.1 of Washington State Department of Health's (DOH) Dealing with Cyanobacteria - Time to Make a Plan recommends a 2.0 safety factor to account for differences between laboratory and real-world results. Values presented in this table include the safety factor.
(2) Maximum shoreline concentration during the 2021 HAB event.
(3) Anatoxin-a HAL is the Ohio DOH value for sensitive populations.
(4) Maximum concentration found during 2018 algal bloom event in Salem, Oregon.
(5) Washington DOH threshold for increased monitoring, (0.2 μg/L) was used rather than 80% of the HAL (0.24 μg/L) since it is more conservative.

Using the cyanotoxin concentrations and treatment goals shown in Table 1, we evaluated the Butterfield WTP's current, near-term, and long-term treatment processes based on their ability to remove cyanotoxins. Cyanotoxin removal was modeled using CyanoTox®, a software developed by the American Water Works Association that calculates cyanotoxin oxidation based on recent experimental data and oxidation kinetics.

Based on the near-term analysis of the existing treatment tools provided at the Butterfield WTP the following conclusions were drawn:

- Butterfield WTP currently has limited contact time for permanganate which may limit the plant's effectiveness at treating anatoxin-a.
- A permanganate residual of 0.14 mg/L successfully treated anatoxin-a (28.8 μg/L) to below 80 percent of the Health Advisory Level (HAL) (0.24 μg/L) but was just above the raw water monitoring requirement (0.20 μg/L, 66 percent of the HAL).
- Maintaining current disinfection operations was sufficient to completely remove cylindrospermopsin in the clearwell.
- Microcystins are more difficult to treat at Butterfield WTP since permanganate and chlorine, the two oxidants available at Butterfield WTP, are both only moderately effective at oxidizing microcystins.

Because the existing treatment tools are not sufficient to fully treat the anticipated range and concentration of algal toxins that may someday be present in Columbia River water, additional analysis was conducted, evaluating the following long-term treatment technologies:

- Granular Activated Carbon (GAC).

- Powdered Activated Carbon (PAC).
- Ozone.

The results of this analysis are summarized in Table 2.

Table 2 Capital and Operation and Maintenance Costs for Long-Term Treatment Approaches

Technology	GAC Contactors	PAC	Ozone
Capital Cost	$12,257,000	$2,712,000	$24,463,00
Average Annual O&M	$2,011,000	$1,651,000	$198,000
20-Year NPV(1)	$48,787,000	$32,720,000	$28,061,000
Key Benefits	Only used when needed, low maintenance.	Only used when needed, low capital cost.	Year-round water quality improvements.
Key Challenges	Frequent media change-outs, intermediate pumping.	High maintenance, high solids production. Not compatible with direct filtration.	Complex ozone generation equipment.

Notes:
(1) 20-year NPV was calculated using the following rates: discount rate, 5.5%; inflation, 4%; real rate of return, 1.5%.
O&M - operations and maintenance.

Each of the evaluated long-term technologies provided treatment for the cyanotoxins of concern. However, based on the above evaluation, **ozone was the recommended long-term treatment technology for removing cyanotoxins.** Ozone provides several other process benefits in addition to cyanotoxin destruction, including lowering required coagulant dose, improving filter performance, removing organic compounds (when followed by biologically active filtration), removing taste and odor causing compounds, and potentially providing disinfection credit.

Aquatic Plant Life Mitigation at the Intake

During the summer months, the Butterfield WTP has experienced significant issues with plugging of the existing intake screens. The timing coincides with the fragmentation of milfoil which is likely the source of much of the aquatic material being caught on the screens. The existing screens and cleaning system were installed in 2015 and include two stainless steel wedge wire tee screens with an air burst cleaning system. The equipment was provided by Bilfinger Water Technologies, Inc. Screen cleaning is accomplished using an air burst system incorporating a 15 horsepower (hp) compressor and a 660-gallon horizontal receiver tank.

J-U-B reviewed diver video of the screen cleanings to determine the effectiveness of the screen cleaning system. In the videos showing the air bursts, it was noted that while the initial burst moved air out around the perimeter of the screen, the air immediately moved vertically toward the water surface and much of the debris moved back onto the screen surface, resulting in ineffectual clean. Because this automated system is unable to clean the screens sufficiently, the City has historically hired divers to manually clean the screens, in order to maintain water production at the WTP.

Several recommended improvements to the existing intake screen cleaning system and associated cost are summarized below:

- Increase Air Burst Frequency: *Negligible* (slight increase in power usage by compressor).
- Add Actuators to the Existing Intake Pipe Valves: *$48,000*.
- Added Storage and Compressor Capacity: *$125,000* (Cost assumes there is sufficient power available at the pump station to add the additional 25 hp compressor).
- Replace Air Pipes to Screens: *$180,000*.

However, given the magnitude of the existing screen plugging issues, it is not certain any of the options described above will sufficiently resolve the plugging problems. For a more robust and resilient screen cleaning solution, **replacement of the air burst screens with ISI mechanically cleaned screens was recommended.** This type of screen is currently in use at the City's intake facility. Assuming no significant modifications to the intake supports the cost to make change the screens to mechanically cleaned screens was estimated at $820,000.

CIP Update

The CIP originally incorporated into the 2022 Facilities Plan has been updated in order to incorporate the recommendations made in the Resiliency Plan: Cyanotoxins Technical Memorandum and the Butterfield Water Treatment Plant Intake Aquatic Plant Life Technical Memorandum.

The City has identified several low interest loan programs as well as grants that may help support additional capital expenditures in the near-term , allowing improvements at the Butterfield WTP to proceed more quickly, including implementation of the recommendations for algal toxin and aquatic plant resilience.

In order to incorporate these high priority improvements into the CIP, several modifications to the timing and sequence of CIP projects have been made. Additionally, some previously recommended projects have been made redundant with the reduced timeline of the CIP. As such, the 20-year CIP provided previously has been condensed into a 12-year CIP. A summary of these changes is provided below, with the refined list of projects provided in Table 3.

- Intake screen replacement (Project 16) has been added to the CIP to be completed as soon as possible, ideally in early 2024.
- Ozone (11) and Raw Water Pump Station Improvements (3) have been moved up in CIP to be constructed alongside the electrical building (1) and chemical building (5). These four projects are now slated to start in 2023 and continue through 2026 (Phase 1).
- Timing of the filters (6) and flocculation basins (8) have been adjusted to allow construction of these projects to begin in 2027 (phase 2), after completion of phase 1 construction.
- Flocculation and sedimentation basin improvements (4) has been removed due to the accelerated schedule. However, some advanced preventative maintenance is recommended in lieu of the complete project.
- Ultraviolet (UV) Disinfection (7) has been removed from the CIP due to the installation of ozone early in the CIP. Ozone will provide disinfection, making UV unnecessarily redundant.
- Slight adjustments to the burn rate for Residuals Improvements (Phase 1) (9), but project stayed starting in 2027.
- Misc. Improvements and Compressor Replacement (2) and WTP Repairs (15) have not moved from their priority position in 2023.
- The remaining projects, including Finished Water Pump Station (10), Residuals Improvements (Phase 2) (12), Admin Building (13), Backwash Lift Station Redundancy Improvements (14) have been moved up in the CIP schedule accordingly.

In addition to these changes, the costs indicated in the CIP have been updated for inflation to 2023 dollars, using the May 2023 Engineering News-Record U.S. 20-City Construction Cost Index.

Table 3 Refined List of CIP Projects

Project Number	Project Name	Project Description	Estimated Capital Cost (2023 Dollars)(1)
1	Electrical Building	▪ Upgrade the electrical power feed to the WTP, construct a completely new electrical building, and add a standby power generator and storage. New electrical building will include replacement of all major existing electrical system components including transformers, main distribution panels, and MCCs. New electrical building to be designed and sized to accommodate loads from current equipment and future electrical loads, including on-site hypochlorite generation, UV disinfection, and ozone generation.	$12,537,000
2	Miscellaneous Improvements and Air Compressor Replacement	▪ Near-term improvement projects to address aging equipment, resiliency/redundancy, and life safety of existing WTP, including: » Backwash System Improvements: Replace backwash flow control valve actuator to decrease risk of valve failing in an undesirable position and install second backwash flow control valve (in parallel or in series) to add redundancy to critical backwash system. ▪ Air Compressor Replacement: » Replacement of all three aging air compressors (two pneumatic valve compressors and one basin-air bubbler/deicer compressor). ▪ Seismic and Life Safety Improvements: » Lateral and longitudinal bracing on gallery piping. Additional required seismic and life safety improvements may come out of the recommended structural anchorage/seismic study. » Complete recommended structural anchorage/seismic study prior to completing these improvements. ▪ Raw Water Pump Station Reliability Improvements: » General repairs to the existing pump station, including replacement of leaking check valve on raw water pump 9.	$412,000
3	Raw Water Pump Station Improvements	▪ Improvements to the raw water pump station capacity and electrical system. Electrical improvements include replacement of aging electrical equipment, two new VFDs, and installation of a standby power generator and associated electrical equipment to power the raw water pump station and backwash lift pump station. Capacity improvements include replacement of the two smaller raw water pumps (pumps 1 and 3) with new 10 mgd pumps and new VFDs to provide 30 mgd firm capacity. Other improvements include installation of pressure indicators/transmitters on each raw water pump discharge, installation of a redundant level indicator/transmitter on the raw water wet well, and installation of security fencing and cameras around the raw water pump station and backwash lift station to reduce vandalism. ▪ Complete electrical study of the raw water pump station prior to this project or during preliminary design for this project. ▪ Complete raw water pump station capacity and hydraulics study prior to this project (including computational fluid dynamics modeling of the pumping wet well and pressure transient modeling of the raw water pump station).	$6,684,000
4	~~Flocculation and Sedimentation Basin Improvements~~	~~▪ Complete projects to address aging flocculation/mixing system and address identified issues in the flocculation and sedimentation basins. Replace aging and failing paddle flocculation system in north flocculation basins. Complete additional improvements and repairs identified for the flocculation and sedimentation basins.~~	~~$1,420,000~~
5	Chemical Building	▪ Construct a completely new chemical facility providing space and equipment for all existing WTP chemicals (alum, fluoride, caustic soda, potassium permanganate, and filter aid polymer). Chemical building to include facilities and equipment to replace existing chlorine gas system with new onsite sodium hypochlorite generation system. Chemical building will include space for ozone quench chemical needed at the time of ozone installation.	$18,111,000
6	Filters	▪ Construct new filter complex with eight new deep bed granular media filters.	$19,736,000
~~7~~	~~UV Disinfection~~	~~▪ Construct two new UV reactors housed in a dedicated building. UV disinfection must be in service prior to conversion to direct filtration.~~	~~$9,289,000~~
8	Flocculation Basins	▪ Construct two new flocculation basins, including a new flash mix system, flow control equipment, and conveyance channels. ▪ Conduct coagulation study as part of flocculation basin design.	$11,334,000
9	Residuals Improvements (Phase 1)	▪ Design and installation of a new residuals polymer feed system and upgrades to the existing decant drying bed outlet structures. ▪ Conduct residuals dewatering optimization study prior to project.	$1,328,000
10	Finished Water Pump Station	▪ Construct a new finished water pump station with new vertical turbine pumps and clear well sized to provide sufficient operational storage for WTP uses and virus inactivation with chlorine after conversion to direct filtration. ▪ Complete distribution study to determine hydraulic bottlenecks / high service pump pressure issues prior to this project.	$19,159,000
11	Ozone Treatment System	▪ Construct new ozone treatment system, including ozone generation, injection, and concrete ozone contactor.	$24,931,000
12	Residuals Improvements	▪ Construct a new (third) decant / drying bed.	$2,774,000
13	Administration Building	▪ Construct new administration building with an additional space dedicated for maintenance area.	$13,723,000
14	Backwash Lift Station Redundancy Improvements	▪ Rebuild the existing backwash lift station to accommodate a second (redundant) pump. ▪ Complete recommended study - survey and permitting study of existing backwash lift station facility - prior to this project.	$3,294,000
15	WTP Repairs	▪ WTP repair projects that may be included as allowances/adders to other CIP project or be completed by WTP staff, including: » General Structural Repairs: Miscellaneous structural repairs around the WTP to repair spalling concrete, cracking, and other areas of structural concern. ▪ Painting, Coating, and Corrosion Control: » General repair of existing coated surfaces, including non-destructive testing of corroded items, cleaning and re-painting of corroded pipelines. ▪ WTP Building Repairs: » General repair of the existing administration and chemical areas, including repair to the loading dock ceiling and plaster repairs on the treatment building exterior.	$182,000
16	Intake Screen Replacement	▪ Replacement of the existing intake screens with ISI style mechanical brush screens	$1,358,000

Notes:
(1) Costs are provided in May 2023 dollars. Project costs should be escalated for use during budgetary planning. At the time of the writing of this plan, a 4% annual escalation rate was deemed reasonable.
MCC - motor control center; mgd - million gallons per day; VFD - variable frequency drive.

Tables 4 and 5 provide a summary of the updated capital improvement plan. As shown, spending in earlier years has accelerated. Accounting for inflation (at an assumed 5 percent per year) accelerating CIP implementation in this way is expected to save nearly $30M over the previously proposed CIP that extended the time over which the project were completed.

The total WTP CIP cost over the next 20 years is approximately $136M in May 2023 dollars. This is, on average, approximately $6.8M per year over the planning period; however, these costs vary on a year-to-year basis depending on the target maximum annual CIP expenditure. Planning and executing long-term projects may move up on the schedule, or be reprioritized, depending on funding availability and options in the future.

The order of the projects shown in the CIP Summary was determined by feasibility (needing to maintain an operating facility) and urgency of project. Figure 1 illustrates the sequencing requirements and dependencies of these CIP Projects.

Table 4 Capital Improvement Plan Summary

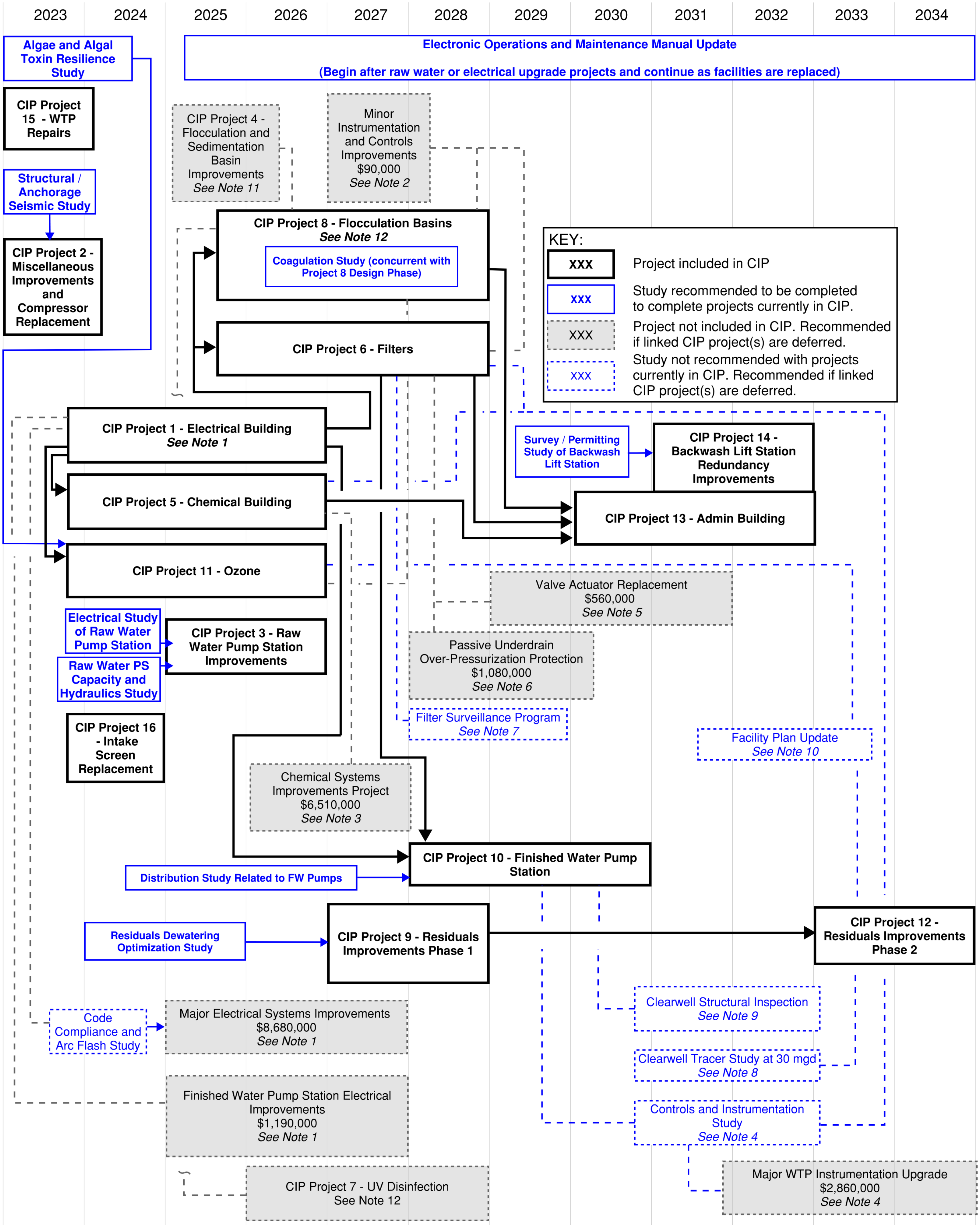
Project		Total CIP Cost Estimate (2023 Dollars)(1)	CIP Phasing											
			2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1	Electrical Building	$12,537,000	$251,000	$2,507,000	$5,015,000	$4,764,000	$-	$-	$-	$-	$-	$-	$-	$-
2	Misc. Improvements and Compressor Replacement	$412,000	$412,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
3	Raw Water Pump Station Improvements	$6,684,000	$134,000	$668,000	$3,342,000	$2,540,000	$-	$-	$-	$-	$-	$-	$-	$-
5	Chemical Building	$18,111,000	$181,000	$3,622,000	$7,788,000	$6,520,000	$-	$-	$-	$-	$-	$-	$-	$-
6	Filters	$19,736,000	$-	$-	$395,000	$1,579,000	$9,868,000	$7,894,000	$-	$-	$-	$-	$-	$-
8	Flocculation Basins	$11,334,000	$-	$-	$227,000	$907,000	$6,234,000	$3,967,000	$-	$-	$-	$-	$-	$-
9	Residuals Improvements (Phase 1)	$1,328,000	$-	$-	$-	$-	$133,000	$1,195,000	$-	$-	$-	$-	$-	$-
10	Finished Water Pump Station	$19,159,000	$-	$-	$-	$-	$-	$1,916,000	$9,580,000	$7,664,000	$-	$-	$-	$-
11	Ozone (including generation)	$24,931,000	$249,000	$4,986,000	$9,972,000	$9,723,000	$-	$-	$-	$-	$-	$-	$-	$-
12	Residuals Improvements (Phase 2)	$2,774,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$832,000	$1,942,000
13	Admin Building	$13,723,000	$-	$-	$-	$-	$-	$-	$-	$1,372,000	$6,175,000	$6,175,000	$-	$-
14	Backwash Lift Station Redundancy Improvements	$3,294,000	$-	$-	$-	$-	$-	$-	$-	$-	$1,318,000	$1,976,000	$-	$-
15	WTP Repairs	$182,000	$182,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
16	Intake Screen Replacement	$1,358,000	$136,000	$1,222,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
CIP Total (2023 Dollars)(1)		**$135,563,000**	**$1,545,000**	**13,005,000**	**$26,739,000**	**$26,033,000**	**$16,235,000**	**$14,972,000**	**$9,580,000**	**$9,036,000**	**$7,493,000**	**$8,151,000**	**$832,000**	**$1,942,000**

Notes:
(1) Costs are provided in May 2023 dollars. Project costs should be escalated for use during budgetary planning. At the time of the writing of this plan, a 4% annual escalation rate was deemed reasonable.

Table 5 Capital Improvement Plan Summary Continued

Project		CIP Phasing Summary			Project Driver			
		Short-Term (2023-2026)(1)	Mid-Term (2027-2030)(1)	Long-Term (2031-2034)(1)	Capacity	Aging Infrastructure	Water Quality	Safety
1	Electrical Building	$12,537,000	$-	$-	80%	20%	0%	0%
2	Misc. Improvements and Compressor Replacement	$412,000	$-	$-	50%	50%	0%	0%
3	Raw Water Pump Station Improvements	$6,684,000	$-	$-	50%	50%	0%	0%
5	Chemical Building	$18,111,000	$-	$-	25%	25%	25%	25%
6	Filters	$1,974,000	$17,762,000	$-	50%	50%	0%	0%
8	Flocculation Basins	$1,134,000	$10,201,000	$-	0%	50%	50%	0%
9	Residuals Improvements (Phase 1)	$-	$1,328,000	$-	100%	0%	0%	0%
10	Finished Water Pump Station	$-	$19,160,000	$-	50%	50%	0%	0%
11	Ozone (including generation)	$24,930,000	$-	$-	0%	0%	100%	0%
12	Residuals Improvements (Phase 2)	$-	$-	$2,774,000	100%	0%	0%	0%
13	Admin Building	$-	$1,372,000	$12,350,000	0%	100%	0%	0%
14	Backwash Lift Station Redundancy Improvements	$-	$-	$3,294,000	50%	50%	0%	0%
15	WTP Repairs	$182,000	$-	$-	0%	100%	0%	0%
16	Intake Screen Replacement	$1,358,000	$-	$-	50%	0%	50%	0%
CIP Total (2023 Dollars)(1)		**$67,322,000**	**$49,823,000**	**$18,418,000**	**$43,981,000**	**$51,250,000**	**$35,805,000**	**$4,528,000**
Annual Cost (2023 Dollars)(1)		$16,831,000	$11,463,000	$993,000	$2,199,000	$2,563,000	$1,790,000	$226,000

Notes:
(1) Costs are provided in May 2023 dollars. Project costs should be escalated for use during budgetary planning. At the time of the writing of this plan, a 4% annual escalation rate was deemed reasonable.



Notes:
1.) Major electrical system improvements recommended within 5 years (2027) if electrical building delayed. All subsequent facility expansion projects (CIP Project 5, 6, 7, 8, 11, and 13) cannot be completed without completing CIP Project 1.
2.) Complete project for instrumentation in floc/sed basins and existing filters in near-term if new filters (CIP Project 6)/floc basins (CIP Project 8) are delayed outside 10-year CIP window.
3.) Major chemical systems improvements recommended within 5 years (2027) if new chemical building delayed (CIP Project 5).
4.) Complete network, firewall, control system, and SCADA system upgrades within 10-year window if CIP projects 5, 6, 8, and 10 are delayed (delaying incremental instrumentation and controls upgrades). Replace aging instrumentation as needed.
5.) Actuator replacement recommended within 10 years (2032) if filters are not replaced (CIP Project 6).
6.) Passive underdrain over-pressurization protection recommended within 5 years (2027) if filters are not replaced (CIP Project 6).
7.) Filter surveillance recommended within 5 years (2027) if filters are not replaced (CIP Project 6).
8.) Clearwell tracer study required to achieve 30 mgd production through existing clearwell, if ozone (CIP Project 11) is not constructed.
9.) Clearwell structural inspection recommended within 10 years (2032) if new finished water pump station is delayed (CIP Project 10).
10.) Complete Facility Plan Update within 10 years if population growth, plant demands, and/or project implementation vary significantly from what is presented in this planning effort.
11.) Flocculation and Sedimentation Basin improvements, including critical flocculator repairs, recommended within 5 years if Flocculation Basins not constructed (CIP Project 8).
12.) Additional disinfection needed (either through UV or a larger clearwell) when switching to direct filtration (flocculation basins only) if ozone is delayed (CIP Project 11).

Figure 1 Updated CIP Project Sequencing and Dependencies

APPENDIX A RESILIENCY PLAN – CYANOTOXINS

City of Pasco Washington

Butterfield Water Treatment Plant Facilities Plan

Resiliency Plan - Cyanotoxins

FINAL / June 2023

carollo®

City of Pasco Washington

Butterfield Water Treatment Plant Facilities Plan

Resiliency Plan - Cyanotoxins

FINAL / June 2023

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Abbreviations

°C	degrees Celsius
µg/L	micrograms per liter
A	Anatoxin-a
AWWA	American Water Works Association
C	Cylindrospermopsin;
Carollo	Carollo Engineers, Inc.
CIP	capital improvements plan
City	City of Pasco
Cl2	Chlorine
DAF	dissolved air floatation
DBP	disinfection byproducts
DOH	Department of Health
EBCT	empty bed contact time
GAC	granular activated carbon
gpm/sf	gallons per minute per square foot
HABs	harmful algal blooms
HALs	health advisory levels
hp	horsepower
HRL	health reference level
KMnO4-	potassium permanganate
kVA	kilovolt-ampere
mg/L	milligrams per liter
mgd	million gallons per day
MIB	2-methyl-isoborneol
Mn	manganese
MRL	minimum reporting level
MS	Microcystin
N/A	non-applicable
No.	number
NOM	natural organic matter
NPV	net present value
O&M	operations and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
PAC	powdered activated carbon
ppd	pounds per day
PWS	Public Water Systems
QAPP	Quality Assurance Project Plan
scfh	standard cubic feet per hour

SMCL	secondary maximum contaminant level
UCMR4	4th Unregulated Contaminant Monitoring Rule
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV/AOP	ultraviolet/advanced oxidation process
WRF	Water Research Foundation
WTP	water treatment plant

SECTION 1 INTRODUCTION

From 2020 through 2022 Carollo Engineers, Inc. (Carollo) worked with the City of Pasco (City) to develop a Facility Plan for the Butterfield Water Treatment Plant (WTP). Developing this plan involved a multi-year process that established performance goals for Butterfield WTP, reviewed past water quality, evaluated WTP performance and condition, evaluated alternatives for WTP processes, and developed a capital improvements plan (CIP) that included repair and replacement projects for the WTP.

During the summer of 2021, while the sequencing of the identified CIP projects was being developed in the Facility Plan, the City and other utilities that utilize water from the Columbia River in this area experienced unprecedented raw water quality issues associated with record algae and aquatic plant (milfoil) growth and the presence of trace levels of cyanotoxins.

The purpose of this report is to provide background on cyanobacteria and cyanotoxin occurrence, summarize recent algal toxin events in the Columbia River, describe the current cyanotoxin regulatory climate, and develop recommendations for cyanotoxin resiliency.

SECTION 2 BACKGROUND

2.1 Cyanobacteria

Cyanobacteria, also commonly referred to as blue-green algae, are photosynthetic prokaryotic organisms that exist in many types of water, including lakes, rivers, and marine environments. Excessive cyanobacteria growth, commonly referred to as harmful algal blooms (HAB), can present ecological and public health concerns. Cyanobacteria can produce toxins that present recreational hazards and cause a public health risk for drinking water supplies. Cyanotoxins are produced and contained within the cyanobacterial cells (intracellular). The release of these toxins in an algal bloom into the surrounding water occurs mostly during cell death and lysis (i.e., cell rupture) as opposed to continuous excretion from the cyanobacterial cells. However, some cyanobacteria species are capable of releasing toxins (extracellular) into the water without cell rupture or death. Cyanobacteria can also produce non-toxic metabolites such as 2-methyl-isoborneol (MIB) and geosmin, both of which can cause an earthy or musty odor to the water thus presenting aesthetic concerns for drinking water supplies.

Several factors influence cyanobacteria growth, including high temperatures, high concentrations of nutrients (e.g., nitrogen and phosphorous), and thermal stratification of the water body. Newcombe et al. (2010) developed a HAB risk matrix, reproduced below in Table 1, that shows how each of these conditions can predict the risk for HABs.

Table 1 HAB Risk Matrix (Source: Newcombe et al. 2010)

HAB Risk	History of Cyanobacteria	Water Temperature	Total Phosphorous	Thermal Stratification
Very Low	No	Less than 15 °C	Less than 10 µg/L	Rare or never
Low	Yes	15 – 20°C	Less than 10 µg/L	Infrequent
Moderate	Yes	20 – 25 °C	10 – 25 µg/L	Occasional
High	Yes	Greater than 25°C	25 – 100 µg/L	Frequent and persistent
Very High	Yes	Greater than 25°C	Greater than 100 µg/L	Frequent and persistent/strong

µg/L - micrograms per liter; °C - degrees Celsius

2.2 Cyanotoxins

This report focuses on the four most prevalent cyanotoxins: anatoxin-a, microcystin, cylindrospermopsin, and saxitoxin. The following information (from *Managing Cyanotoxins in Drinking Water: A Technical Guidance Manual for Drinking Water Professionals,* American Water Works Association (AWWA), Water Research Foundation (WRF) 2016 and *Dealing with Cyanobacteria: Time to Make a Plan, Guidance for Developing a Harmful Algal Bloom Management and Response Plan,* Washington State Department of Health (DOH) 2022 summarizes the characteristics of each of these cyanotoxins.

- **Anatoxin-a** is the smallest of the cyanotoxins and is a potent neurotoxin. Anatoxin-a is one of the four main anatoxin congeners; the others are dihydroanatoxin-a, homoanatoxin-a, and dihydrohomoanatoxin-a.
- **Cylindrospermopsin** is most commonly found in the southern United States[1]. Cylindrospermopsin has three known variants: CYL, 7-epiCYL, and deoxyCYL.
- **Microcystins** are perhaps the most heavily researched group of cyanotoxins. Unlike other cyanotoxins, microcystins are commonly bound within the cell and are only released into water when the cell ruptures.
- **Saxitoxin** is another potent neurotoxin with similar properties to anatoxin-a. Several states have established advisory levels for saxitoxin; however, data on the health effects associated with saxitoxin exposure are lacking. The United States Environmental Protection Agency (USEPA) is not currently considering saxitoxin for future regulation, so saxitoxin is only briefly covered in this report.

SECTION 3 EXISTING AND FUTURE WATER QUALITY REGULATIONS

The following subsections present the current state and federal regulations related to cyanotoxins. As described in these sections, cyanotoxins are closely monitored, but generally unregulated at this time. However, because cyanotoxins present a significant potential acute health risk, proactive planning is recommended for susceptible water supplies to ensure treatment is in place in the event of an HAB.

[1] While most commonly found in the southern US, cylindrospermopsin has been detected in the northwest. It was found in the North Santiam River (Salem, Oregon) and in their distribution system during the City of Salem's 2018 cyanotoxin event.

3.1 Current Regulatory Climate

Cyanotoxins are not currently regulated in the United States by an enforceable national primary drinking water standard. However, because cyanotoxin-creating HABs are increasingly common and because of the health risks associated with cyanotoxins, the USEPA issued health advisory levels (HAL) in May 2015 for microcystin and cylindrospermopsin.

The USEPA recommended lower HALs for children under the age of six, recognizing that young children are more susceptible than older children and adults since they consume more water relative to their body weight. HALs are non-enforceable guidelines "at or below which adverse health effects are not anticipated to occur over specific exposure durations." The microcystin and cylindrospermopsin HALs are based on a 10-day exposure duration.

In 2016, the USEPA published the 4th Unregulated Contaminant Monitoring Rule (UCMR4), which included ten cyanotoxins (total microcystin, six microcystin congeners, nodularin, anatoxin-a, and cylindrospermopsin). In UCMR4, all water systems using surface water or groundwater under the influence of surface water supplying more than 10,000 people were required to collect four consecutive monthly finished water samples between March 2018 and November 2020.

Results from UCMR4, summarized in Table 2, showed that few facilities had cyanotoxin concentrations exceeding the minimum reporting level: 0.02 percent exceeded for total microcystin, 0.04 percent exceeded for cylindrospermopsin, and 0.38 percent exceeded for anatoxin-a (USEPA, 2022). It should be noted that UCMR4 results only sampled presence in finished water and corresponding raw water concentrations, or occurrences are unknown.

Table 2 UCMR 4 Summary

Toxin	MRL (µg/L)	USEPA HRL (µg/L)	Number of Results Exceeding MRL	Maximum Concentration (µg/L)	Number of PWS with Results Exceeding the HRL
Total Microcystins	0.3	0.3	8 of 35,000 (0.02%)	0.83(1)	7 of 3,485
Microcystin-LR(1)	0.02	0.3	1 of 5(1) (20%)	0.08	0 of 5
Nodularin(1)	0.005	N/A	0 of 5(1) (0%)	N/A	0 of 5
Cylindrospermopsin	0.09	0.7	13 of 35,425 (0.04%)	0.87	1 of 3,484
Anatoxin-a	0.03	N/A	132 of 35,405 (0.38%)	13.2	N/A(2)

Notes:
(1) Microcystin congeners and nodularin were only analyzed in UCMR4 samples when total microcystin exceeded 0.3 µg/L; thus, there are very few results for the individual congeners and nodularin.
(2) Only one out of 3,484 public water systems with results had anatoxin-a in one sample above 0.7 µg/L.
HRL - health reference level; MRL - minimum reporting level; N/A - Non-applicable; microcystin congeners and nodularin were only analyzed when total microcystins were detected; PWS - Public Water Systems.

While the USEPA lacks enforceable cyanotoxin water quality standards, several agencies have established their own limits on cyanotoxins. Table 3 shows cyanotoxin advisory levels for several agencies.

Table 3 Cyanotoxin Advisory/Regulatory Concentration

Toxin	Agency	Adults and Children Over 6 years old (µg/L)	Children Under 6 years old (µg/L)
Anatoxin-a	Ohio DOH(4)	1.6	0.3
	California OEHHA	4(1)	4(1)
	Minnesota DOH	0.1(2)	0.1(2)
Microcystins	USEPA	1.6	0.3
	Oregon Health Authority(4)	1.6	0.3
	Ohio DOH	1.6	0.3
	California OEHHA	0.03(3)	0.03(3)
Cylindrospermopsin	USEPA	3	0.7
	Ohio DOH	3	0.7
	Oregon Health Authority	3	0.7
	California OEHHA	0.3(3)	0.3(3)
Saxitoxin	Ohio DOH	1.6	0.3
	California OEHHA	0.5(3)	0.5(3)

Notes:
(1) California OEHHA's notification level. Notification levels are health-based advisory levels established by the State Water Resource Control Board Division of Drinking Water for chemicals that lack regulatory standards. When notification levels are exceeded, the drinking water system is required to notify the local governing body of the local agency in which the users of the drinking water reside.
(2) From Minnesota Department of Health's Toxicological Summary for Anatoxin-a, 2016. CAS: 64285-06-9. This document recommends a short-term non-cancer risk advice of 0.1 µg/L.
(3) California OEHHA's interim notification level.
(4) Concentrations indicated for Ohio and Oregon are regulatory limits enforced at the state level.
OEHHA - Office of Environmental Health Hazard Assessment.

3.2 Washington Regulatory Climate

Washington has recreational guidelines for freshwater cyanotoxins, shown in Table 4; however, there are currently no state drinking water regulatory limits for cyanotoxins, and no current plan to develop them (from *Dealing with Cyanobacteria: Time to Make a Plan, Guidance for Developing a Harmful Algal Bloom Management and Response Plan, Washington State DOH* 2022). If a water system exceeds USEPA HAL for microcystins or cylindrospermopsin in treated drinking water, the Washington State DOH recommends a utility should provide a "do not drink" advisory to their customers (Washington State DOH 2022).

Table 4 Washington State Recreational Guidance for Freshwater Cyanotoxins (2021)

Toxin	Recreational Guidance
Anatoxin-a	1 µg/L
Microcystins	8 µg/L
Cylindrospermopsin	15 µg/L
Saxitoxin	75 µg/L

SECTION 4 CYANOTOXINS IN WASHINGTON

In 2005, the Washington State legislature established the Washington State Freshwater Algae Control Program. This program maintains a database and website that lists reported blooms and sampling results. The database relies on local jurisdictions and residents to make reports, so does not reflect a representative sampling of water bodies across the state. However, it does provide an indication of blooms observed and cyanotoxins detected.

Sampling and detection data are summarized in Table 5. Most of the samples for Columbia River-associated sampling occurred during 2021 and make up a significant portion of the overall Washington count. This could reflect an increased bloom occurrence or an increase in awareness/monitoring; the remainder of Washington did not exhibit the same increase for 2021. Anatoxin-a, microcystin, and saxitoxin were all detected in Columbia River associated sites in the 2007-2022 period. Cylindrospermopsin was not detected in the Columbia but was detected elsewhere in Washington.

Table 5 Count of Samples Collected and Cyanotoxin Detection in the Freshwater Algae Bloom Monitoring Program

	Washington(1) (2007 – 2022)		Washington(1) (2021)		Columbia River-Associated(2) (2007 – 2022)		Columbia River – Associated(2) (2021)	
Cyanotoxin	Samples Collected	Cyanotoxin Detections	Samples Collected	Cyanotoxin Detections	Samples Collected	Cyanotoxin Detections	Samples Collected	Cyanotoxin Detections
Anatoxin-A	9,360	1,710	945	181	108	88	79	68
Cylindrospermopsin	614	27	108	1	15	0	15	0
Microcystin	13,078	4,469	933	335	27	3	15	0
Saxitoxin	695	149	105	27	12	1	12	1

Notes:
(1) Inclusive of Columbia River associated sites.
(2) Database lists samples by collection location. These numbers reflect those location readily identified as being on the Columbia River.

SECTION 5 CYANOTOXINS IN THE COLUMBIA RIVER

As noted above, cyanotoxins have been detected in the Columbia River and its tributaries for several years. However, significant algal toxins in the Columbia River, specifically in the Tri-Cities area, were not detected until the Summer of 2021.

5.1 Summer 2021 Occurrences

During the summer and early fall of 2021, while the sequencing of the identified CIP projects was being developed, the City and other utilities that utilize water from the Columbia River in the Tri-Cities area experienced raw water quality issues associated with record algae and aquatic plant (milfoil) growth and the presence of cyanotoxins.

In early September 2021, several dogs died after swimming in the Columbia River, prompting increased recreational sampling along the banks of the river. During this sampling, anatoxin-a was detected near Richland. Consequentially, the facilities treating Columbia River water began sampling for cyanotoxins in their raw water.

During the 2021 HAB, recreational water quality samples were regularly collected from the same locations along the Columbia River Water in the Tri-Cities area from September to November 2021[2]. Only anatoxin-a was found above detectable limits in these recreational samples throughout the 2021 sampling period, occurring in 89 samples. Cylindrospermopsin, microcystins, and saxitoxin were sampled for but were not detected in these samples.

Figure 1 is a cumulative frequency graph of the anatoxin-a concentrations detected in recreational water quality samples. Approximately 14.4 percent of the samples exceed 0.3 µg/L (Ohio's advisory for children under six years old (see Table 3) and 4.2 percent of the samples exceeded 1 µg/L (Washington's recreational guidance limit (see Table 4). Approximately 2.3 percent of samples were above 4 µg/L, which exceeds advisory levels for all populations in jurisdictions with anatoxin advisory levels (See Table 3). This demonstrates that, while a significant portion of the concentrations were low, several detections occurred at levels requiring treatment if used as a drinking water source.

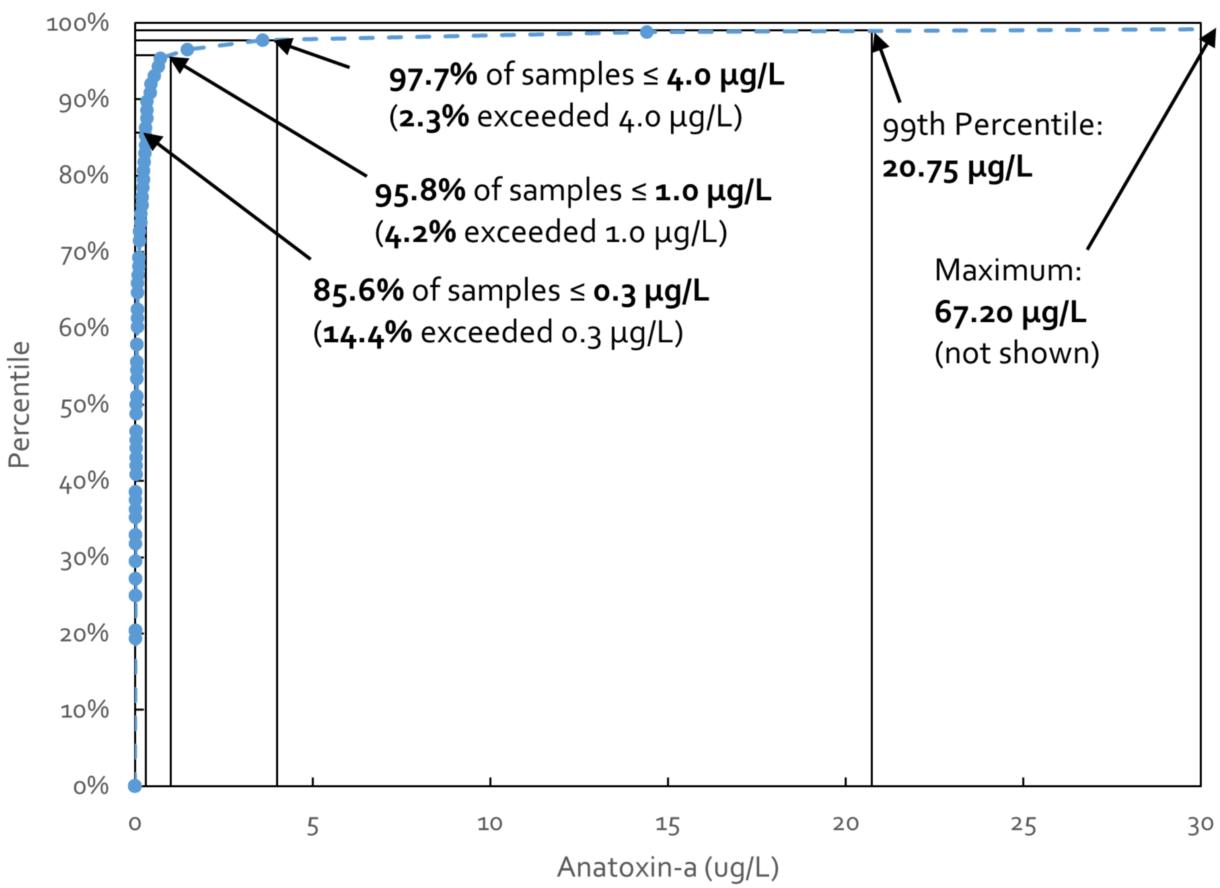


Figure 1 Recreational Water Samples for Anatoxin-a (2021)

[2] Some, but not all, of these samples are included in the WA State Freshwater Algae Control Database.

Water treatment plant raw water samples were collected from September through November 2021 and are summarized in Figure 2. As shown, these raw water samples focused on anatoxin-a, with 22 detects out of 96 samples ranging from 0.046 µg/L at Butterfield WTP to 0.385 µg/L at Richland. Microcystins were below detectible limits during the 2021 WTP sampling, and saxitoxin and cylindrospermopsin were not sampled in the WTP dataset.

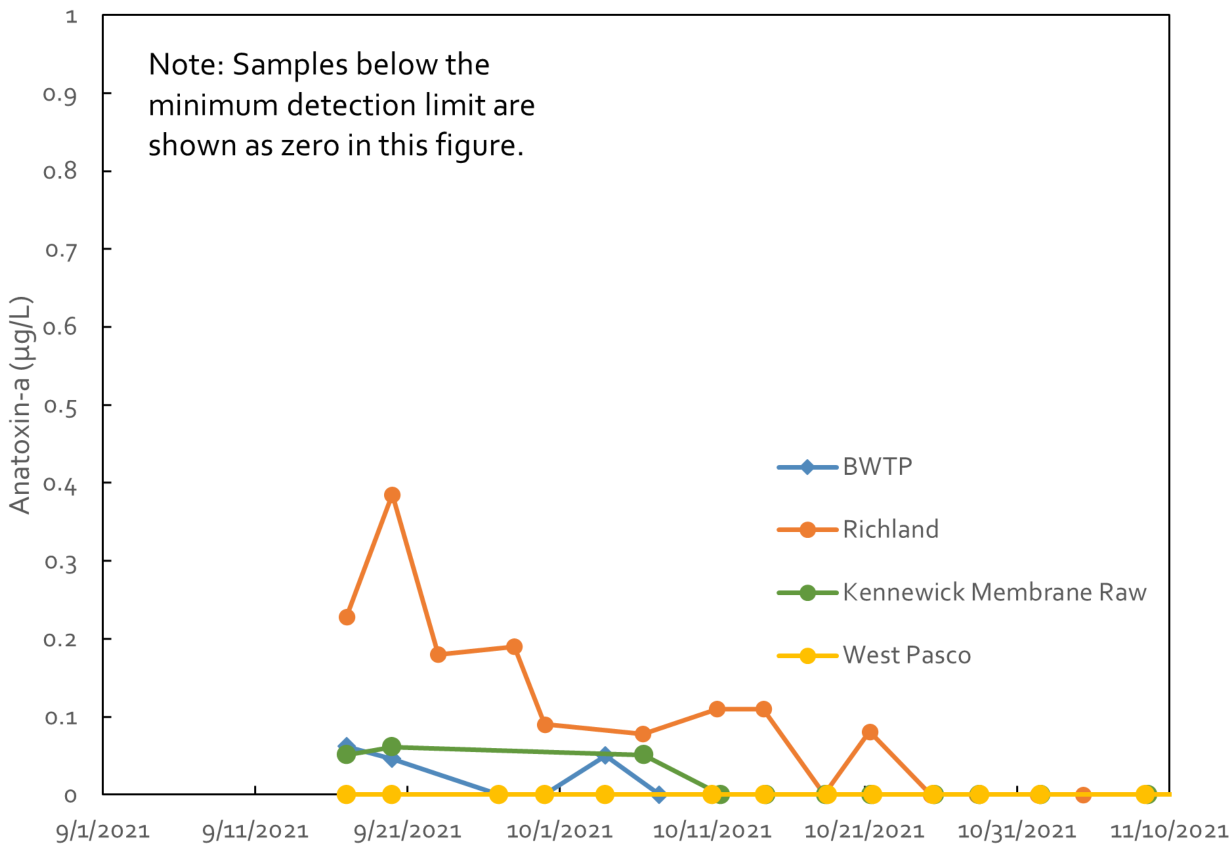


Figure 2 Raw Water WTP Samples for Anatoxin-a (2021)

5.2 Summer 2021 Conditions

Understanding the conditions that caused the 2021 HAB can help the systems treating Columbia River water make informed decisions on treatment strategies. Several factors can cause HABs including high temperatures, high concentrations of nutrients, slow-moving water, and thermal stratification of the water body. As such, we reviewed Columbia River flow data from the United States Geological Survey (USGS) just below the Priest Rapids Dam (USGS site number 12472800) and raw water temperature from the Butterfield WTP monthly reports to see if a relationship could be developed to help predict HAB formation potential.

Figure 3 shows the average daily Columbia River flow from 2012 to 2021. Compared with other years, the spring of 2021 had the lowest average flow while average summer flows were more typical. As can also be seen in the figure, fall flows, which correspond to the period cyanotoxins were observed, are historically lower than summer flows, with the average early Sept 2021 flow being lower than many other years.

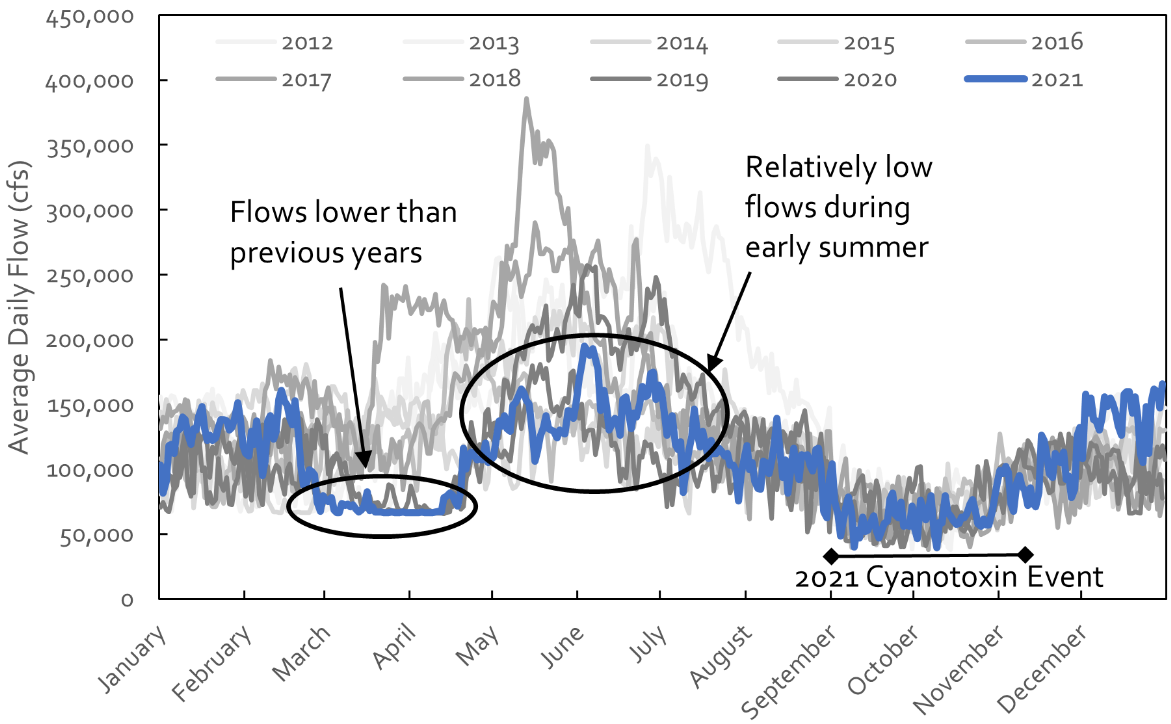


Figure 3 Columbia River Flow at Priest Rapids Dam from 2012 to 2022

Figure 4 shows the average monthly temperature of the raw water at Butterfield WTP from 2015 to 2022 (data from July 2020 through December 2020 was not available for this analysis). The months leading up to the HAB had higher than average water temperatures. Specifically, July had the second-highest average raw water temperature, and August had the hottest.

Ultimately, it appears likely that the combination of the relatively low flows released from the Priest Rapids Dam and the hotter summer temperatures contributed to the 2021 HAB.

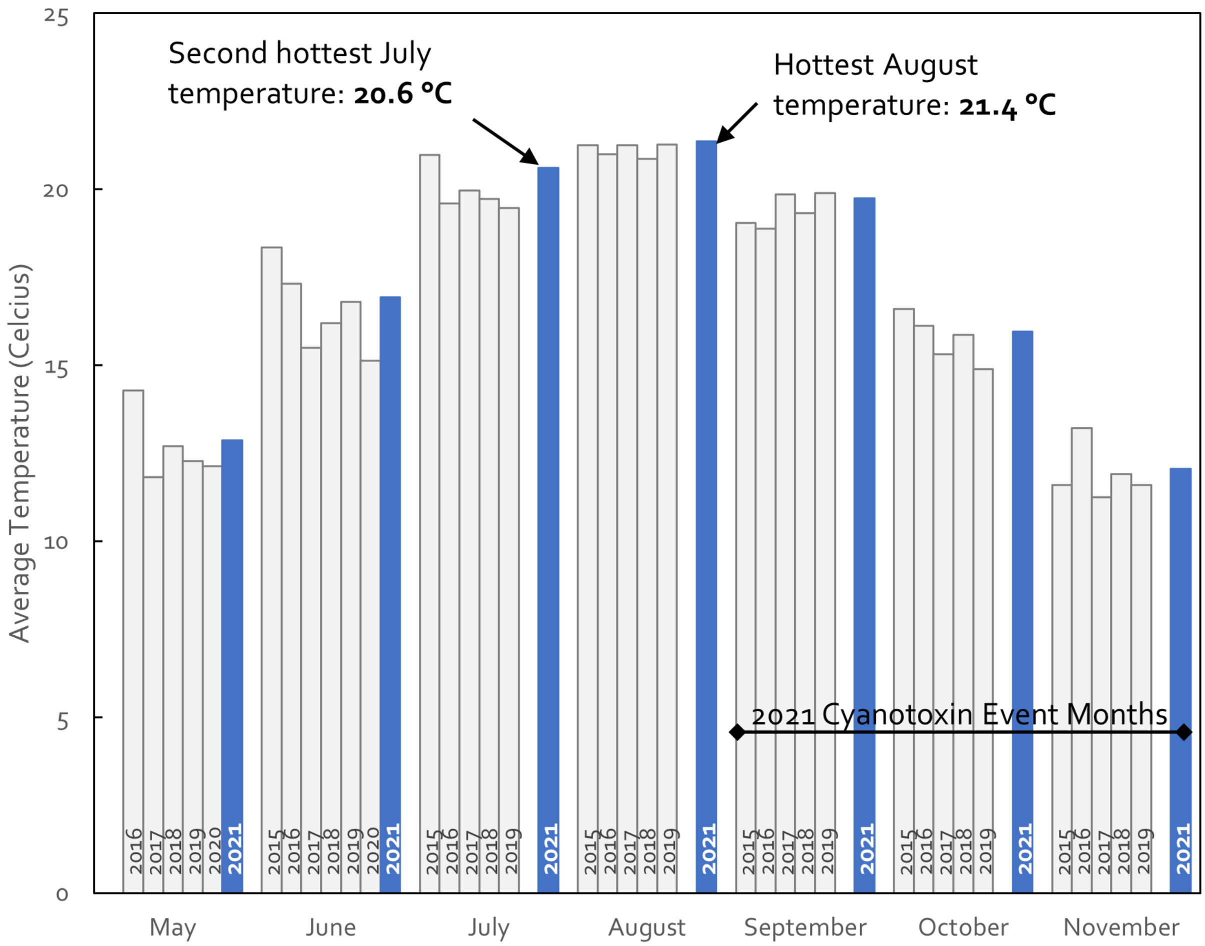


Figure 4 Average Raw Water Temperature at the Butterfield WTP from 2015 to 2022

5.3 Subsequent Actions

After the HAB in 2021 increased monitoring, communications, and collaboration between Oregon Health Authority and the Tri-Cities drinking water utilities regarding cyanotoxin monitoring and response was maintained. The following sequence of events summarizes key activities that occurred after and in response to the 2021 HAB:

- **February 2022:** Washington State DOH published "Quality Assurance Project Plan (QAPP) for Cyanotoxin-Producing Harmful Algal Bloom 2022 Monitoring in the Columbia River at Richland, Pasco, and Kennewick, Washington". This document established twice per month sampling of the drinking water intakes and established continuous and grab sample monitoring of algal growth indicators.
- **April 2022:** Washington State DOH revised "Dealing with Cyanobacteria: Time to Make a Plan. Guidance for Developing a Harmful Algal Bloom Management and Response Plan".
- **April 1, 2022,** to **November 30, 2022**: HAB monitoring, and sampling was conducted per the QAPP.

- **July 2022:** RH2 Engineering published *Algal Bloom Management and Response Plan*. This plan evaluated existing treatment systems, provided a recommended monitoring program, and proposed some long-term strategies for each facility treating Columbia River water in the Tri-Cities area. This response plan recommended the Butterfield WTP install a permanganate dosing system near the raw water intake to provide additional contact time for permanganate, which the City is currently implementing.
- **December 2022:** Several Agencies (Benton-Franklin Health District, Kennewick, Pasco, Richland, King County Environmental lab, DOH-Drinking water, DOH-Climate Change) met to review the Cyanotoxin 2022 season and plan for 2023. Through this meeting the associated utilities and agencies continued to refine the Columbia River Cyanotoxin Response Plan, including improvements to monitoring and public communications plans. As part of the December 20, 2022 meeting between the interested parties, the Washington State DOH recommended the trigger level for additional *raw water* monitoring is 0.2 µg/L for WTPs that can demonstrate an active robust treatment barrier for anatoxin-a. This value is used as the anatoxin-a *finished water* treatment goal in Section 6.3.1.
- **January 2023 to Present**: The City is currently working on adding a liquid sodium permanganate feed system into the raw water transmission line to both Butterfield WTP[3] and the West Pasco WTP, to have in place by the summer of 2023.

SECTION 6 CYANOTOXIN TREATMENT

The following sections summarize treatment options for cyanotoxins and evaluate their effectiveness and viability for implementation at the Butterfield WTP. This includes:

- An overview of cyanotoxins treatment methods and ways to remove or destroy them.
- A summary of Butterfield WTP's operations and treatment performance during the 2021 HAB.
- An evaluation of Butterfield WTP's existing treatment system and the near-term treatment strategy of installing a permanganate feed system, replacing the existing feed location for increased contact time.
- An evaluation of treatment technologies for use in a longer-term cyanotoxin treatment strategy.

6.1 Treatment Overview

This section provides an overview of the treatment technologies for intracellular cyanotoxins (found within cyanobacterial cells) and extracellular cyanotoxins (found outside the cyanobacteria cells).

6.1.1 Intracellular Cyanotoxin Treatment Technologies

Intracellular toxins exist within the cyanobacteria cells. Up to 95 percent of anatoxin-a, cylindrospermopsin, and microcystin are typically found to be intracellular during a HAB (AWWA/WRF 2016). Treatment technologies for intracellular cyanotoxin removal typically focus on removing the intact cells, however, some oxidation chemicals can both rupture cells and remove the

[3] The Butterfield WTP currently doses potassium permanganate at the WTP, but the contact time is extremely limited. This project adjusts the dosing location to provide more contact time for treatment.

toxins inside. Table 6 summarizes the treatment processes used for algal cell removal (summarized from AWWA and the WRF *Managing Cyanotoxins in Drinking Water: A Technical guidance Manual for Drinking Water Professionals 2016)* and includes the relative cost of implementing each technology at Butterfield WTP.

Table 6 Common Cyanotoxin Treatment Practices and their Relative Effectiveness – Intracellular Cyanotoxins (modified from AWWA/WRF 2016)

Treatment Process	Relative Effectiveness	Relative Cost of Implementation
Conventional treatment (see Section 6.2.1)	Effective for the removal of intracellular/particulate toxins by removing, intact cells. Generally, more cost effective than chemical inactivation/degradation, removes higher fraction of intracellular taste and odor compounds, and easier to monitor	Currently implemented at Butterfield WTP
Dissolved Air Floatation	Effective for removal of intracellular cyanotoxins because many toxin-forming cyanobacteria are buoyant	$$$
Strainers	15-45 µm (typically 30-35 µm) strainers are somewhat effective at removing algal cells and large protozoans, but not viruses or bacteria. Micro-strainers can remove 40% to 70% algae and 5% to 20% turbidity (1)	$$
Membranes	Effective at removing intracellular/particulate toxins. Typically, membranes require pretreatment.	$$$
Pretreatment oxidation	Pre-oxidation processes can negatively impact cyanotoxin removal as oxidation may lyse cells, causing the cyanotoxins contained within to be released. However, ozone oxidation has been shown to be effective at both lysing cells and oxidizing the cyanotoxins within. This strategy can be effective, provided that the ozone dose and contact time are sufficient.	$$$

Notes:
(1) From AWWA's Manual of Water Supply Practices M57, Algae Source to Treatment.

6.1.2 Extracellular Cyanotoxin Treatment Technologies

Extracellular cyanotoxins are those released into water by the cell death or lysing of cyanobacteria. Once released, the primary treatment methods are destroying the compounds (e.g., chemical oxidation) or removing them (e.g., adsorption).

To facilitate discussion, the technologies were assigned icons, shown in Table 7, based on their ability to treat for cyanotoxins.

Table 7 Scoring Iconography and Corresponding Criteria

Robust Treatment Provided	Some Treatment Provided, With Limitations	Little or No Treatment Provided	Unknown Treatment Performance or Inadequate Information is Available
			?

Utilizing the above iconography, common cyanotoxin treatment practices were evaluated for each of the four common cyanotoxins, based on their relative effectiveness for extracellular cyanotoxin removal, as shown in Table 8.

Table 8 Common Cyanotoxin Treatment Practices and their Relative Effectiveness - Extracellular Cyanotoxin Removal

Technology(1)	Anatoxin	Cylindro	Microcystins	Saxitoxin	Relative Cost of Implementation
Chlorine	○	●	◐	◐	Already implemented
Chloramine	○	○	○	○	$$
Chlorine Dioxide	○	○	○	○	$$
Potassium Permanganate	●	○	◐	○	Already implemented
Ozone	●	●	●	○	$$$
UV/AOP	●	●	◐	?(3)	$$$
PAC(2)	●	●	●	●	$$
GAC(2)	●	●	●	●	$$$

Notes:
(1) Relative effectiveness for chlorine, chloramine, chlorine dioxide, potassium permanganate, ozone, and UV/AOP were modified from Washington State Department of Health's Guidance for Developing a Harmful Algal Bloom Management and Response Plan (2022).
(2) Adsorption effectiveness varies by carbon source and water chemistry.
(3) Inadequate information to determine UV/AOP effectiveness at treating saxitoxin.
GAC - granular activated carbon; PAC - powdered activated carbon; UV/AOP - ultraviolet/advanced oxidation process.

6.2 Treatment Evaluation: 2021 HAB

Utilizing the existing treatment processes, the existing treatment processes and skillful operations staff at the Butterfield WTP were able to successfully remove raw water algal toxins to non-detectable levels in finished water samples throughout the 2021 HAB. This section summarizes the treatment tools and operations that were effectively utilized to achieve this feat.

6.2.1 Existing Butterfield WTP Cyanotoxin Treatment Systems

Butterfield WTP's treatment process, shown in Figure 5, currently has three treatment technologies that can treat for cyanotoxins, both intracellular and extracellular:

- **Conventional Treatment:** (flocculation, sedimentation, and filtration). This treatment method removes intact algal cells but has limited effectiveness for cyanotoxin removal once cells have lysed.
- **Chlorine:** Butterfield WTP has two injection locations: one upstream of flocculation basin and one downstream of the filters. Chlorine injected upstream of the flocculation basin is used for disinfection when the clearwell cannot provide sufficient contact time.
- **Permanganate:** Potassium permanganate can be dosed upstream of the flocculation basins and has a short residence time in the raw water pipe before entering the flocculation basins.

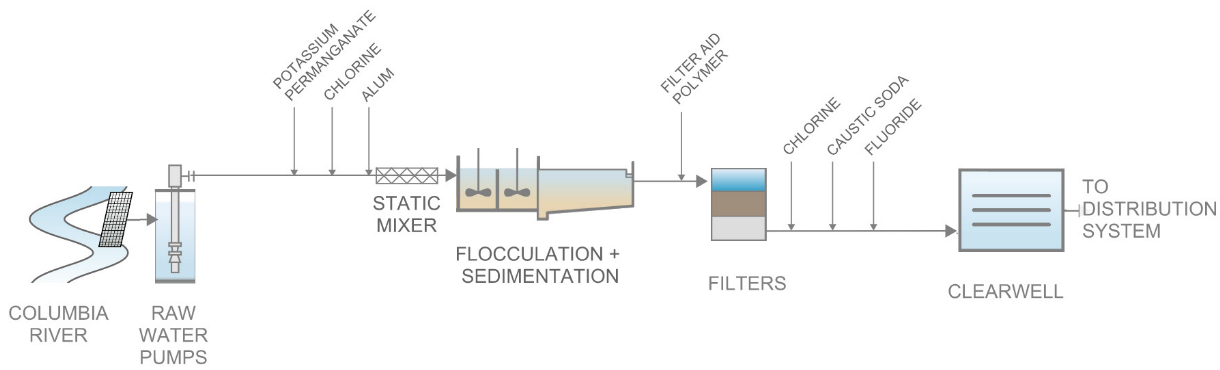


Figure 5 Simplified Process Flow Diagram for the Existing Butterfield WTP

Table 9 summarizes the existing Butterfield WTP treatment system's overall ability to remove cyanotoxin. Each of these technologies are discussed in greater detail in the following sections.

Table 9 Butterfield WTP Cyanotoxin Treatment Summary

Parameter	Intracellular	Extracellular			
		Anatoxin-a	Cylindrospermopsin	Microcystin	Saxitoxin
Chlorine	○	○	●	◐	◐
Permanganate	○	●	○	◐	○
Conventional Treatment	●	○	○	○	○

6.2.1.1 Conventional Treatment

Conventional treatment provides a robust barrier against intracellular cyanotoxins by coagulating and settling algal cells in the flocculation and sedimentation processes. Any remaining intact algal cells are filtered out in the filtration step. However, care must be taken in conventional treatment to limit lysing algal cells (through oxidation or aggressive agitation).

6.2.1.2 Chlorine

Free chlorine is the most common oxidant used in water treatment, both for pre-oxidation and primary disinfection. Free chlorine is a moderately strong oxidant that is highly effective at neutralizing viruses, moderately effective at neutralizing Giardia, and slightly effective at oxidizing some cyanotoxins and taste and odor compounds.

Butterfield WTP achieves disinfection via two chlorine dosing locations, one upstream of pretreatment and one at the upstream end of the clearwell.

As shown in Table 9, chlorine is ineffective at oxidizing anatoxin-a. It is therefore not considered as a stand-alone, robust technology for cyanotoxin treatment. However, it can be utilized with other technologies, that can effectively destroy other toxins in the water to create an effective strategy for cyanotoxin treatment.

6.2.1.3 Permanganate

Permanganate is a versatile oxidant for water treatment. It is typically used for iron and manganese removal, oxidizing some taste and odor compounds (hydrogen sulfide), control of nuisance organisms, and reducing the formation of disinfection byproducts (DBP) by oxidizing precursors. Permanganate also reduces demand for other disinfectants such as chlorine; however, it is a poor disinfectant and not typically used for this purpose. Two forms of permanganate are used at water treatment facilities:

- Potassium permanganate, currently used at Butterfield WTP, is typically stored dry (as a solid), and requires a dry feeder, mixing unit, solution storage tanks, and feed pumps.
- Sodium permanganate is delivered as a liquid solution and requires solution storage tanks and feed pumps.

Although permanganate provides several treatment benefits, it is an operationally difficult chemical to use. Over-dosing permanganate can cause a pink color in the water that is not removed during filtration, and dry-feed systems can be operationally intensive. Furthermore, the USEPA has a secondary maximum contaminant level (SMCL) for manganese (Mn), a component of permanganate, of 0.05 milligrams per liter (mg/L). Increasing or over-dosing permanganate can cause the finished water to exceed this SMCL[4.]

The historical average typical potassium permanganate dose at Butterfield WTP is approximately 0.19 mg/L (0.14 mg/L as potassium permanganate [$KMnO_4^-$]). Butterfield WTP. During the facility assessment, conducted as part of the Facility Plan (Carollo, 2022), staff noted that exceeding this approximate value had caused pink water challenges previously.

As noted with chlorine, permanganate alone will not provide a robust barrier against all cyanotoxins. Additional treatment barriers are required since permanganate is ineffective at oxidizing Cylindrospermopsin and only partially effective for microcystins.

6.2.2 Evaluation

Carollo reviewed Butterfield WTP operations data provided by the City during the 2021 HAB to confirm treatment performance. During the 2021 HAB, staff dosed potassium permanganate and chlorine upstream of the flocculation basins, and chlorine downstream of the filters. Table 10 summarizes the chemical doses and residuals throughout the event.

Table 10 Chemical Doses and Residuals during the 2021 HAB (September through November)

Chemical	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)
Potassium Permanganate Dose	0.14	0.17	0.24
Chlorine Residual, Pretreatment (1)	0.08	0.25	0.41
Chlorine Residual, Clearwell(2)	0.75	0.93	0.98

Notes:
(1) Measured at the sedimentation basins.
(2) Measured downstream of the clearwell.

[4] Additionally, Mn was in the list of contaminants sampled in UCMR4 and may be considered for future regulation as primary MCL. In Feb 2023, California State Water Board released draft notification and response level of 0.02 mg/L and 2 mg/L, respectively.

Anatoxin-a was the primary toxin of concern during the HAB, as no other cyanotoxins were above detectible limits in the relevant Columbia River raw water samples. Figure 6 shows the raw and finished water anatoxin-a concentrations at Butterfield WTP during the HAB and the health advisory limit (0.3 µg/L).

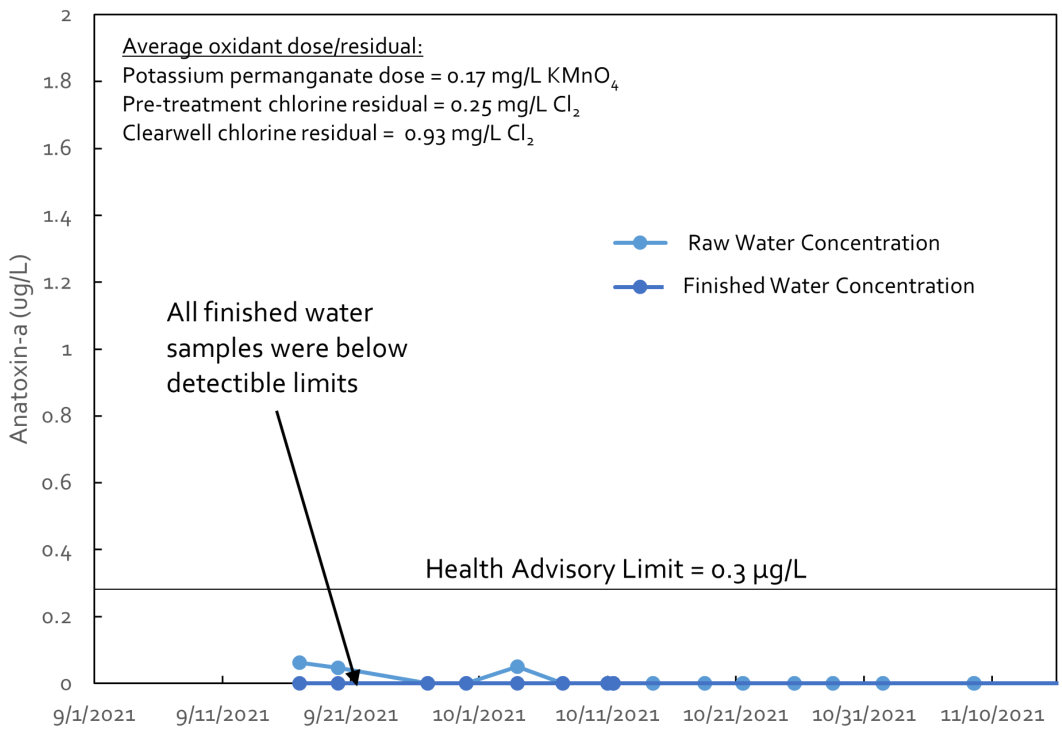


Figure 6 Summer 2021 Anatoxin-a Concentration at the Butterfield WTP

The following can be noted at Butterfield WTP based on the 2021 HAB event:

- All anatoxin-a samples at the plant effluent were below the detectible limit.
- All microcystin samples were below 0.3 mg/L.
- No cylindrospermopsin was found in the raw water samples.

6.2.3 Conclusions

The Butterfield WTP successfully treated water through the HAB– none of the finished water samples had measurable concentrations of anatoxin-a.

While the data shows Butterfield WTP successfully removed anatoxin-a, the City is proactively taking steps to improve Butterfield WTP's ability to treat cyanotoxins by adding an upstream permanganate dosing location (and discontinuing feeding at the existing location, but keeping the dosing location there for redundancy). Increasing the permanganate contact time may allow for higher permanganate doses, leading to increased cyanotoxin oxidation. However, as shown previously, permanganate alone is unlikely to remove algal toxins other than anatoxin-a.

The next section of this report evaluates Butterfield WTP's resilience to treat other cyanotoxins and at higher concentrations.

6.3 Treatment Evaluation: Existing and Near-Term

The previous section established that Butterfield WTP's existing treatment system successfully treated the 2021 HAB which consisted of measured concentrations of anatoxin-a alone. However, historical cyanotoxin data for the Columbia River relies on a limited data set. If future HABs occur, the cyanotoxin type and concentrations may differ from the 2021 HAB. Consequentially, this section evaluates the Butterfield WTP treatment processes' robustness in treating higher concentrations and different types of cyanotoxins.

Figure 7 shows Butterfield WTP's near-term treatment process, i.e., after installing the additional permanganate dosing location further upstream in the raw water pipeline. While this system will have the same three cyanotoxin treatment technologies as during the 2021 HAB, installing permanganate further upstream increases contact time for pre-treatment cyanotoxin oxidation.

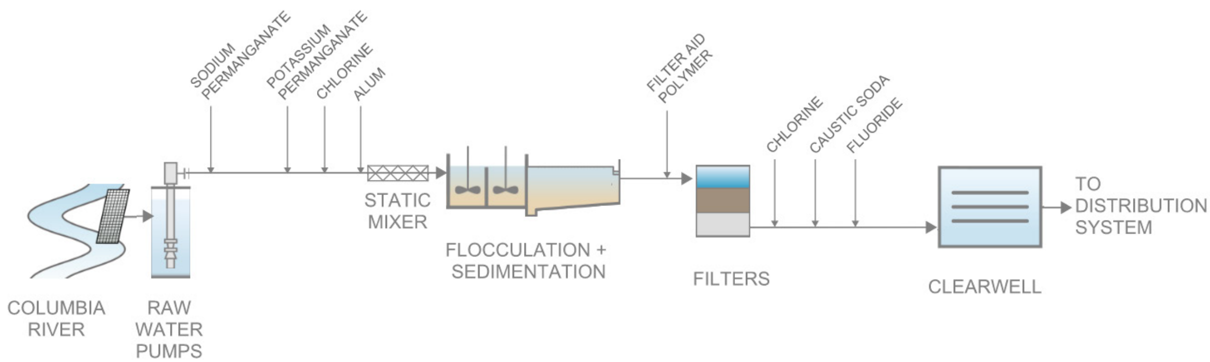


Figure 7 Process Flow Diagram – Near-Term

This evaluation of cyanotoxin removal uses the AWWA CyanoTOX®, an excel-based tool that models cyanotoxin destruction using kinetics and underlying equations and rate constants based upon the best-available peer-reviewed literature and accepted modeling principles. The results from this tool as presented in this report provide a planning-level estimate of treatment performance – actual results will vary depending on site-specific water quality and operating conditions.

6.3.1 Treatment Goals

Evaluating cyanotoxin removal requires establishing finished water goals and raw water cyanotoxin concentrations.

This evaluation sets the finished water goal as 80 percent of regulatory advisory levels for microcystin (USEPA) and cylindrospermopsin (USEPA) to conservatively evaluate treatment performance. Anatoxin-a does not have an EPA HAL, so 80 percent (0.24 µg/L) of Ohio DOH advisory level (0.3 µg/L) was initially considered. However, in the December 2022 Columbia River Cyanotoxin Response Plan meeting with Washington DOH and representatives from the surrounding treatment facilities, the DOH recommended increased monitoring from twice per month to twice per week once raw water samples exceed 0.2 µg/L anatoxin-a for facilities providing robust anatoxin-a treatment. This increased monitoring threshold, 0.2 µg/L, is more stringent than 80 percent of the advisory level (0.24 µg/L) and therefore was used as the finished water goal for anatoxin-a.

Since cyanotoxins in the Columbia River are a recent phenomenon, there is limited historical data for establishing raw water cyanotoxin concentrations. Consequentially, we reviewed the literature and several data sources for benchmarking:

- **Washington State DOH's Dealing with Cyanobacteria: Time to Make a Plan, 2022.** This document includes cyanotoxin concentration for waterbodies with public water system intakes. Table 11 summarizes the maximum water concentrations at various locations throughout Washington.
- **Measurements from the City of Salem's 2018 HAB.** Carollo's involvement in helping the City of Salem compare cyanotoxin treatment alternatives provided additional data for estimating maximum raw water concentrations.
- Recreational and treatment plant cyanotoxin measurements from the 2021 and 2022 Tri-Cities HAB.

Table 11 Washington Waterbodies with Public Water System Intakes and Cyanotoxin Detections (from Washington State DOH's Dealing with Cyanobacteria: Time to Make a Plan, 2022)

Name	County	Cyanotoxin	Date	Maximum Concentration
Crescent Lake	Clallam	Anatoxin-a	10/1/2019	0.010 µg/L
		Microcystins	10/1/2019	0.968 µg/L
Columbia River at Kennewick, Pasco, and Richland	Benton and Franklin	Anatoxin-a	9/2021 – 11/2021	14.4 µg/L(1)
Lake Margaret	King	Anatoxin-a	6/5/2027	0.027 µg/L
Lake McMurray	Skagit	Microcystins	8/10/2015	1.160 µg/L
Lake Whatcom	Whatcom	Microcystins	12/12/2017	0.200 µg/L

Notes:
(1) Maximum concentration of the shoreline samples.

Washington State DOH's *Dealing with Cyanobacteria- Time to Make a Plan* (2022) recommends applying a 2.0 safety factor to CyanoTOX® results to account for differences between laboratory and real-world results. This safety factor was applied to each raw water cyanotoxin concentration found as part of the literature/data review.

Table 12 shows the design raw water concentrations and finished water goals used for this evaluation in bold.

Table 12 Raw Water Cyanotoxin Assumptions and Effluent Goals for Butterfield WTP

Toxin	Estimated Raw Water Concentration (µg/L)	Design Raw Water Concentration (µg/L)(1)	HAL (µg/L)	Finished Water Goal, (µg/L)
Anatoxin-a	14.4 (2)	**28.8**	0.3(3)	**0.20(5)**
Microcystins (total)	4.6 (4)	**9.2**	0.3	**0.24**
Cylindrospermopsin	7.0 (4)	**14.0**	0.7	**0.56**

(Estimated → Design: x2; HAL → Finished Water Goal: 80%)

Notes:
(1) Appendix A.1 of Washington State DOH's Dealing with Cyanobacteria – Time to Make a Plan recommends a 2.0 safety factor to account for differences between laboratory and real-world results. Values presented in this table include the safety factor.
(2) Maximum shoreline concentration during the 2021 HAB event.
(3) Anatoxin-a HAL is the Ohio DOH value for sensitive populations.
(4) Maximum concentration found during 2018 algal bloom event in Salem, Oregon.
(5) WA DOH threshold for increased monitoring, (0.2 µg/L) was used rather than 80% of the HAL (0.24 µg/L) since it is more conservative.

6.3.2 Evaluation

Butterfield WTP's use of potassium permanganate and chlorine provides cyanotoxin oxidation: permanganate effectively destroys anatoxin-a, chlorine effectively destroys cylindrospermopsin, and both are somewhat effective at destroying microcystin. This evaluation investigates the combined effects of chlorine and permanganate at destroying cyanotoxins and meeting finished water quality goals for existing and near-term operations.

Both existing and near-term treatment evaluations use the existing chlorine dosing locations and doses but differ in the permanganate dosing location. The existing treatment evaluation assumes permanganate dosed at the static mixer, shortly before water enters the flocculation basin inlet channels. The near-term evaluation assumes the permanganate injection has been relocated near the WTP's intake structure, thus increasing the contact volume for algal toxin destruction. The following oxidant dosing locations and operational constraints were used for the evaluations:

- **Permanganate dosed in the raw water pipe at the current location for the short-term evaluation or near the raw water pump station for the near-term evaluation.** The maximum potassium permanganate residual was limited to 0.19 mg/L (0.14 mg/L as $KMnO_4^-$) based on historical operations and dosing limitations to avoid pink water.
- **Chlorine dosed in the raw water pipe upstream of the flocculation basins.** The average chlorine residual through pretreatment was 0.25 mg/L chlorine (Cl_2) during the 2021 HAB. The historical average chlorine dose during winter when cold water makes disinfection difficult is 0.2 mg/L. This evaluation calculates toxin oxidation using a chlorine residual of 0.2 mg/L through the sedimentation basins and excludes the additional contact time through the filters.
- **Chlorine dosed upstream of the clearwell.** Chlorine is added upstream of the clearwell to maintain the historical average chlorine residual, 0.95 mg/L, at pH 7.5.

These dosing locations and operational constraints, combined with existing design criteria and related associated parameters were used in the CyanoTOX® model to holistically evaluate potential treatment schemes. The results of this analysis are provided in the next section.

6.3.3 Results

Tables 13 and 14 summarize the CyanoTOX® results of the existing (Table 13) and potential near-term treatment strategy (Table 14) utilizing permanganate and free chlorine to destroy cyanotoxins. The tables below include operating conditions, cyanotoxin concentrations in the influent and effluent of each treatment process, and the maximum allowable cyanotoxin concentration that can be removed through each individual process while still meeting the treatment goals.

Table 13 Cyanotoxin Treatment Summary – Existing Conditions

Parameter	Raw Water Pipe			Flocculation and Sedimentation			Clearwell		
Chemical Dosing									
Total Plant Flow	30 mgd			30 mgd			30 mgd		
Oxidant	Permanganate			Chlorine			Chlorine		
Residual	0.14 mg/L as permanganate			0.2 mg/L as Cl_2			0.95 mg/L as Cl_2		
pH	8.1[1]			8.1[1]			7.5[2]		
Temperature	15 °C[3]			15 °C[3]			15 °C[3]		
Volume	940 gallons			1,896,000 gallons			450,000 gallons		
Baffling Factor	1.0			0.5 (flocculation), 0.4 (sedimentation)			0.7 [4]		
Contact Time	0.0063 mg*min/L			7.64 mg*min/L			14.36 mg*min/L		
Cyanotoxin Concentrations (μg/L)[5]									
Toxin	**A**	**MS**	**C**	**A**	**MS**	**C**	**A**	**MS**	**C**
Influent	28.8	9.20	14.0	27.3	9.20	14.0	27.2	7.25	1.13
Treatment Goal	0.20	0.24	0.56	0.20	0.24	0.56	0.20	0.24	0.56
Effluent	27.7	9.19	14.0	27.2	7.25	1.13	27.0	2.96	0.00
Maximum Influent Concentration To Meet Treatment Goal	0.21	0.24	0.56	0.24	0.30	6.72	0.20	0.59	>1,000

Notes:
(1) Average raw water pH between June and October from 2015 through 2022.
(2) Target pH for disinfection at Butterfield WTP.
(3) Lowest 50th percentile temperature between June and October from 2015 through 2022.
(4) The baffling factor used to calculate contact time through the clearwell is based on 2008 tracer study that was approved by the Washington State DOH.
(5) Theoretical oxidation performance/cyanotoxin removal was determined using AWWA's CyanoTOX® oxidation calculator. The kinetics and underlying equations and rate constants are based upon the best-available peer-reviewed literature and accepted modeling principles and are planning-level estimates of cyanotoxin concentrations. Actual destruction rates may vary depending on water quality.
A – anatoxin-a; C – cylindrospermopsin; mgd – million gallons per day; MS – microcystin.

Table 14 Cyanotoxin Treatment Summary - Near-Term

Parameter	Raw Water Pipe	Flocculation and Sedimentation	Clearwell
Chemical Dosing			
Total Plant Flow	30 mgd	30 mgd	30 mgd
Oxidant	Permanganate	Chlorine	Chlorine
Residual	0.14 mg/L as permanganate	0.2 mg/L as Cl_2	0.95 mg/L as Cl_2
pH	8.1[1]	8.1[1]	7.5[2]
Temperature	15 °C[3]	15 °C[3]	15 °C[3]
Volume	84,600 gallons	1,896,000 gallons	450,000 gallons
Baffling Factor	1.0	0.5 (flocculation), 0.4 (sedimentation)	0.7 [4]
Contact Time	0.57 mg*min/L	7.64 mg*min/L	14.36 mg*min/L

Parameter	Raw Water Pipe			Flocculation and Sedimentation			Clearwell		
Cyanotoxin Concentrations (µg/L)(5)									
Toxin	**A**	**MS**	**C**	**A**	**MS**	**C**	**A**	**MS**	**C**
Influent	28.8	9.2	14.0	0.24	8.62	14.0	0.24	6.80	1.12
Treatment Goal	0.20	0.24	0.56	0.20	0.24	0.56	0.20	0.24	0.56
Effluent	0.24	8.62	14.0	0.24	6.80	1.12	0.24	2.78	0.00
Maximum Influent Concentration To Meet Treatment Goal	24.12	0.26	0.56	0.20	0.30	6.72	0.20	0.59	> 1,000

Notes:
(1) Average raw water pH between June and October from 2015 through 2022.
(2) Target pH for disinfection at Butterfield WTP.
(3) Lowest 50th percentile temperature between June and October from 2015 through 2022.
(4) The baffling factor used to calculate contact time through the clearwell is based on 2008 tracer study that was approved by the Washington State DOH.
(5) Theoretical oxidation performance/cyanotoxin removal was determined using AWWA's CyanoTOX® oxidation calculator. The kinetics and underlying equations and rate constants are based upon the best-available peer-reviewed literature and accepted modeling principles and are planning-level estimates of cyanotoxin concentrations. Actual destruction rates may vary depending on water quality.

It is important to note that cyanotoxin oxidation follows second-order reaction kinetics, meaning the total amount of cyanotoxins the oxidants can destroy is higher if the starting concentration is higher. Conversely, lower cyanotoxin concentrations result in less cyanotoxin oxidation. For example, in Table 14, the microcystin concentration entering the clearwell is 6.8 µg/L, and the effluent concentration is 2.8 µg/L, meaning 4.0 µg/L microcystins have been oxidized. However, the maximum influent concentration that will result in meeting the 0.24 µg/L treatment goal is 0.6 µg/L, since the lower influent concentration (0.6 µg/L) results in slower reaction kinetics, thus less cyanotoxin oxidation.

To further explain the modeling results, Figure 8 graphically depicts modeled cyanotoxin concentrations through the existing and proposed (potential) treatment process. The darker bars show the influent cyanotoxin concentration being fed to each cyanotoxin removal process and lighter bars show the resulting effluent cyanotoxin concentration. As such, the initial raw water toxin concentrations for each cyanotoxin, defined in Tables 13 and 14 and derived from historical data in Table 12, are shown by the darker bar on the far left of each figure. The resulting finished water effluent concentration are shown by the lighter bars on the far right of each figure.

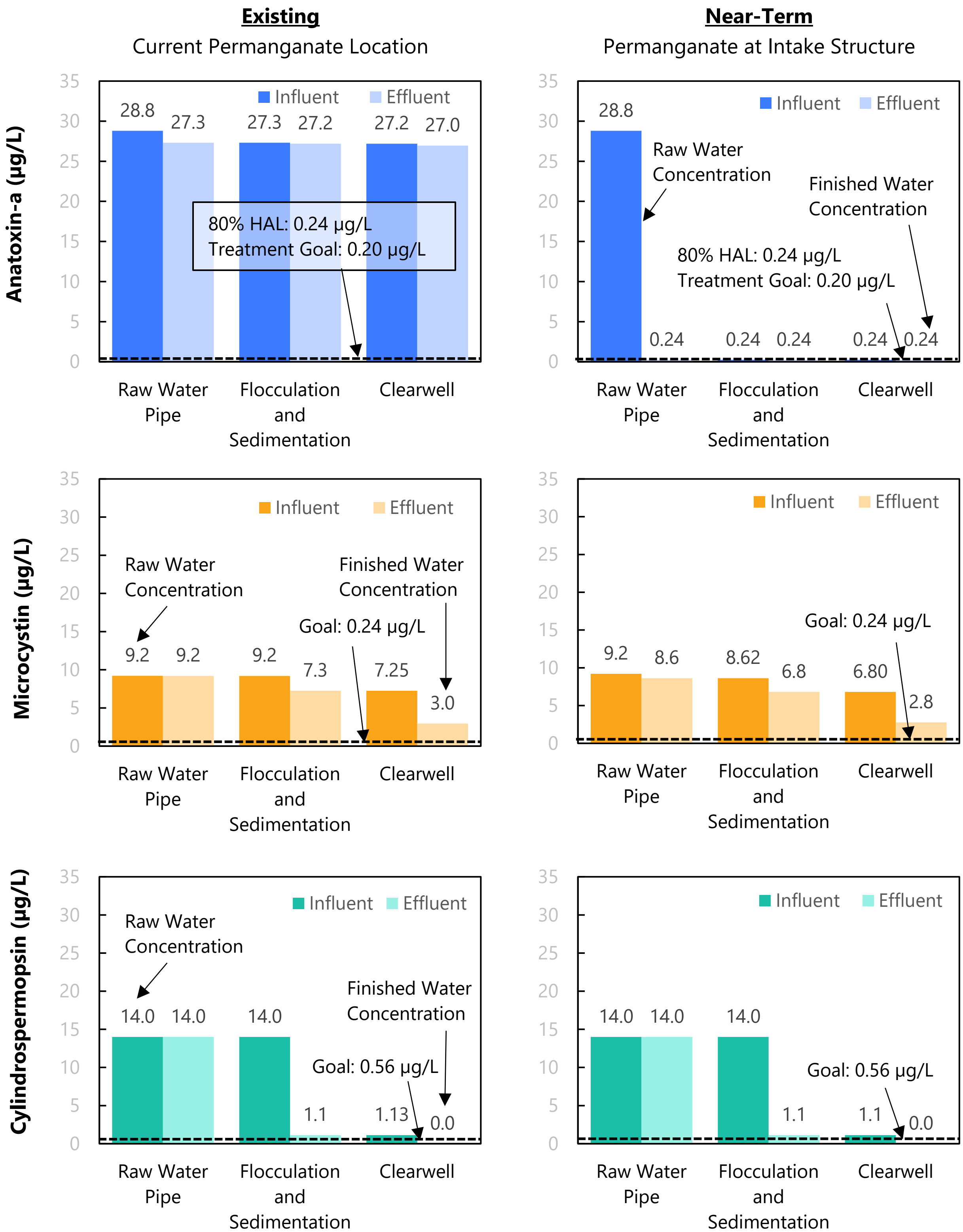


Figure 8 Cyanotoxin Treatment Performance – Short-Term (left) and Near-Term (right)

The key model results are summarized below:

- **Butterfield WTP currently has limited contact time for permanganate which may limit the plant's effectiveness at treating anatoxin-a.** Table 13 shows the maximum allowable anatoxin-a is 0.21 µg/L, only slightly above the 0.20 µg/L goal. This limited removal is attributed to the short contact time for permanganate to react with anatoxin-a – only a short run of pipe separates the permanganate injection from the flocculation basins. However, the near-term strategy of moving injection location further upstream considerably increases the contact volume. Doing so increases the maximum allowable influent anatoxin-a concentration from 0.21 µg/L to 24.1 µg/L.
- **A permanganate residual of 0.14 mg/L successfully treated anatoxin-a (28.8 µg/L) to below 80 percent of the HAL (0.24 µg/L), but was just above the raw water monitoring requirement (0.20 µg/L, 66 percent of the HAL).** Thus, if the WTP experienced the modeled conditions, the plant is anticipated reduce the concentration below EPA's HAL but will be above the goal of 0.2 µg/L.
- **Maintaining current disinfection operations was sufficient to completely remove cylindrospermopsin** in the clearwell. Maintaining 0.95 mg/L through the clearwell at pH 7.5 and 15°C can treat cylindrospermopsin concentrations of over 1,000 µg/L to the 0.54 µg/L treatment goal.
- **Microcystins are more difficult to treat at Butterfield WTP**, since both permanganate and chlorine are only somewhat effective at destroying microcystin at the conditions used for this analysis. Adding permanganate at the raw water pipe, chlorine at pretreatment, and chlorine upstream of the filters lowered microcystin concentrations from 9.2 µg/L (raw water) to 2.8 to 3.0 µg/L (plant effluent, depending on permanganate dosing location). The chlorine in the clearwell contribute the most to microcystin removal (removes approximately 4.0 to 4.3 µg/L) compared to chlorine in the flocculation and sedimentation basins (removes 1.8 to 1.9 µg/L) and permanganate in the raw water pipe (removes 0.0 to 0.6 µg/L).

Ultimately, relocating the permanganate dosing location further upstream can increase Butterfield's capability of removing anatoxin-a.

Furthermore, because of the difficulty in removing microcystins in the existing plant (regardless of whether the permanganate injection location is moved) with the near-term strategy, i.e., cyanotoxin oxidation with permanganate and chlorine, additional analysis was conducted to determine the operational upper limits of this scheme. This evaluation purposefully excluded removal from upstream basins since they are more subject to operating changes (e.g., lowering chlorine dose through the flocculation and sedimentation basins to reduce DBP formation will also lower cyanotoxin oxidation), thus conservatively modeling cyanotoxin destruction through Butterfield WTP. Figure 9 shows the potential effectiveness of this scheme at lower influent microcystins concentrations, lower Butterfield WTP production flowrates (increased contact time), and higher residual chlorine concentrations in the clearwell.

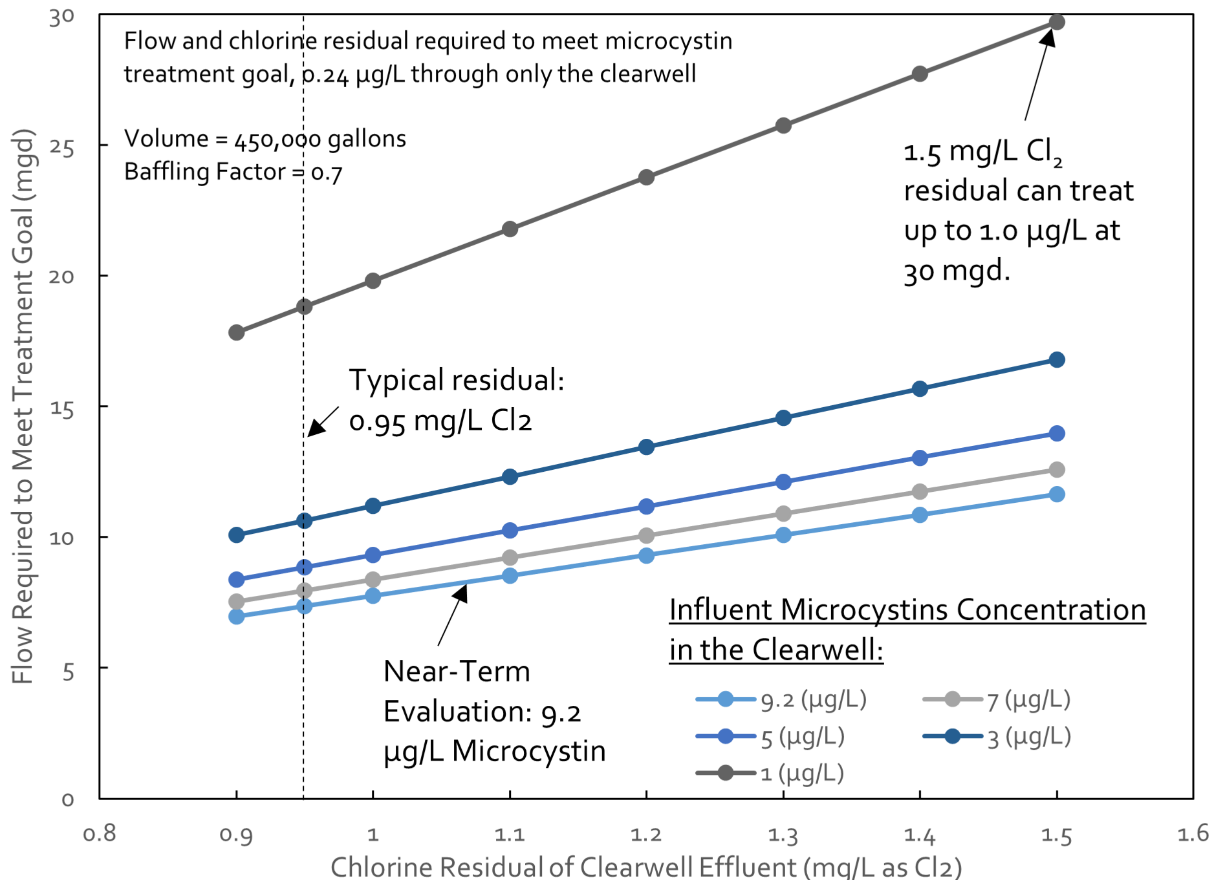


Figure 9 Flow and Chlorine Residual Required to Meet Microcystins Treatment Goal

As shown in Figure 9, microcystins removal down to the treatment goal of 0.24 µg/L is possible, provided influent microcystins concentrations are low enough, Butterfield WTP production flow rates are low enough, and chlorine residual is high enough.

6.3.4 Conclusions

The following conclusions can be made based on this evaluation using the CyanoTOX® modeling software and the assumed operating conditions:

- The near-term strategy of relocating the permanganate injection upstream can meet finished water goals for anatoxin-a and cylindrospermopsin at or below the design influent concentration.
- Microcystins are more difficult to remove through the existing treatment process than anatoxin-a and cylindrospermopsin. The current capacity of the clearwell can only treat an influent concentration of 0.6 µg/L at 30 mgd as shown in Table 14.
- Lowering the plant flow and/or increasing the chlorine residual downstream of the clearwell can sufficiently treat microcystins; however, doing so increases DBP formation potential.

6.4 Treatment Evaluation: Long-Term

Evaluation of the near-term cyanotoxin treatment scheme showed that Butterfield WTP can meet the anatoxin-a and cylindrospermopsin treatment goals and remove some of the potential microcystins. However, this approach is operationally difficult – it requires dosing permanganate with enough residual to oxidize anatoxin-a but without overdosing, creating pink water. Additionally, if microcystins occur, it is likely that the chlorine residual will need to be increased or flows restricted.

For the long-term evaluation, various treatment technologies and strategies that can provide robust cyanotoxin treatment for all anatoxin-a, microcystin, and cylindrospermopsin were screened. Preliminary screening of technologies shown previously in Table 6 and Table 8 was conducted before developing the detailed analysis and evaluation for a long-term treatment strategy. The following were eliminated due to their ineffectiveness for extracellular cyanotoxin removal or excessively high cost of implementation:

- **Dissolved air floatation (DAF):** While DAF is excellent at removing intact algal cells, it provides limited other process benefits. Furthermore, DAF is operationally complex, and cannot remove extracellular cyanotoxins. Adding this process only for intact algal cell removal would not be cost effective compared with other technologies as another technology would still be required for extracellular cyanotoxin removal.
- **Strainers:** Strainers provide no barrier against extracellular cyanotoxins so are not effective as a standalone cyanotoxin removal technology. However, strainers may be considered as an additional pre-treatment step to remove algae, thus intracellular cyanotoxins, upstream of the filters. This pre-treatment step could be advantageous should algae mats around the intake grow in such significance that high concentrations of algae drawn in through the intake begin blinding the filters and leading to short filter run times. Strainers are often the most cost-effective means for intact algal cell removal (when other raw water quality parameters do not govern pre-treatment needs) and can be considered alongside any of the other screened extracellular algal toxin alternatives.
- **Membranes:** Larger membranes (microfiltration) provide intracellular cyanotoxin removal but provide no treatment barriers for extracellular cyanotoxins. Reverse osmosis membranes can remove intracellular cyanotoxins, but capital and operations costs are prohibitively high.
- **Chloramine:** Chloramine is a weak oxidant common to many treatment plants, but it is ineffective at efficiently destroying cyanotoxins.
- **Chlorine dioxide:** Water treatment plants use chlorine dioxide for pre-oxidation and disinfection, but like chloramines, it is ineffective at oxidizing cyanotoxins.
- **UV/AOP:** While UV light is routinely used cost-effectively for disinfection, UV doses for cyanotoxin are orders of magnitude higher than disinfection, significantly increasing power demand. To create an AOP reaction, doses of chlorine or hydrogen peroxide must be used and then quenched with an additional chemical, resulting in substantial chemical costs. The high power and chemical consumption makes this technology economically unviable on both a capital and operations cost basis.

Based on this preliminary screening the following long-term treatment technologies were considered in more detail, since each provide robust cyanotoxin removal/destruction:

- GAC.
- PAC.
- Ozone.

Carollo reviewed each of the treatment technologies and considered how they can be implemented and integrated with other Butterfield WTP processes, to provide robust cyanotoxin treatment for Butterfield WTP. Each of the technologies were evaluated based on the following:

- Cyanotoxin treatment efficacy.
- Layout and integration with current and planned future Butterfield WTP processes.
- Power requirements.
- Hydraulic limitations.
- Process implications.

Additionally, cost estimates were prepared to evaluate the costs of each technology. The cost estimates in this document are equivalent to an Association for the Advancement of Cost Engineering Class 5 estimate, used for "order-of-magnitude" cost comparisons, with an expected accuracy range between -50 percent to +100 percent. All costs are presented in 2023 dollars and were developed using historical project costs and previous vendor quotes. The costs consist of two main components:

- **Capital costs:** These costs focused on the major facilities and equipment required for each technology with allowances for civil, mechanical, and electrical work.
- **Operations and Maintenance (O&M) costs:** These costs include major equipment power use, chemical use, disposal costs, and maintenance allowances.

The following general factors were applied to direct costs to estimate the total construction costs:

- Contractor Overhead and Profit: 10 percent.
- Sales Tax: 8.9 percent.
- General Conditions: 12 percent.
- Scope Contingency: 30 percent.

Engineering, administrative, and permitting costs were assumed as 25 percent of the construction cost. The following sections provide an overview of the screened cyanotoxin treatment technologies and describe the results of this evaluation.

6.4.1 Granular Activated Carbon

GAC is an adsorbent material used in water treatment as a stand-alone treatment process or as a filter media.

Activated carbon is a well-established technology for removing extracellular cyanotoxins. Key considerations for GAC effectiveness at removing cyanotoxins are the amount and characteristics (e.g., molecule size) of other natural organic matter (NOM) in the water, as this greatly influences adsorption capacity since it competes with cyanotoxins for adsorption sites. However, GAC can provide excellent cyanotoxin removal with fresh media (with available adsorption sites) and enough contact time (typically a minimum of 10 minutes).

For the Butterfield WTP, four options were considered:

- **Option 1:** Install GAC filter media in the existing filters.
- **Option 2:** Install GAC filter media in the future filters (filter adsorbers).
- **Option 3:** Install GAC filter media in new GAC contactors, downstream of filtration.
- **Option 4:** Install GAC in new pressure vessels downstream of filtration.

Further consideration ruled out Option 1, since the empty bed contact time (EBCT) is insufficient for cyanotoxin removal at current and future flows. The existing filters are shallow, dual-media filters designed with 20 inches of anthracite over 10 inches of sand. Replacing the existing anthracite with GAC (Alternative 1) results in an EBCT of 3.1 minutes at the current summer peak flow 22 mgd. This EBCT is well-below what is typically required or recommended for effective cyanotoxin removal (about 10 minutes).

Options 2 and 3 were also ruled out under further consideration due to cost and practicality:

- Installing GAC in new filters (Option 2) would require approximately 11 feet of GAC media to meet the target 10 minutes of EBCT at 30 mgd and a filtration rate of 8 gallons per minute per square foot (gpm/sf). While the media design could be made to work, utilizing the filters as adsorbers in this way means that the media would likely become exhausted (adsorption sites used up) very quickly from adsorbing NOM year-round. This would require frequent media change outs which is both complicated and costly.
- Meeting 10 minutes EBCT could be achieved with 66-inches of media at 4 gpm/sf in separate GAC contactors downstream of the existing filters (Option 3). These would be significantly larger contactor boxes, similar in shape and function but double the size of the filters. Intermediate pumping would also be required. All of these factors contribute significant costs.

Ultimately, installing GAC pressure vessels downstream of filtration (Option 4) was the only GAC based option used for further analysis.

6.4.1.1 Design Criteria

Installing GAC upstream of the filters will exhaust the GAC's adsorption capacity sooner than if installed downstream of the filters. As such, for this evaluation, GAC is assumed to be installed downstream of the filters. Additionally, the maximum headloss through the GAC contactors is approximately 20 feet (8.7 pounds per square inch). There is limited head downstream of the filters so an intermediate pump station must be installed.

Table 15 Design Criteria – GAC

Parameter	Value
GAC Contactors	
Type	Pressure Vessel
Flow	30 mgd
Number of Vessels (online + standby)	15 + 1
EBCT, one contactor offline	11.7 minutes
EBCT, all contactors online	12.4 minutes

Parameter	Value
Intermediate Pump Station	
Number of pumps (online + standby)	5 + 1
Flow, each	6 mgd
Power, each	35 horsepower (hp)

6.4.1.2 Additional Considerations

Table 16 provides an overview of additional considerations related to implementation and operation of GAC pressure vessels.

Table 16 Granular Activated Carbon Pressure Vessels – Additional Considerations

Parameter	Value
Treatment Mechanism	▪ Cyanotoxin removal via adsorption (primary mechanism). ▪ Algal cell removal via filtration (secondary mechanism).
Major Equipment	▪ Pressure vessels, GAC media, intermediate pump station.
Layout	▪ High number of vessels requires large footprint. ▪ Increases size of the future finished water pump station to backwash pressure vessels.
Hydraulics	▪ Requires intermediate pump station due to insufficient head downstream of filters. ▪ Approximately 20 feet of headloss through contactors at 30 mgd.
Power Requirements	▪ Intermediate pump station: 35 hp per pump (five total).
Process Implications	▪ Pros: » Can remove other organic contaminants such as pharmaceuticals. » Can be bypassed when cyanotoxins are not a concern, extending the life of the media. » Reduces DBP formation potential. » Can be designed and operated to develop a biofilm for additional treatment. » Similar operation to conventional filters. ▪ Cons: » Cannot carry chlorine residual through media, so a chlorine injection location must be installed downstream of the GAC contactors (before the clearwell). » Requires intermediate pumping if implemented at Butterfield WTP.

6.4.1.3 Costs

Table 17 shows the capital and average annual O&M cost for installing GAC pressure vessels at Butterfield WTP. Costs were developed with the following assumptions:

- Maximum flow: 30 mgd.
- Average summer flow: 26 mgd.
- Number of days in use per year: 120 days.
- GAC is replaced yearly and is trucked offsite for disposal.

Table 17 Granular Activated Carbon – Costs

Parameter	Cost
Capital Cost	$12,257,000
Average Annual OM Cost	$2,011,000
20-Year Net Present Value (NPV)	$48,787,000

Notes:
(1) 20-year NPV was calculated using the following rates: discount rate, 5.5%; inflation, 4%; real rate of return, 1.5%.

6.4.2 Powdered Activated Carbon

PAC is added directly to the WTP influent process stream, gaining contact time in raw water piping and the flocculation basins, and is removed through sedimentation. PAC is stored in either a silo or slurry tanks and is fed as a slurry to the dosing point.

PAC slurry systems typically consist of two to three slurry tanks that keep the PAC continually mixed while being stored and dosed. In slurry systems, a slurry pump station continuously recirculates the PAC slurry and provides the motive pressure for feeding PAC to the treatment process.

PAC silo systems store the PAC dry and use a dry feed system to meter the PAC into a high-pressure water eduction system. The eduction system also hydrates and conveys the PAC slurry to the dosing location. Because the PAC is stored as a dry, fine powder, installing a PAC silo system creates an explosive dust hazard which requires a hazard analysis and appropriate mitigation.

PAC is widely used as temporary treatment for sudden changes in raw water quality, such as taste and odor compounds and cyanotoxins. PAC is a non-selective technology that effectively adsorbs anatoxin-a, microcystins, and cylindrospermopsin.

While PAC can effectively remove cyanotoxins, the PAC dose required for treatment varies per toxin. Table 18 from the 2009 International Guidance Manual for the Management of Toxic Cyanobacteria shows typical suggested PAC doses for each cyanotoxin.

Table 18 PAC Doses Based on Influent Cyanotoxin Concentration (2009 International Guidance Manual for the Management of Toxic Cyanobacteria, IWA).

Toxin		Inlet Concentration (µg/L)	PAC Dose (mg/L)	Type of PAC
Microcystins	mLR	1 – 2	12 – 15	Chemically activated wood-based, or steam-activated high mesopore coal
		2 – 4	15 – 25	
	mLA	1 – 2	30 – 50	
		2 – 4	Not Recommended	
	mYR	1 – 2	10 – 15	
		2 – 4	15 – 20	
	mRR	1 – 2	8 – 10	
		2 – 4	15 – 20	
Cylindrospermopsin		1 – 2	10 – 20	As above
		2 – 4	10 – 15	
Saxitoxin		5 – 10 STX eq	30 – 50	Steam activated coal wood or coconut

Notes:
(1) General Recommendations for PAC Application in Source Water with a DOC of 5 mg/L or less and contact time of 60 minutes. These doses were estimated from laboratory experiments using the most effective PAC. The actual doses required will depend strongly on raw water quality and effectiveness of activated carbon. Site and PAC specific testing is recommended.

6.4.2.1 Design Criteria

For infrequent (seasonal) utilization of PAC a silo based dry PAC system is recommended. Storing PAC dry, instead of a slurry, provides significant benefits when it is not being fed constantly. The dry PAC may be stored in the silo, untouched from season to season, versus a PAC slurry that requires constant mixing and maintenance, even when not in use.

For storage of the dry PAC, bulk bags or a silo can be used. However, storage of bulk bags can be problematic, given the explosive hazard potential of the dry material. Additionally, emptying dry PAC bags requires additional personal protection gear and can be operationally challenging. As such the recommended design criteria includes the use of a PAC silo.

To establish the anticipated PAC dose, the design criteria utilizes the dose ranges established in Table 18. The selected dose range is considered typical based on design criteria from other utilities and bench scale testing of similar waters.

Using PAC generates significant solids. These solids must be removed in a sedimentation process (PAC use is not compatible with direct filtration). Because the solids generated from PAC use represents a significant impact to plant operations, criteria for solids handling is also considered as integral to this alternative.

Table 19 summarizes the design criteria for long-term implementation of PAC treatment at the Butterfield WTP.

Table 19 Powdered Activated Carbon – Design Criteria

Parameter	Value
PAC Storage	
Type	Silo
Storage Volume	1,200 cubic feet
Storage at max flow, average dose	3 days
PAC Feed	
Dosing Location	Raw water pipe near the raw water pump station
Flow, maximum	30 mgd
Dose, maximum	50 mg/L
Dose, average	30 mg/L
Feed Rate, max	12,500 dry ppd
Contact Volume	1,981,046 gallons
Contact Time	96 minutes
Solids Handling	
Dewatering Type	Geotextile dewatering bags
Percent Solids	25%
Polymer Use	12 lb polymer/dry ton PAC

6.4.2.2 Additional Considerations

Table 20 provides on overview of additional considerations related to implementation and operation of a PAC treatment system.

Table 20 Powdered Activated Carbon – Additional Considerations

Parameter	Value
Treatment Mechanism	▪ Cyanotoxin removal via adsorption.
Major Equipment	▪ PAC storage silo, dry feed system, screw feeder, dust collector, motive water booster pumps, eductor assembly, polymer system for geotubes.
Layout	▪ Smaller footprint compared to GAC pressure vessels, comparable to other types of chemical dosing systems. ▪ Requires conventional treatment (i.e., sedimentation basins). ▪ Can be installed near the intake, saving footprint at the Butterfield WTP.
Hydraulics	▪ No changes to hydraulic profile.
Power Requirements	▪ Exhaust blower: 2 hp. ▪ Hopper refill airlock rotary feeder: 1 hp. ▪ Volumetric screw feeder: 1 hp. ▪ Inlet supply booster pump: 2 hp. ▪ Air compressor system: 2 hp.
Process Implications	▪ Pros: » Reduces DBP formation downstream. » Removes other organic contaminants such as PFAS and pharmaceuticals. » Can remove color and taste and odor compounds. » Can be turned-off during seasons when cyanotoxins are not a concern. ▪ Cons: » Reacts with oxidants such as chlorine and permanganate which will lower their effectiveness. » Significantly increases solids production. » Cannot be used with direct filtration. » Additional complexity of settling out PAC upstream of conventional filters. » Additional polymer system requires additional land near the intake, which is already has limited site footprint.

6.4.2.3 Costs

Table 21 shows the capital and average annual O&M cost for installing PAC at Butterfield WTP. Costs were developed with the following assumptions:

- Average summer flow: 26 mgd.
- Average dose: 30 mg/L.
- Number of days in use per year: 120 days.
- PAC is installed near the raw water pump station.
- PAC solids are pumped to geotextile bags for dewatering.
- Solids are trucked offsite for disposal.

Table 21 Powdered Activated Carbon - Costs

Parameter	Cost
Capital Cost	$2,712,000
Average Annual O&M Cost	$1,651,000
20-Year NPV(1)	$32,720,000(1)

Notes:
(1) 20-year NPV was calculated using the following rates: discount rate, 5.5%; inflation, 4%; real rate of return, 1.5%.

6.4.3 Ozone

Ozone is a strong oxidant that is unstable and reacts quickly with dissolved organics, toxins, and pathogens in the water. Ozone can be applied at the entry to the WTP (pre-ozone) or just upstream of the filters (intermediate ozone).

Ozone is generated onsite in an ozone generator by applying a high voltage to molecules of oxygen. Oxygen for this purpose is typically stored in liquid form and vaporized before being fed to the ozone generators. The resulting ozone is dosed into the water stream via a side stream injection system or fine bubble diffusion configuration. An isolated concrete contactor structure then provides ozone contact time for the oxidation to occur before any remaining ozone is quenched. Any ozone that does not dissolve into the water is pulled from the contactor headspace and destroyed in dedicated ozone destruct equipment. A quenching agent is injected after ozone to remove any ozone residual.

Ozone is highly effective at neutralizing Giardia and viruses as well as effective at oxidizing most taste and odor compounds and many other contaminants of concern (including cyanotoxins, metals, pesticides, pharmaceuticals, and other organics).

Of the cyanotoxin destruction technologies considered (permanganate, chlorine, and ozone), ozone provides the most robust treatment for cyanotoxins. As shown previously in Table 9, ozone effectively treats anatoxin-a, microcystins, and cylindrospermopsin, but does not treat saxitoxin.

6.4.3.1 Design Criteria

Table 22 shows the ozone design criteria for Butterfield WTP. These criteria are from the 2022 Facilities Plan and are sized to remove taste and odor causing compounds, rather than criteria for cyanotoxin removal. The dose and contact time required for cyanotoxin destruction is much lower than the dose for taste and odor removal, so this higher dose governs treatment.

Table 22 Ozone – Design Criteria (from 2022 Facilities Plan, Appendix F)

	Units	Value
Design Flow Rate	mgd	30
Max Applied Dose	mg/L	2.3
Contactor		
Type		Concrete Basin
Number of Basins		2
Contact Time	minutes	12
Destruct Units (No./Size)	No./hp	3 (2+1)

	Units	Value
Ozone Generators		
Capacity (each)	ppd	320
Number of Generators	No.	2 (1+1)
Power Requirement (each)	kVA	100
Liquid Oxygen System		
Number of Tanks	No.	1
Volume	gallons	6,000
Vaporizer		
Type	-	Ambient
Number of Units	No.	2 (1+1)
Capacity (each)	scfh	3000
Cooling Water System		
Closed Loop Cooling Water Pumps		
Number of Pumps	No.	2
Power Requirement (each)	hp	2
Heat Exchanger		
Type		Plate and Frame
Open Loop Cooling Water Pumps		
Number of Pumps	No.	2
Power Requirement (each)	hp	3
Nitrogen Boost System		
Type		Dual compressors with receiver tank
Number of Compressors	No	2
Ozone Injection System		
Type	-	Side-stream
Side-stream Pumps (Number / Size)	No./hp	2 / 25

kVA - kilovolt-ampere; No. - number; ppd - pounds per day; scfh - standard cubic feet per hour.

6.4.3.2 Additional Considerations

Table 23 provides an overview of additional considerations related to implementation and operation of an ozone treatment system.

Table 23 Ozone – Additional Considerations

Parameter	Value
Treatment Mechanism	▪ Cyanotoxin destruction via oxidation.
Major Equipment	▪ Ozone generators, liquid oxygen storage, oxygen vaporizers, side stream injection equipment, ozone destruct units.
Layout	▪ Large footprint required for structures (ozone contactor, ozone generator building, however the footprint has already been included in the Facility Plan.
Hydraulics	▪ Approximately 2 – 5 feet headloss through contactor and associated conveyance infrastructure.
Power Requirements	▪ Ozone Generators: 100 kVA each (2 total). ▪ Cooling Water System Pumps: 2 hp each (2 total). ▪ Side Stream Pumps: 25 hp each (2 total).
Process Implications	▪ Pros: » Lyses algal cells and readily oxidizes any algal by-products released. » Oxidizes taste and odor causing compounds. » Alters structure of organic carbon in source water to make it more bioavailable for removal in biologically active filters; produces more stable water in the distribution system. » Potentially decreases coagulant use. » Consistently reliable for cyanotoxin removal and is operationally easier to dose compared to permanganate. » Potential for disinfection credit. ▪ Cons: » Complex ozone generation equipment. » Bromate formation if bromide is present in raw water source.

6.4.3.3 Costs

Table 24 shows the costs for installing ozone, which were developed with the following assumptions:

- Average annual flow = 17 mgd (future average daily demand).
- Average raw water dose: 1.0 mg/L.
- A continuous dose of 0.5 mg/L of calcium thiosulfate for quenching.
- Number of days in use per year: 365 (continuous annual use).

Table 24 Ozone - Costs

Cost	Long-Term
Capital Cost	$24,463,00
Average Annual OM Cost	$198,000
20-Year NPV	$28,061,000(1)

Notes:
(1) 20-year NPV was calculated using the following rates: discount rate, 5.5%; inflation, 4%; real rate of return, 1.5%.

6.4.4 Summary of Long-Term Cyanotoxin Mitigation Alternatives

Table 25 summarizes the costs and considerations for the long-term algae and cyanotoxin mitigation alternatives (GAC contactors, PAC, and ozone).

Table 25 Capital and O&M Costs for Long-Term Treatment Approaches

Technology	GAC Contactors	PAC	Ozone
Capital Cost	$12,257,000	$2,712,000	$24,463,00
Average Annual O&M	$2,011,000	$1,651,000	$198,000
20-Year NPV(1)	$48,787,000	$32,720,000	$28,061,000
Key Benefits	Only used when needed, low maintenance.	Only used when needed, low capital cost.	Year-round water quality improvements.
Key Challenges	Frequent media change-outs, intermediate pumping.	High maintenance, high solids production. Not compatible with direct filtration.	Complex ozone generation equipment.

Notes:
(1) 20-year NPV was calculated using the following rates: discount rate, 5.5%; inflation, 4%; real rate of return, 1.5%.

6.4.4.1 Conclusion

Each of the screened technologies provide robust treatment for cyanotoxins of concern, thus the long-term technology evaluation focuses on layout, process, hydraulics, power, and costs. Detailed considerations for each were provided in the individual technology evaluation sections, however, comparative observations based on this evaluation are summarized below:

- GAC:
  - *Adsorbs other organic contaminants, such as pharmaceuticals, personal care products, and PFAS, and can lower DBP formation potential.*
  - *Requires 16 pressure vessels, consuming significant site footprint.*
  - *GAC has the highest 20-year NPV and requires substantial site footprint.*
- PAC:
  - *Benefits are similar to GAC.*
  - *Requires a sedimentation basin to settle PAC out of the process. Generates significant solids.*
- Ozone:
  - *Ozone will be dosed continually, regardless of the presence of cyanotoxins in the raw water, since it provides several other process benefits: lowers coagulant dose, improves filter performance, removes organic compounds, removes taste and odor causing compounds, and potentially provides disinfection credit.*
  - *Ozone has the lowest 20-year NPV of the three long-term treatment technologies and provides the most treatment benefits on a continual basis.*

Based on the above evaluation, considerations, and comparison, **ozone is the recommended long-term treatment technology for removing cyanotoxins.** Ozone provides several other process benefits in addition to cyanotoxin destruction, including lowering required coagulant dose, improving filter performance, removing organic compounds, removing taste and odor causing compounds, and potentially providing disinfection credit. The short-term strategy defined previously can continue to be used while incremental replacement of the existing facilities is conducted, and ozone is implemented.

SECTION 7 ADDITIONAL RECOMMENDATIONS AND CONSIDERATIONS

The following lists of recommendations and considerations detail items that were identified during the development of this report that should be considered alongside the overall near-term and long-term recommendations.

- **Continue working with agencies to characterize cyanotoxins resulting from harmful algal blooms.** This evaluation estimated raw water cyanotoxin concentrations using data from similar events in the region (e.g., Salem, Oregon 2018 HAB event), and the limited dataset for the Columbia River. Collecting additional data during HAB's will provide additional data on raw water toxin concentrations that can inform future treatment decisions. Particularly, monitoring for the presence of microcystins in the raw water is important, as presence of this cyanotoxin will challenge the near-term cyanotoxin treatment scheme.
- **Optimize anatoxin-a and microcystin removal with permanganate once the raw water dosing location is online.** Monitor permanganate dose in the raw water and residual concentration at the flocculation basins to avoid overdosing permanganate. The City has purchased a manganese dose measurement instrument. Once the unit is installed, we recommend testing the unit's performance to determine the reliability and correlation with existing dosing data.
- **Investigate increasing chlorine residual through the clearwell.** Modeling showed that microcystin oxidation through the clearwell at a lower pH (7.5) is significantly improved compared to microcystin oxidation in pre-treatment at a higher pH (8.1). Additionally, increasing the dose to 1.5 mg/L Cl_2 allows for a maximum influent microcystin concentration of 1.0 µg/L while still meeting the treatment goal, 0.24 µg/L. Adjustment to chlorine disinfection will impact DBP formation. The City should perform simulated distribution system benchtop tests on filter effluent several times throughout the year to quantify this impact if significant adjustments are considered.
- **Understand the limitations and challenges of the near-term algae and cyanotoxin treatment scheme.** If microcystin concentrations exceed 0.6 µg/L, consider short-term strategies such as lowering plant flow and increasing chlorine residual. A temporary PAC feed system has been utilized elsewhere on an emergency basis for this purpose but would be challenging to manage with explosive dust mitigation safety measures and additional stress on solids handling infrastructure.

SECTION 8 REFERENCES

- American Water Works Association. 2010. Algae Source to Treatment Manual of Water Supply Practices M57.
- American Water Works Association. 2016. Managing cyanotoxins in drinking water: A technical guidance manual for drinking water professionals. Water Research Foundation, Denver.
- Carollo Engineers, Inc. 2018. Geren Island Water Treatment Facility: Cyanotoxin Mitigation Testing Results and Recommendations.
- Carollo Engineers, Inc. 2022. Butterfield Water Treatment Plant Facilities Plan.
- California Environmental Protection Agency Office of Environmental Health Hazard Assessment. Lauren Zeise, Ph.D to Darrin Polhemus, May, 3, 2021, Anatoxin-a Notification Level Recommendation.
- Global Water Research Coalition. 2009. International Guidance Manual for the Management of Toxic Cyanobacteria. Edited by Dr. Gayle Newcombe.
- Minnesota Department of Health. August 2016. Toxicological Summary for Anatoxin-a, 2016. CAS: 64285-06-9.
- Newcombe, G., House, J., Ho, L., Baker, P., & M. Burch. 2010. Management Strategies for Cyanobacteria (blue-green algae): A Guide for Water Utilities. Water Quality Research Australia, Adelaide.
- RH2 Engineering, Inc. July 2022. Quad Cities Algal Bloom Management and Response Plan.
- United States Environmental Protection Agency. January 2022. The Fourth Unregulated Contaminant Monitoring Rule: Data Summary.
- Washington Department of Health. 2022. Dealing with Cyanobacteria: Time to Make a Plan, Guidance for Developing a Harmful Algal Bloom Management and Response Plan.

APPENDIX B AQUATIC PLANT LIFE TECHNICAL MEMORANDUM

HELPING EACH OTHER
CREATE BETTER COMMUNITIES

J-U-B

THE LANGDON GROUP | GATEWAY MAPPING INC.

J-U-B FAMILY OF COMPANIES

MEMORANDUM

DATE: June 7, 2023

TO: Teresa Reed-Jennings, PE
Senior Engineer
City of Pasco

CC: Ali Leeds, PE
Carollo Engineers

FROM: Gary Weatherly, PE
Marcus Miller, PE
J-U-B ENGINEERS, Inc.

SUBJECT: Butterfield Water Treatment Plant Intake
Aquatic Plant Life Technical Memorandum

J-U-B Engineers, Inc. (JUB) was retained by Carollo Engineers, Inc. to evaluate the impact of aquatic plants, algae and debris on the City of Pasco's Butterfield Water Treatment Plant intake facility due to issues with late summer screen plugging during some years. The facility withdraws water from the left bank of the Columbia River at approximately River Mile 328.6. The withdrawal is located in a reach of the Columbia River where the river width is narrower and confined between Clover Island to the south and the Corps of Engineer's dike to the north.

Information Review and Field Investigation

JUB's initial effort on the project began during December 2022 and included gathering and reviewing specifications, construction drawings, as-built drawings and diver video of the screens following installation.

The existing intake screens and cleaning system were installed in 2015 and include two stainless steel wedge wire tee screens with an air burst cleaning system. The equipment was provided by Bilfinger Water Technologies, Inc. The tee screens are 42 inches in diameter and 140 inches in length and each screen provides approximately 82.9 square feet of screen surface area. Based on information provided by the City each tee screen was to be designed for a flow rate of 12,500 gpm (27.85 cfs). At this flow rate the water approaches the intake screens at an average velocity of 0.34 feet per second (fps) which is below the maximum NOAA Fisheries allowable approach velocity of 0.4 fps. Individually, each intake screen is capable of providing up to approximately 14,900 gpm. During peak water use periods, both screens are required to be in operation to ensure approach water velocities do not exceed 0.4 fps. Stainless steel wedge wire tee and barrel screens meeting the same requirements as those installed at the City of Pasco's intake are used successfully at most pump stations located on the Columbia and Snake Rivers throughout the region. Some screens have no automated cleaning system, some are air burst cleaned, and some are mechanically cleaned.

The Bilfinger screens use a dual pipe interior flow modifier to generate more uniform flow velocities across the intake screen. This differs from the single perforated baffle pipes used by most screen manufactures. The screens have an air burst discharge pipe installed along the interior bottom of the screen to disperse the air during an air burst cleaning. This arrangement is typical of all air burst screen manufacturers.

Screen cleaning is accomplished using an air burst system incorporating a 15 hp compressor and a 660 gallon horizontal receiver tank. The contract specifications indicate the compressor must be capable of filling the receiver tank from 0 psi to 125 psi in 15 minutes or less. The compressor has a 70% duty cycle which provides a maximum cleaning frequency for each screen of about once every 45 minutes. Nominal 4 inch diameter IPS SDR 11 HDPE pipes extend from the receiver tank to each intake screen. The distance between the receiver tank and intake screens is approximately 105 ft. The total interior volume of each tee screen is 875 gallons. This volume includes the steel pipe segment located between the two screen sections.

Review of the diver videos showed the screens with aquatic debris on them. The material itself appeared similar to what we have seen on other screens in the region. In the videos showing the air bursts, we noted that while we see the initial burst moving air out around the perimeter of the screen, the air immediately moves vertically toward the water surface and much of the debris appears to move back onto the screen surface. The initial air burst should move the material far enough off the screens that it does not return to the screen surface and instead is carried downstream by the river. The Ballard Marine emergency cleaning video showed a much heavier debris load than was present when the air burst videos were recorded.

A Teams meeting was held on December 12, 2022 to discuss the intake screen plugging issue. During the meeting, operations staff noted milfoil issues in 2016, 2020 and particularly bad problems in 2021. The problems typically occur in August and September when water temperatures are elevated and river flow rates may be lower. When the screen plugging has been the worst and the air burst system was not able to remove debris, the City employed a diver to remove the material manually. It was noted that even when moderate plugging was occurring the air burst system only appeared to clean about 20% to 30% of the screen surface area. There have been two instances where divers encountered material adhering to the screens that were not removed by the air burst system and were not ordinary aquatic weed debris. The first instance occurred in 2019 and the material, described as a sponge, had to be removed with a wire brush. The second instance occurred in 2021 and was described as a white slime that spanned the screen openings and was not removed by the air burst system. Wiping the material by hand removed it. Some descriptions of possible aquatic plants and organisms that the divers may have encountered are discussed in the section titled Aquatic Plant and Animal Life.

On January 23, 2023 J-U-B staff toured the Butterfield intake facility. Because the screens are submerged in the river J-U-B was only able to inspect the air burst system and further discuss operation of the system with City staff.

We performed a cursory review of Columbia River flowrates below Priest Rapids Dam for years 2015 through 2022 in the months of August and September to look for flow rate variations that could have resulted in lower intake screen sweeping velocities, higher water temperatures and lower water levels that could have exacerbated aquatic weed and algae growth. While water levels at the site are regulated by McNary Dam, the inflow rate is regulated by Priest Rapids Dam. Data for Priest Rapids Dam suggested a minimum flow rate in all years of about 38,000 cfs. Water temperature information at the McNary Dam forebay was also reviewed. None of the information appeared to show any trends the City could use to predict when excessive late summer intake screen plugging might occur.

Our review noted one potential source of aquatic debris that could be affecting the Butterfield intake screens. The Corps of Engineers (COE) has a drainage ditch and pond located on the north side of the dike from which they pump water to the river. The pond regularly fills with aquatic plants that move toward the pump station when pumping occurs. The pump station is screened to remove much of the material from the water discharged to the river. The COE pump station discharge is on the same side of the river as the City's intake and approximately 2,600 ft upstream. Any debris that is discharged by the COE pump station may be following the shoreline into the area where the City's intake screens are located. Future evaluation of the COE pump station's contribution to the aquatic plant and algae load may be worthwhile.

From a strictly anecdotal perspective, in recent years spill over the Columbia River dams during the summer has increased. At the same time we have encountered more river withdrawals having screen plugging issues. Although not scientifically supported, we have surmised that more debris is now passing over the dams rather than being trapped behind them.

Aquatic Plant and Animal Life

Aquatic Plants

Ecology's Lake Environment Database (https://apps.ecology.wa.gov/lakes/) was reviewed to look at aquatic plants present in the McNary Dam pool (Lake Wallula) and assess their potential impact on the Butterfield intake screens. The database identified numerous aquatic plants present in the pool, including:

- Pondweed (Numerous Species)
- Water Star Grass
- Common Waterweed
- Curly Leaf Pondweed
- Eurasian Milfoil

Numerous species of Pondweed are present in the McNary Pool including Grass-leaved, Richardson's, Sago and Longleaf. Pondweed and Water Star Grass are generally native aquatic plants that propagate using rhizomes and seeds. Their propagation method likely results in them not being a significant source of the aquatic material that ends up on the Butterfield intake screens.

Common Waterweed generally blooms from July through September and propagates using fragmentation. Fragmentation results in waterborne aquatic plant material that can plug intake screens. The time of year when fragmentation is likely to occur coincides with the time of year the intake screens have had plugging issues.

The Curly Leaf Pondweed and Eurasian Milfoil are considered noxious plants that can create surface mats that are subject to breakup with heavy wave action and boating traffic. Mats of these plants can break free and float down the river with the current. Depending on their location in the water column they can impinge on intake screens.

Curly Leaf Pondweed reproduces using turions that drop to the river bottom. Turions are a type of bud, therefore propagation of the Curly Leaf Pondweed probably is not a significant contributor to aquatic material moving in the river.

Eurasian Milfoil (EM) is likely the largest contributor to the floating aquatic plant material load plugging the intake screens. Eurasian Milfoil is present throughout the Columbia

River system and will grow in water depths up to about 33 ft. Where the water depth is 16 ft or less EM can grow to the water surface and create mats. Propagation of EM is accomplished through rhizomes, autofragments and allofragments. Autofragmentation is a process that occurs in late summer when the plants develop roots between 6" and 8" below the stem tips and automatically separate from the parent plant and float down stream. Allofragmentation is created by mechanical disturbances such as wave action and boat propellors. Given the proliferation of EM in the Columbia River system, autofragmentation and allofragmentation likely lead to large amounts of aquatic plant debris in the water.

Algae

Filamentous green algae is present in the Columbia River. The filamentous nature of the algae creates a material that does not pass through the intake screens and can contribute to plugging.

Freshwater Sponges and Bryozoans (Animals)

There are about 32 species of freshwater sponges in North America. They are found in clean streams, rivers and lakes and are sensitive to water conditions. Their presence indicates high water quality with low levels of pollutants. Freshwater sponges occur in several colors, including white and tan, but may appear green due to algal symbiosis. Sponges have a coarse texture and are not slimy like algae. To reproduce and survive winter, drought and other adverse conditions sponges produce gemmules. Gemmules are poppy seed sized, hard embryonic cells that can hatch and form new sponges. The gemmules can adhere to hard objects. Sponges are widely distributed across North America, but the distribution is heavily influenced by biogeographic factors and fewer species of sponges have been reported in the western United States. We were able to find literature that indicated sponges had been found in the Hanford Reach of the Columbia River above the Butterfield withdrawal site and the upper Columbia River.

Bryozoans have also been found in the Columbia River and are a micro-organism that forms colonies. They range in color from clear to dark purple, can reach sizes up to several feet in diameter and are gelatinous and slimy. Literature suggests there has been an increase in bryozoan blooms which typically occur in later summer when water temperatures reach their peak.

We note these micro-organisms because during the summer of 2021 a diver cleaning the intake screens noted some locations where a slimy white material was present on the intake screens. The question was asked whether it could be a freshwater sponge. The material spanned the open slots between the wedge wire and was not removed by the air burst. It was noted the material could easily be removed by hand. Because the material was described as being slimy and easily removed it would not appear to have been sponges. It was also noted at one point that material was present on the screens that had to be removed with a wire brush. Sponges do strongly adhere to hard objects and may require brush removal if present.

We contacted two diving contractors who clean screens in the area and neither has encountered a slimy white material on any screens. Of the two micro-organisms noted the Bryozoan colonies can be somewhat slimy but do not generally adhere to screen surfaces. If the material is encountered on the screens in the future, collection of a sample for testing may be a worthwhile exercise.

Summer of 2021 Summary

The City experienced significant intake screen plugging issues during the late summer in 2021. The timing coincides with the fragmentation of milfoil which is likely the source of much of the aquatic material being caught on the intake screens. Problems were first noticed on August 2, 2021. In response the City lowered the air burst cleaning interval to 4 hours. The following outlines the sequence of events:

- 8/2/21 Plugging issues were first noted.
- 8/18/21 Screens are manually cleaned by a diver.
- 8/25/21 Screens plugged again so a manual air burst cleaning was initiated.
- 8/27/21 Plugging continued so weekly diver cleaning was initiated.
- 9/2/21 Plugging continued so intake pipes were shutoff individually to eliminate water flow toward the screens during air burst. Air burst schedule remained at 4 hours.
- 9/8/21 Screen plugging issues were on-going.
- 9/9/21 Screens were manually cleaned by a diver.
- 9/15/21 Screens were manually cleaned by a diver.
- 9/24/21 Screens were manually cleaned by a diver.

Beginning in late August 2021, air bursting of the intake screens with the intake pipe isolation valve closed was completed on a daily basis.

No additional manual cleaning was required after September 24, 2021. We do not have information that suggests when the air burst interval was increased from 4 hours. However, City staff have indicated that they typically air burst the screens once per day during the winter and typically every 6 to 8 hours during the summer.

Recommendations

Although we have had concerns about the effectiveness of air burst as the cleaning method for intake screens, wedge wire intake screens with air burst cleaning systems, similar to the Butterfield site, are installed at numerous pump stations in the Columbia and Snake Rivers in this region and function well. Our concern stems from the fact that air will rise when discharged in water making it less effective at cleaning the lower surfaces of the intake screens. We did reach out to a water withdrawal owner where new stainless steel wedge wire intake screens with an air burst cleaning system were installed in February 2021. The system is just below McNary Dam and began operation in March 2021. The system operated without issue during the 2021 time period when the City was experiencing its plugging problem. The owner has noted that the air burst system does not clean the bottom quarter of the screens as well as it cleans the remainder of the screens.

The City's intake screen site is located where the river narrows between Clover Island on the south and the Corps of Engineer dike on the north. Although we did not evaluate sweeping velocity around the screens, the reduction in river width at the site should result in reasonable sweeping velocities. We would expect those velocities to be sufficient to move loose debris away from the intake screens. Although the orientation used on the Butterfield screens is not uncommon, in recent years we have oriented the intake screen tee vertically so the screens are above the intake pipe. This eliminates the possibility that the intake pipes are creating eddies or masking portions of the intake screens from sweeping flows. If it is determined the debris on the screens is removed but future investigations show it is not moving out of the area, then changing the orientation of the screens may provide a solution. Moving the intake screens to positions above the intake pipes would require modification of their internal air burst piping.

With no readily apparent and obvious cause of the screen plugging issues and the air burst cleaning system ineffectiveness, we cannot be certain any of the options described in the following sections will resolve all of the plugging problems. Of the options described, replacement of the existing intake screens with Intake Screens Inc brush cleaned screens provides the most certain resolution.

Increase Air Burst Frequency

Our first thought on how to improve the screen cleaning would be to shorten the time interval between air bursts as the plugging issues increase. The written notes we reviewed describing the summer of 2021 problems indicated an air burst interval of 4 hours was used. Additional conversations with City staff suggested the cycle time may have been reduced to around 2 hours at times. It appears the supplied air compressor has a 70% duty cycle. Using the 15 minute receiver tank fill time noted in the contract and this duty cycle, it should be possible to air burst each screen at roughly a 45 minute interval. City staff have indicated the compressor fills the receiver tank to a pressure of 160 psi in 10 to 12 minutes which would allow an even shorter air burst cycle time. Increasing air burst frequency so that bursts occur before they may be necessary could minimize the build up of debris on the screens and improve air burst efficacy. While we don't have any way to know if this would have helped in 2021, it could be tested without additional cost, should the City encounter the problem in the future. If the screens are cleaned more frequently there will be less debris and more opportunity to effectively clean them.

Although increasing the air burst frequency would generally be considered an option for cleaning plugged screens, City staff who are familiar with the problem do not believe it would be effective. The City also experienced a compressor failure when more frequent air bursting was employed, suggesting the duty cycle of the existing compressor would need to be evaluated.

Air Burst With Intake Pipe Isolation Valve Closed

Air burst cleaning systems generally air burst with the screen in operation and effectively clean the screen. However, during those periods of time when plugging was at its worst and air bursting was not effective, City staff experimented with closing the isolation valve on the pipe leaving the screen. They had noted that when the screens were air burst with the valve open a portion of the air moved through the intake pipe to the pump wet well. This reduced the volume of air exiting through the intake screen. Closing the isolation valves forces all of the air out through the intake screen and eliminates the movement of water towards the screen. Eliminating the movement of water toward the screen during and following the air burst allows debris removed from the screen surface to more easily be swept downstream and out of the screen area.

While the intake pipe valve is closed the quantity of water the City can withdraw and still meet NOAA Fisheries intake screen approach velocity requirements is reduced. When one valve is closed and only one screen is available for use the withdrawal rate should not exceed about 14,900 gpm.

If this approach is selected to improve the efficiency of the existing air burst system, we would suggest electric actuators be added to the two valves to make opening and closing the valves more convenient, less time consuming and allow remote operation.

Modify Air Burst System

A number of factors affect the operation of the air burst system. Those factors include intake screen submergence depth, receiver tank volume, air burst pipe diameter and valve opening speed. The various screen manufacturers have proprietary methods for calculating tank and pipe size requirements. Our field inspection and cursory calculations suggested the receiver tank size and the air pipes between the receiver tank and screens might both be small. This determination was based on a different recently installed air burst intake screen installation in the Columbia River that has performed successfully. The supplier of those screens was Elgin Separation Solutions. We spoke to Elgin about the Butterfield intake and based on their proprietary sizing method they agreed the tank size and air burst pipe size were probably somewhat small.

The Bilfinger intake screen purchase contract notes a 620 gallon receiver tank but goes on to describe a tank capable of storing 3 times the screen volume which would be about 1600 gallons. The contract also describes delivering 2/3 of the receiver tank volume to the screens in the first second of the air burst. The videos provided showing the screens being air burst suggest a longer burst time, and may indicate the air delivery pipe is smaller than necessary. We presume that Bilfinger’s tank and pipe size calculations suggested the smaller air volume and delivery pipe size would work so the sizes were reduced.

Based on information provided by the system operator, the receiver tank pressure is set at 160 psi when air bursts occur and the actuated valves open in about 1 second. Both of these settings are reasonable.

We would suggest making the following changes to improve the effectiveness of the air burst cleaning:

- Increase air burst frequency as previously discussed.
- Increase the volume of receiver tank air storage. This could be completed using a second tank. We would recommend adding a 400 gallon receiver tank to provide a total of 1,060 gallons of air storage. Installation of a second tank would require the fabrication of a pipe manifold between the two tanks and relocation of the existing pneumatically actuated air valves so they delivered the combined air volume to the intake screens. The pipe manifold would be fabricated with nominal 6 inch diameter IPS SDR 11 HDPE pipe. This pipe has an inside diameter of 5.35 inches and will convey the air with lower pressure losses. If the existing compressor is used to fill both tanks, the fill time will increase which will increase the minimum time between air bursts. Therefore, a second compressor should be added or the existing compressor replaced with a larger compressor. NOAA Fisheries standards call for an ability to clean the screens every 5 minutes. We are not aware of any intake screens that have this capability but shorter intervals between air bursts will provide better cleaning. An additional approximately 25 hp in compressor capacity would be required to reach a cycle time approaching every 5 minutes. See attached Sheet 1 for a schematic layout of the proposed air tank and compressor. Addition of a second compressor would provide some redundancy should one fail.
- Replace the air burst pipes from the actuated valves to the intake screens with nominal 6 inch diameter IPS SDR 11 HDPE pipe. This pipe has an inside diameter of 5.35 inches and will deliver more air to the screens in a shorter time period than the existing pipes. The existing nominal 4 inch diameter IPS SDR 11 HDPE pipe has an inside diameter of only 3.63 inches which is likely reducing the initial air burst air volume delivered to the intake screens. We are assuming the 6 inch pipe would be able to follow the same route as the existing pipe. It may be possible to replace the air burst pipes without getting Corps of Engineers Section 404 and Section 10 permits given the pipes are already in place. This assumes they would not look at the increase in pipe size as putting more materials in the river. If Corps permits are required it could take in excess of a year from the time the application is submitted to receive them. A Hydraulic Project Approval (HPA) from the Washington State Department of Fish and Wildlife (WDFW) will be required. HPA's generally take 4 to 6 months to receive after submission of the application. Preparation and submission of the applications would probably require 2 to 3 months.

The City could add the storage and compressor capacity and see if it resolves the issue the next time a problem occurs. If it does not resolve the plugging, the City can come back and replace the air burst pipelines. The second option would be to replace the pipes at the same time the storage is added.

In Carollo's Butterfield Water Treatment Plant Facilitites Plan dated September 2022, the electrical systems evaluation noted that the electrical equipment was old and needed to be replaced and that the main distribution panel appeared to be overloaded. City staff noted they were having trouble sourcing replacement parts for the equipment. This could preclude the installation of additional compressor capacity without completing what may be significant electrical improvements.

Mechanical Brush Cleaned Intake Screens

If improvements to the air burst system do not resolve the issue the intake screens could be replaced with mechanical brush cleaned screens like those manufactured by Intake Screens Inc. (ISI). This type of screen is currently in use at the City's West Pasco intake facility. JUB has experience with ISI screens in several locations going back to early 2015. At a location near Wallula, WA the screens operate in water with heavy sediment and aquatic debris loads and there is little sweeping velocity to carry debris removed from the screens out of the area. The screens have been in operation over 7 years without any issues. Installation of the ISI screens would likely resolve the City's screen plugging issue. One caveat is the removal of the type of material City staff noted as having to be wire brushed. The ISI screens have relatively rigid nylon brushes on the inside and outside of the screen surface. The brushes may not remove hard material well adhered to the screen surface.

Installation of the ISI screens would decrease the electrical load at the station. The current compressor at the site is 15 hp. With the ISI screens the compressor would be replaced with four 1 hp motors.

Permitting for replacement of the tee screens with the ISI screens may not require Corps of Engineer's permits if the existing concrete screen support/anchor structures can be reused. If they need to be replaced and the support size changes Corps permits will likely be required. The ISI screens are considerably heavier than the air burst screens so some support modifications may be required. Corps permits are currently taking a little over a year to acquire after submission of the application. The project would require an

HPA from the WDFW. HPA's have been taking 4 to 6 months to receive following submission of the application. Preparation of the applications would likely take 2 to 3 months.

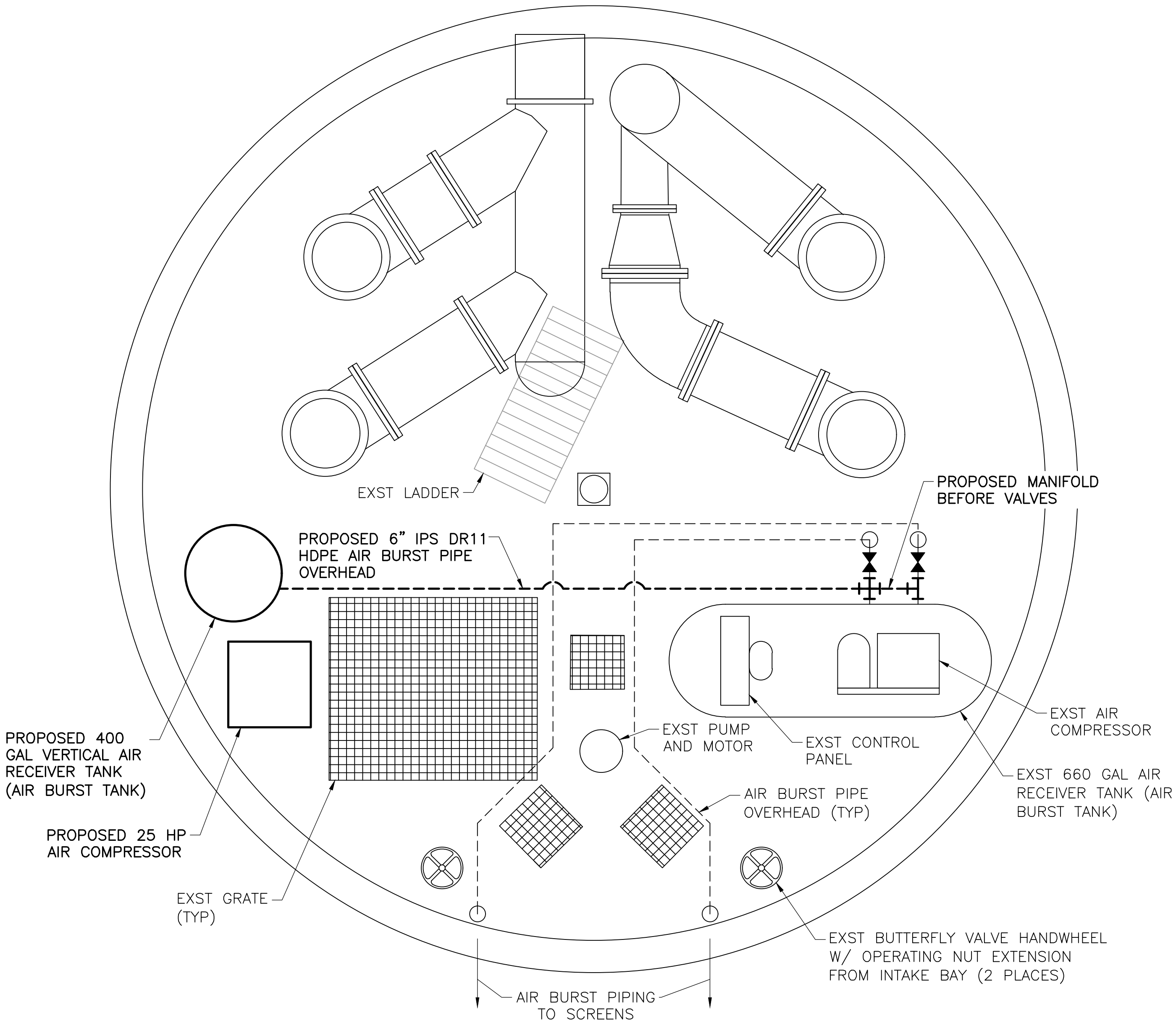
Given the early May 2023 plugging problems the City experienced, it may be worth considering moving directly to installation of the ISI screens since they provide the best opportunity for a solution.

Estimated Costs

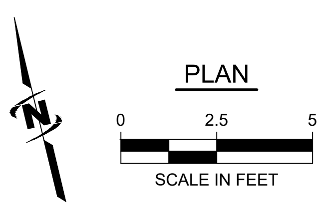
- Increase Air Burst Frequency: ***Negligible*** (slight increase in power usage by compressor)
- Add Actuators to the Existing Intake Pipe Valves: ***$48,000****
- Added Storage and Compressor Capacity: ***$125,000****
  (Cost assumes there is sufficient power available at the pump station to add the additional 25 hp compressor)
- Replace Air Pipes to Screens: ***$180,000****
- Replacement of the air burst screens with ISI mechanically cleaned screens assuming no significant modifications to the supports: ***$820,000****

* Estimated costs include 15% Engineering, 20% Contingency, and Sales Tax.

The City could plan to rely on commercial divers to clean the intake screens during significant plugging events. The estimated cost to have commercial divers come to the site and clean the screens is **$4,000 per day**.



PLAN



GENERAL NOTE:
NO FIELD DIMENSIONS WERE TAKEN FOR THE PURPOSE OF THIS DRAWING. DIMENSIONS AND LOCATION OF EXST STRUCTURES ARE BASED ON RECORD DRAWINGS AND FIELD PHOTOS. FURTHER DESIGN WILL REQUIRE ACTUAL FIELD DIMENSIONS.

NO.	REVISION DESCRIPTION	BY	APR.	DATE

FILE: 30-20-042_AIRTANKDETAIL
JUB PROJ. #: 30-20-042
DRAWN BY: KCV
DESIGN BY: GJW
CHECKED BY:
LAST UPDATED: 3/14/2023

J-U-B ENGINEERS, INC.

CITY OF PASCO
BUTTERFIELD WTP

INTAKE SCREEN AIR BURST
PROPOSED AIR RECEIVER TANK AND COMPRESSOR EXPANSION

SHEET
1

APPENDIX C 2023 CAPITAL IMPROVEMENT PLAN UPDATE

Project ID: 1
Project Name: Electrical Building

Go to CIP Summary Table

Project Description:

Upgrade the power feed to the WTP and construct a new electrical building. Add a standby power generator and fuel storage.

New electrical building will include replacement of all major existing electrical system components including transformers, main distribution panels, and MCCs. New electrical building to be designed and sized to accommodate loads from current equipment and future electrical loads, including on-site hypochlorite generation, UV disinfection, and ozone generation.

Preliminary design of the new electrical building will include an evaluation of an overall holistic approach to supply power in the short-term and long-term.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
Electrical Building and Standby Generation	$ 5,262,509	$ 1,626,115	$ 6,888,624	$ 2,066,587	$ 8,955,212	$ 3,582,085	$ 12,537,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
Total Project Cost (2023 $)							$ 12,537,000

Notes on Cost Estimation:

The electrical building is proposed to be a 2400 sf building with an additional 600 sf space reserved for exterior electrical equipment slabs. Building is assumed to be metal framed standalone building with slab on grade, slabs on grade for standby generator and other electrical distribution equipment.

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Cost Allocation:

Project Type	Percent	Cost
Capacity:	80%	$ 10,029,600
Aging Infrastructure:	20%	$ 2,507,400
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 12,537,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Predesign	2%	2023	$ 250,740	$ 250,740
Design & Preprocurement	20%	2024	$ 2,507,400	$ 2,607,696
Construction - Year 1	40%	2025	$ 5,014,800	$ 5,424,008
Construction - Year 2	38%	2026	$ 4,764,060	$ 5,358,920
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 12,537,000	$ 13,641,363

Notes:

Project ID: 2
Project Name: Misc. Improvements and Compressor Replacement

Go to CIP Summary Table

Project Description:

Backwash System Improvements:
-Replace backwash flow control valve actuator to decrease risk of valve failing in an undesirable position.
-Install second backwash flow control valve (in parallel or in series) to add redundancy to critical backwash system.
Air Compressor Replacement:
Replace all three aging air compressors (pneumatic valve compressors x2 and basin-air bubbler / deicer compressor x1). Assumes replacement with packaged air compressor units.
Seismic and Life Safety Improvements: Install lateral and longitudinal bracing on all gallery piping hanging from ceiling and check for adequate anchorage for all gallery piping anchored to floor. Includes lateral bracing and pipe supports in gallery, anchor-safe piping on floor, and conduit support bracing. Complete recommended structural anchorage/seismic study prior to initiating this project.
Raw Water PS Reliability Improvements:
-Install ledger angle to support tread plate in RWPS (currently unsupported at the wall). Install ledger angle to support tread plate.
-Weld pump plate to baseplate (pump baseplate not attached on equipment pad).
-Replace leaking check valve on raw water pump #9.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Backwash System Improvements	$ 45,993	$ 14,212	$ 60,204	$ 18,061	$ 78,266	$ 31,306	$ 110,000
Air Compressor Replacement	$ 62,339		$ 62,339		$ 62,339		$ 62,000
Seismic and Life Safety Improvements	$ 30,477	$ 9,417	$ 39,894	$ 11,968	$ 51,863	$ 20,745	$ 73,000
Raw Water PS Reliability Improvements	$ 118,583	$ 10,198	$ 128,782	$ 38,634	$ 167,416		$ 167,000
Total Project Cost (2023 $)							$ 412,000

Notes on Cost Estimation:
Air compressors are assumed to be replaced in kind. Replacement cost includes equipment cost of $15,000 each and a 25% allowance for installation. No significant power or piping modifications are anticipated.

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	50%	$ 206,000
Aging Infrastructure:	50%	$ 206,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 412,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
BW Improvements	100%	2023	$ 110,000	$ 110,000
			$ -	$ -
Air Compressor Replacement	100%	2023	$ 62,000	$ 62,000
Seismic and Life Safety Improve	100%	2023	$ 73,000	$ 73,000
Raw Water PS Reliability Impro	100%	2023	$ 167,000	$ 167,000
			$ -	$ -
			$ -	$ -
		Total Project Cost	$ 412,000	$ 412,000

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 3
Project Name: Raw Water Pump Station Improvements

Go to CIP Summary Table

Project Description:

Raw Water Pump Station Capacity, Standby Power, and Electrical Improvements:

-Replace electrical distribution panels and harmonic filters at raw water pump station. Includes replacement of distribution panels, harmonic filters, two new VFDs, and miscellaneous panelboards, wiring, and hardware.
-Install standby power generator for raw water pump station and backwash lift station, including generator, switchgear, and other electrical equipment.
-Replace two of the smaller RW pumps (#1 and #3) with 10 mgd pumps to provide 30 mgd firm capacity. Assumes replacement of two smaller pumps with larger pumps and motors (150 HP based on previous evaluations) and installation of VFDs for each pump. Includes costs for associated piping and valving associated with pump replacements.
-Install pressure indicator/transmitters on each raw water pump discharge.
-Install redundant level indicator/transmitter on raw water wet well.
-Includes installation of security fencing and cameras around raw water pump station and backwash lift station to reduce vandalism.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Raw Water Pump Station Standby Power & Electrical Improvem	$ 2,805,721	$ 866,968	$ 3,672,688	$ 1,101,807	$ 4,774,495	$ 1,909,798	$ 6,684,000
		$ -	$ -	$ -	$ -		$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 6,684,000

Notes on Cost Estimation:

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Cost Allocation:

Project Type	Percent	Cost
Capacity:	50%	$ 3,342,000
Aging Infrastructure:	50%	$ 3,342,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 6,684,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Predesign	2%	2023	$ 133,680	$ 133,680
Design	10%	2024	$ 668,400	$ 695,136
Construction - Year 1	50%	2025	$ 3,342,000	$ 3,614,707
Construction - Year 2	38%	2026	$ 2,539,920	$ 2,857,065
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 6,684,000	$ 7,300,588

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 4
Project Name: Flocculation and Sedimentation Basin Improvements

Go to CIP Summary Table

Project Description:

Complete projects to address aging flocculation/mixing system and address identified issues in the flocculation and sedimentation basins.

-Replace flocculation/mixing system in the north flocculation basins. Replace aging and failing paddle flocculation system in the north flocculation basins with a newer flocculation/mixing system that provides better redundancy. Includes new horizontal paddle flocculators, concrete walkways, and associated mechanical and electrical costs.
-Install scum drain system on north end of north basin influent channel to allow scum to be drained periodically (and manually) drain from channel surface. Includes saw cutting, core and sleeving concrete, new piping and valves, and miscellaneous grout and anchors.
-Inspect flocculation [illegible] basin concrete [illegible] confirm concrete [illegible] good condition [illegible] ng. Repair areas of exposed rebar and any damage to floor [illegible] sealant. [illegible] assessment and repair project will increase [illegible] e basins.
-Install permanent and sealed plates over south basin influent channel openings (between floc and sed basins). This will allow this conveyance/channel system to provide true redundancy to the north channel. Includes metal plates, sealant, and hardware.
-Replace corroded pipe supports [illegible] adjacent to floc/sed basins. [illegible] high humidity area that has [illegible] accelerated corrosion of piping in this area. Includes demolition of old supports and new supports.

not used - not required with early flocculation basin project

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
Replace Flocculation System	$ 482,528	$ 149,101	$ 631,630	$ 189,489	$ 821,119	$ 328,447	$ 1,150,000
Scum Drain System	$ 35,049	$ 10,830	$ 45,879	$ 13,764	$ 59,642	$ 23,857	$ 83,000
Sed Basin Structural Assessment and Repairs	$ 33,248	$ 10,274	$ 43,521	$ 13,056	$ 56,578	$ 22,631	$ 79,000
Plates Over Openings	$ 27,014	$ 8,347	$ 35,361	$ 10,608	$ 45,969	$ 18,388	$ 64,000
Replace Pipe Supports	$ 18,286	$ 5,650	$ 23,937	$ 7,181	$ 31,118	$ 12,447	$ 44,000

Total Project Cost (2023 $) $ 1,420,000

Notes on Cost Estimation:

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Cost Allocation:

Project Type	Percent	Cost
Capacity:	0%	$ -
Aging Infrastructure:	100%	$ 1,420,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 1,420,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Floc Basin Repairs	100%		$ 1,420,000	$ 0
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
		Total Project Cost	$ 1,420,000	$ 0

Notes:

Flocculation mixing equipment is at the end of its useful life and is not anticipated to function through 2033 (Project 8 to replace flocculation basins).

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 5
Project Name: Chemical Building

Go to CIP Summary Table

Project Description:

Construct a new chemical building with new chemical storage and metering facilities for all existing WTP chemicals: alum, fluoride, caustic soda, potassium permanganate, and filter aid polymer. New chemical building to also include all equipment and facilities for on-site hypochlorite generation to replace the existing chlorine gas system. Potassium permanganate system assumed to be installed and operated until ozone treatment is constructed.

The chemical building is proposed to be an approximately 8,100 sf building.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Chemical Building	$ 7,602,210	$ 2,349,083	$ 9,951,293	$ 2,985,388	$ 12,936,681	$ 5,174,672	$ 18,111,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $) $ 18,111,000

Notes on Cost Estimation:

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Cost Allocation:

Project Type	Percent	Cost
Capacity:	25%	$ 4,527,750
Aging Infrastructure:	25%	$ 4,527,750
Water Quality:	25%	$ 4,527,750
Safety:	25%	$ 4,527,750
Total Project Cost	100%	$ 18,111,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Predesign	1%	2023	$ 181,110	$ 181,110
Design & Preprocurement	20%	2024	$ 3,622,200	$ 3,767,088
Construction - Year 1	43%	2025	$ 7,787,730	$ 8,423,209
Construction - Year 2	36%	2026	$ 6,519,960	$ 7,334,068
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 18,111,000	$ 19,705,475

Notes:

Design phase scheduled ahead of construction to facilitate additional funding opportunities for project construction. Design will need to consider actual time of construction when selecting applicable codes for design of the facility.

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 6
Project Name: Filters

Go to CIP Summary Table

Project Description:

Construct eight new filters, assumed to operate at 8 gpm/sf, in an N+1 configuration to provide 30 mgd firm capacity with one filter out of service for backwashing. New filters to include air scour and pumped backwash system.

Temporary piping will be required to tie into the existing settled water channel and existing clearwell if filters are constructed prior to new flocculation basins and disinfection.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
8 New Filters	$ 8,283,943	$ 2,559,738	$ 10,843,682	$ 3,253,104	$ 14,096,786	$ 5,638,714	$ 19,736,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 19,736,000

Notes on Cost Estimation:

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Cost Allocation:

Project Type	Percent	Cost
Capacity:	50%	$ 9,868,000
Aging Infrastructure:	50%	$ 9,868,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 19,736,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Predesign	2%	2025	$ 394,720	$ 426,929
Design	8%	2026	$ 1,578,880	$ 1,776,025
Construction - Year 1	50%	2027	$ 9,868,000	$ 11,544,164
Construction - Year 2	40%	2028	$ 7,894,400	$ 9,604,745
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 19,736,000	$ 23,351,863

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 7
Project Name: UV Disinfection

Go to CIP Summary Table

Project Description:
Construct new disinfection facility. Facility assumed to included two UV reactors in a buried vault structure and piping from the filters to the new UV facility. If UV facility is constructed before new finished water pump station, temporary piping will need to be constructed to connect UV effluent to existing clearwell/finished water pump station. New disinfection must be in service prior to converting to direct filtration operation.

not used - not required with early ozone

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
UV Disinfection	$ 3,898,848	$ 1,204,744	$ 5,103,592	$ 1,531,077	$ 6,634,669	$ 2,653,868	$ 9,289,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 9,289,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	100%	$ 9,289,000
Aging Infrastructure:	0%	$ -
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 9,289,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design	10%		$ 928,900	$ 0
Construction - Year 1	40%		$ 3,715,600	$ 0
Construction - Year 2	40%		$ 3,715,600	$ 0
Construction - Year 3	10%		$ 928,900	$ 0
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 9,289,000	$ 0

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 8
Project Name: Flocculation Basins

Go to CIP Summary Table

Project Description:

Construct new flocculation basins sized to treat 30 mgd with a 20 minute detention time at maximum flow with a new flash mix building connected as one structure. Project assumed to include two new flocculation basins each with vertical turbine flocculators and influent/effluent channels and flash mix building with pumped injection flash mixing. Additional clearwell disinfection volume, UV disinfection, or ozone, will need to be constructed prior to placing flocculation basins in-service and converting to direct filtration.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
Flocculation Basins	$ 4,757,470	$ 1,470,058	$ 6,227,528	$ 1,868,258	$ 8,095,786	$ 3,238,314	$ 11,334,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
Total Project Cost (2023 $)							$ 11,334,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	0%	$ -
Aging Infrastructure:	50%	$ 5,667,000
Water Quality:	50%	$ 5,667,000
Safety:	0%	$ -
Total Project Cost	100%	$ 11,334,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Predesign	2%	2025	$ 226,680	$ 245,177
Design	8%	2026	$ 906,720	$ 1,019,937
Construction - Year 1	55%	2027	$ 6,233,700	$ 7,292,547
Construction - Year 2	35%	2028	$ 3,966,900	$ 4,826,340
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 11,334,000	$ 13,384,001

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 9
Project Name: Residuals Improvements (Phase 1)

Go to CIP Summary Table

Project Description:

Improve the dewatering process in the existing decant drying beds by installing a residuals polymer feed system and upgrading decant drying drying bed outlet structures and drainage. Phase 1 residuals improvements are anticipated to increase capacity and delay need for additional decant/drying beds.

Polymer system to be housed in a new structure. Decant outlet and drainage improvements include installing a mud valve in drying bed no. 1 to match drying bed no. 2 and a reconfiguration of outlet structures.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
Residuals Improvements (Phase 1)	$ 557,330	$ 172,215	$ 729,545	$ 218,864	$ 948,409	$ 379,364	$ 1,328,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $) $ 1,328,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	100%	$ 1,328,000
Aging Infrastructure:	0%	$ -
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 1,328,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design	10%	2027	$ 132,800	$ 155,357
Construction	90%	2028	$ 1,195,200	$ 1,454,144
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 1,328,000	$ 1,609,501

Notes:

Conversion to direct filtration and corresponding decrease in coagulant dose assumed to lessen solids loading challenges in near-term. Project timing can be revisited if solids handling challenges increase.

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 10
Project Name: Finished Water Pump Station

Go to CIP Summary Table

Project Description:

Construct a new finished water pump station with new finished water pumps and backwash pumps housed in a new building. Costs for the finished water pump station include a pump wet well sized to provide virus inactivation requirements after UV disinfection. Virus inactivation with chlorine will need to be provided in the wet well/clearwell to meet regulatory disinfection requirements with UV disinfection sized only to meet Giardia inactivation requirements.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Finished Water Pump Station	$ 8,042,148	$ 2,485,024	$ 10,527,172	$ 3,158,152	$ 13,685,323	$ 5,474,129	$ 19,159,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 19,159,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	50%	$ 9,579,500
Aging Infrastructure:	50%	$ 9,579,500
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 19,159,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design	10%	2028	$ 1,915,900	$ 2,330,985
Construction - Year 1	50%	2029	$ 9,579,500	$ 12,121,124
Construction - Year 2	40%	2030	$ 7,663,600	$ 10,084,775
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 19,159,000	$ 24,536,884

Notes:

Project ID: 11
Project Name: Ozone (including generation)

Go to CIP Summary Table

Project Description:
Install a new ozone treatment system including outdoor liquid oxygen storage and vaporization, ozone generation (in a new ~2,000 sf building), and ozone contactors. Ozone will be operated as pre-zone. Construct necessary piping to connect ozone treatment facilities to raw water pipe upstream of pretreatment.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Ozone (including generation)	$ 10,464,593	$ 3,233,559	$ 13,698,152	$ 4,109,446	$ 17,807,597	$ 7,123,039	$ 24,931,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $) $ 24,931,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	0%	$ -
Aging Infrastructure:	0%	$ -
Water Quality:	100%	$ 24,931,000
Safety:	0%	$ -
Total Project Cost	100%	$ 24,931,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Predesign	1%	2023	$ 249,310	$ 249,310
Design & Preprocurement	20%	2024	$ 4,986,200	$ 5,185,648
Construction - Year 1	40%	2025	$ 9,972,400	$ 10,786,148
Construction - Year 2	39%	2026	$ 9,723,090	$ 10,937,154
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 24,931,000	$ 27,158,260

Notes:

Project ID: 12
Project Name: Residuals Improvements (Phase 2)

Go to CIP Summary Table

Project Description:

Install third decant / drying bed (decant/drying bed no. 3). Assumes 22,000 sf of additional lagoon area with piping, valves, and decant structures.

Construction of third decant/drying bed assumed to take the place of the current area used for solids drying. Additional land for solids drying or more frequent solids hauling will be required after new drying bed constructed.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		8.6%		30%		40%	
Residuals Improvements (Phase 2)	$ 1,824,391	$ 156,898	$ 1,981,289		$ 1,981,289	$ 792,516	$ 2,774,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 2,774,000

Notes on Cost Estimation:

Construction cost based on recent bid prices that included overhead and profit and general conditions. No markups added for these factors. No contingency added given level of similarity to recent bid used for cost development.

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	100%	$ 2,774,000
Aging Infrastructure:	0%	$ -
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 2,774,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design/Construction - Year 1	30%	2033	$ 832,200	$ 1,231,859
Construction - Year 2	70%	2034	$ 1,941,800	$ 2,989,312
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 2,774,000	$ 4,221,171

Notes:

Project timing dependent on impact of phase 1 improvements and long-term trends in solids loading rates after conversion to direct filtration. Even with reduction in coagulant dose, solids loading rates anticipated to be comparable to existing at end of 20-year planning period.

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 13
Project Name: Admin Building

Go to CIP Summary Table

Project Description:

Construct a new admin and maintenance building.

The administration building will serve as the main area for WTP operations, including a main operations control room, water quality laboratory, maintenance area, and instrument repair, as well as facilities for staff including offices, conference room, break room, and locker room. There would also be space allocated for storage, supporting equipment (server room, mechanical room, etc), and restrooms.

The Administration building is currently proposed to be an 8,100 square foot two story building, with an additional 1,350 square feet dedicated maintenance area (1-story, with mezzanine storage level).

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Admin Building	$ 5,760,165	$ 1,779,891	$ 7,540,056	$ 2,262,017	$ 9,802,073	$ 3,920,829	$ 13,723,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
Total Project Cost (2023 $)							$ 13,723,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	0%	$ -
Aging Infrastructure:	100%	$ 13,723,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 13,723,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design	10%	2030	$ 1,372,300	$ 1,805,853
Construction - Year 1	45%	2031	$ 6,175,350	$ 8,451,393
Construction - Year 2	45%	2032	$ 6,175,350	$ 8,789,449
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 13,723,000	$ 19,046,695

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 14
Project Name: Backwash Lift Station Redundancy Improvements

Go to CIP Summary Table

Project Description:

-Install appropriate fittings and duct work to backwash lift station ventilation. Hillside encroaching on HVAC ductwork. fittings to turn ductwork upward will resolve this issue.
- Rebuild backwash lift station to accommodate a second (redundant) pump. Includes a new pump station and building with associated electrical and instrumentation improvements.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
Backwash Lift Station Redundancy Improvements	$ 1,382,550	$ 427,208	$ 1,809,759	$ 542,928	$ 2,352,686	$ 941,074	$ 3,294,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 3,294,000

Notes on Cost Estimation:

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	50%	$ 1,647,000
Aging Infrastructure:	50%	$ 1,647,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 3,294,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design/Construction - Year 1	40%	2031	$ 1,317,600	$ 1,803,227
Construction - Year 2	60%	2032	$ 1,976,400	$ 2,813,033
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
Total Project Cost			$ 3,294,000	$ 4,616,260

Notes:

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 15
Project Name: WTP Repairs

Go to CIP Summary Table

Project Description:

General Structural Repairs:
-Repair spalling concrete leak near north flash mix pipe.
-Install railing or other means of fall protection on chemical facility roof walkway.
-Repair concrete spalling and cracking (multiple areas).

Painting, Coating, and Corrosion Control:
-Conduct non-destructive testing of corroded items.
-Clean and paint/coat corroded exposed pipelines.

WTP Building Repairs:
Repair ceiling in the loading dock area and repair wall plaster on treatment building exterior.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC 30.9%	Subtotal	Scope Contingency 30%	Total Construction Cost	Engineering / Legal / Admin 40%	Total Project Cost
General Structural Repairs	$ 50,010	$ 15,453	$ 65,463	$ 19,639	$ 85,102	$ 34,041	$ 119,000
Painting, Coating, and Corrosion Control	$ 33,248		$ 33,248		$ 33,248		$ 33,000
WTP Building Repairs	$ 12,745	$ 3,938	$ 16,683	$ 5,005	$ 21,688	$ 8,675	$ 30,000
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 182,000

Notes on Cost Estimation:
Lump sum allowance provided for painting, coating, and corrosion control.

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	0%	$ -
Aging Infrastructure:	100%	$ 182,000
Water Quality:	0%	$ -
Safety:	0%	$ -
Total Project Cost	100%	$ 182,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Perform Work	100%	2023	$ 182,000	$ 182,000
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
		Total Project Cost	$ 182,000	$ 182,000

Notes:
Projects may be included separately as allowances/adders to other CIP projects at the WTP. Projects potentially could be completed by WTP staff.

City of Pasco
Butterfield Water Treatment Plant Improvements Plan
Capital Improvement Plan

Project ID: 16
Project Name: Intake Screen Replacement

Go to CIP Summary Table

Project Description:

Replacement of the existing air burst intake screens with ISI mechanically cleaned screens, Assumes no significant modifications to the supports.

Project Cost Estimate:

Project Element	Direct Construction Cost ($)	Sales Tax / OH&P / GC	Subtotal	Scope Contingency	Total Construction Cost	Engineering / Legal / Admin	Total Project Cost
		30.9%		30%		40%	
Intake Screen Replacement	$ 570,000	$ 176,130	$ 746,130	$ 223,839	$ 969,969	$ 387,988	$ 1,358,000
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -

Total Project Cost (2023 $)	$ 1,358,000

Notes on Cost Estimation:

Direct Construction Cost derived from $820,000 indicated in Aquatic Plant Life TM (which included 15% engineering, 20% contingency, and sales tax, 2023 $). Using common cost factors for all projects for consistency.

Go to Assumptions Tab

Cost Allocation:

Project Type	Percent	Cost
Capacity:	50%	$ 679,000
Aging Infrastructure:	0%	$ -
Water Quality:	50%	$ 679,000
Safety:	0%	$ -
Total Project Cost	100%	$ 1,358,000

Project Timing:

Project Element	% of Total Project Cost	Timing	Cost (2023 $)	Cost (Future $)
Design	10%	2023	$ 135,800	$ 135,800
Construction	90%	2024	$ 1,222,200	$ 1,271,088
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
			$ -	$ -
		Total Project Cost	$ 1,358,000	$ 1,406,888

Notes:

Projects may be included separately as allowances/adders to other CIP projects at the WTP. Projects potentially could be completed by WTP staff.

APPENDIX D 2023 LOAD STUDY UPDATE

LOAD STUDY REPORT

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	SWGR-XX		
DESCRIPTION	SWGR-	PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION		LARGEST MOTOR	450HP
VOLTAGE	480	COMMENTS	
BUS AMPS	10000		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
3491.4	4199.5

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
4364.3	5249.4

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
3752.9	4514.0

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

SUBFED EQUIPMENT

TAG	DESCRIPTION	EQUIPMENT SIZE	EQUIPMENT UNITS	STATUS	OPERATING KVA	OPERATING AMPS	BUS COMMENTS
MCC-CHEMICAL SYSTEMS		600.0	AMPS	NEW	136.9	164.6	*(Representative loads associated with CIP Project 5 - Chemical Building)*
MCC-FILTERS		800.0	AMPS	NEW	460.8	554.3	*(Representative loads associated with CIP Project 6 - Filters)*
MCC-FINISHED WATER PUMPS		3,200.0	AMPS	NEW	1712.7	2060.0	*(Representative loads associated with CIP Project 10 - Finished Water Pump Station)*
MCC-FLASH MIX		600.0	AMPS	NEW	28.3	34.0	*(Representative loads associated with CIP Project 8 - Flocculation Basins)*
MCC-FLOCCULATION		600.0	AMPS	NEW	63.9	76.8	*(Representative loads associated with CIP Project 8 - Flocculation Basins)*
MCC-OZONE		600.0	AMPS	NEW	305.7	367.7	*(Representative loads associated with CIP Project 11 - Ozone)*
MCC-PLANT UTILITIES		600.0	AMPS	NEW	265.0	318.7	
MCC-RAW WATER		1,200.0	AMPS	NEW	518.2	623.3	*(Representative loads associated with raw water pump station after all improvements to existing raw water pump station completed as part of CIP Project 3 - Raw Water Pump Station Improvements and CIP Project 16 - Intake Screen Replacement)*
				OPERATING LOAD SUBFED SUBTOTAL	3491.4	4199.5	

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

RESERVOIR.

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-CHEMICAL SYSTEMS		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION	CHEMICAL SYSTEMS	LARGEST MOTOR	3HP
VOLTAGE	480	COMMENTS	
BUS AMPS	600		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
136.9	164.6

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
171.1	205.8

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
171.1	205.8

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

SUBFED EQUIPMENT

TAG	DESCRIPTION	EQUIPMENT SIZE	EQUIPMENT UNITS	STATUS	OPERATING KVA	OPERATING AMPS	BUS COMMENTS
XFMR-CHEMICAL SYSTEMS		75.0	KVA	NEW	26.9	32.3	
				OPERATING LOAD SUBFED SUBTOTAL	26.9	32.3	

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	ONSITE HYPO GENERATION SYSTEM-1	55	KVA		DUTY / CONTINUOUS	NEW	55.0	66.2	
	ONSITE HYPO GENERATION SYSTEM-2	55	KVA		DUTY / CONTINUOUS	NEW	55.0	66.2	
	ONSITE HYPO GENERATION SYSTEM-3	55	KVA		STANDBY	NEW			
					OPERATING LOAD SUBTOTAL		110.0	132.3	

(Representative loads for On-Site Hypochlorite Generation included as part of CIP Project 5 - Chemical Building)

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	PNL-CHEMICAL SYSTEMS		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 4W, 65 KAIC KASC
LOCATION	CHEMICAL SYSTEMS	**LARGEST MOTOR**	3HP
VOLTAGE	208	**COMMENTS**	
BUS AMPS	100		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
26.9	74.6

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
33.6	93.3

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
33.6	93.3

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	ALUM METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	ALUM METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	ALUM METERING PUMP-3	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	CAUSTIC SODA METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	CAUSTIC SODA METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	CAUSTIC SODA METERING PUMP-3	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	CALCIUM THIOSULFATE METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	CALCIUM THIOSULFATE METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	FLUORIDE METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	FLUORIDE METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	FILTER AID METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	FILTER AID BATCHING UNIT-1	1.20	KVA	FVNR	DUTY / CONTINUOUS	NEW	1.2	10.0	
	FILTER AID METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	POT PERM BATCHING UNIT-1	1.20	KVA	FVNR	DUTY / CONTINUOUS	NEW	1.2	10.0	

Date/Time displayed in this report reflect time in PST

(Representative loads for assumed chemical systems included as part of CIP Project 5 - Chemical Building)

LOAD STUDY REPORT

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	PNL-CHEMICAL SYSTEMS		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 4W, 65 KAIC KASC
LOCATION	CHEMICAL SYSTEMS	**LARGEST MOTOR**	3HP
VOLTAGE	208	**COMMENTS**	
BUS AMPS	100		

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	POT PERM METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	POT PERM METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	SODIUM HYPOCHLORITE METERING PUMP-1	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	SODIUM HYPOCHLORITE METERING PUMP-2	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	SODIUM HYPOCHLORITE METERING PUMP-3	1.20	KVA		DUTY / CONTINUOUS	NEW	1.2	10.0	
	HYDROGEN BLOWER-1	3	HP	FVNR	DUTY / CONTINUOUS	NEW	4.1	34.0	
	HYDROGEN BLOWER-2	3	HP	FVNR	STANDBY	NEW			
					OPERATING LOAD SUBTOTAL		26.9	224.0	

(Representative loads for assumed chemical systems included as part of CIP Project 5 - Chemical Building)

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

RESERVOIR.

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-FILTERS		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 3W, 65 KAIC KASC
LOCATION	FILTERS	**LARGEST MOTOR**	250HP
VOLTAGE	480	**COMMENTS**	
BUS AMPS	800		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
460.8	554.3

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
576.1	692.9

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
533.6	641.8

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	BACKWASH PUMP-1	250	HP		DUTY / CONTINUOUS	NEW	251.1	302.0	
	BACKWASH PUMP-2	250	HP		STANDBY	NEW			
	AIR SCOUR BLOWER-1	150	HP		DUTY / CONTINUOUS	NEW	149.6	180.0	
	AIR SCOUR BLOWER-2	150	HP		STANDBY	NEW			
AC	AIR COMPRESSOR	15	HP		DUTY / CONTINUOUS	NEW	17.5	21.0	
F-13	AIR COMPRESSOR	3/4	HP		DUTY / CONTINUOUS	NEW	1.3	1.6	
F-14	AIR COMPRESSOR	3/4	HP		DUTY / CONTINUOUS	NEW	1.3	1.6	
HEATER	HEATER	30	KW		DUTY / CONTINUOUS	NEW	30.0	36.1	
HEATER2	HEATER2	10	KW		DUTY / CONTINUOUS	NEW	10.0	12.0	
					OPERATING LOAD SUBTOTAL		460.8	554.3	

(Representative loads for new filters and ancillary systems constructed as part of CIP Project 6 - Filters)

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-FINISHED WATER PUMPS		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION	FINISHED WATER PUMPS	LARGEST MOTOR	450HP
VOLTAGE	480	COMMENTS	
BUS AMPS	3200		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
1712.7	2060.0

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
2140.8	2575.0

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
1819.7	2188.8

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	PUMP-1	450	HP		DUTY / CONTINUOUS	NEW	428.2	515.0	
	PUMP-2	450	HP		DUTY / CONTINUOUS	NEW	428.2	515.0	
	PUMP-4	450	HP		DUTY / CONTINUOUS	NEW	428.2	515.0	
	PUMP-3	450	HP		DUTY / CONTINUOUS	NEW	428.2	515.0	
	PUMP-5	450	HP		STANDBY	NEW			
					OPERATING LOAD SUBTOTAL		1712.7	2060.0	

(Representative loads for new finished water pumps to be constructed as part of CIP Project 10 - Finished Water Pump Station)

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

RESERVOIR

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-FLASH MIX		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 3W, 65 KAIC KASC
LOCATION	FLASH MIX	**LARGEST MOTOR**	25HP
VOLTAGE	480	**COMMENTS**	
BUS AMPS	600		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
28.3	34.0

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
35.3	42.5

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
35.3	42.5

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	DIFFUSION MIX PUMP-1	25	HP	FVNR	DUTY / CONTINUOUS	NEW	28.3	34.0	
	DIFFUSION MIX PUMP-2	25	HP	FVNR	STANDBY	NEW			
					OPERATING LOAD SUBTOTAL		28.3	34.0	

(Representative loads for flash mix pumps and flash mixing included with new flocculation basins as part of CIP Project 8 - Flocculation Basins).

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-FLOCCULATION		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION	FLOCCULATION	LARGEST MOTOR	3HP
VOLTAGE	480	COMMENTS	
BUS AMPS	600		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
63.9	76.8

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
79.8	96.0

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
64.8	78.0

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	FLOCCULATOR MOTOR-1	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-2	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-3	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-4	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-5	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-6	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-7	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-8	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-10	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-11	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-12	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-13	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-9	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-14	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	

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(Representative loads associated with new flocculation basins as part of CIP Project 8 - Flocculation Basins).

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LOAD STUDY REPORT

RESERVOIR.

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-FLOCCULATION		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 3W, 65 KAIC KASC
LOCATION	FLOCCULATION	**LARGEST MOTOR**	3HP
VOLTAGE	480	**COMMENTS**	
BUS AMPS	600		

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	FLOCCULATOR MOTOR-15	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
	FLOCCULATOR MOTOR-16	3	HP		DUTY / CONTINUOUS	NEW	4.0	4.8	
					OPERATING LOAD SUBTOTAL		63.9	76.8	

(Representative loads associated with new flocculation basins as part of CIP Project 8 - Flocculation Basins).

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

RESERVOIR.

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-OZONE		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION	OZONE	LARGEST MOTOR	25HP
VOLTAGE	480	COMMENTS	
BUS AMPS	600		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
305.7	367.7

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
382.1	459.6

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
357.8	430.3

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	OZONE DESTRUCT UNIT-1	7.50	KW		DUTY / CONTINUOUS	NEW	7.5	9.0	
	OZONE DESTRUCT UNIT-2	7.50	KW		DUTY / CONTINUOUS	NEW	7.5	9.0	
	OZONE DESTRUCT UNIT-3	7.50	KW		STANDBY	NEW			
	OZONE GENERATORS + COOLING WATER-1	160	KW		DUTY / CONTINUOUS	NEW	160.0	192.5	
	OZONE GENERATORS + COOLING WATER-2	160	KW		STANDBY	NEW			
	NITROGEN BOOST SYSTEM	5	KW		DUTY / CONTINUOUS	NEW	5.0	6.0	
	SIDESTREAM PUMP-1	25	HP	FVNR	DUTY / CONTINUOUS	NEW	28.3	34.0	
	SIDESTREAM PUMP-2	25	HP	FVNR	DUTY / CONTINUOUS	NEW	28.3	34.0	
	SIDESTREAM PUMP-3	25	HP	FVNR	DUTY / CONTINUOUS	NEW	28.3	34.0	
	SIDESTREAM PUMP-4	25	HP	FVNR	DUTY / CONTINUOUS	NEW	28.3	34.0	
	OPEN LOOP COOLING WATER PUMP-1	5	HP	FVNR	DUTY / CONTINUOUS	NEW	6.3	7.6	
	OPEN LOOP COOLING WATER PUMP-2	5	HP	FVNR	DUTY / CONTINUOUS	NEW	6.3	7.6	
					OPERATING LOAD SUBTOTAL		305.7	367.7	

(Representative loads associated with ozone generation facilities and ozone contact basin included as part of CIP Project 11 - Ozone).

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

RESERVOIR

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-PLANT UTILITIES		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION	PLANT UTILITIES	LARGEST MOTOR	0HP
VOLTAGE	480	COMMENTS	
BUS AMPS	600		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
265.0	318.7

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
331.3	398.4

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
331.3	398.4

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

SUBFED EQUIPMENT

TAG	DESCRIPTION	EQUIPMENT SIZE	EQUIPMENT UNITS	STATUS	OPERATING KVA	OPERATING AMPS	BUS COMMENTS
XFMR-PLANT UTILITIES		500.0	KVA	NEW	265.0	318.7	
				OPERATING LOAD SUBFED SUBTOTAL	265.0	318.7	

Date/Time displayed in this report reflect time in PST

LOAD STUDY REPORT

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	PNL-PLANT UTILITIES		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 4W, 65 KAIC KASC
LOCATION		LARGEST MOTOR	0HP
VOLTAGE	208	COMMENTS	
BUS AMPS	1200		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
265.0	735.6

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
331.3	919.5

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
331.3	919.5

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	LIGHTING	15	KVA		DUTY / CONTINUOUS	NEW	15.0	41.6	
	HVAC AND LIGHTING LUMP	250	KVA		DUTY / CONTINUOUS	NEW	250.0	2083.3	
					OPERATING LOAD SUBTOTAL		265.0	2125.0	

Date/Time displayed in this report reflect time in PST

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LOAD STUDY REPORT

RESERVOIR

PROJECT INFORMATION

PROJECT	BUTTERFIELD WTP FACILITY PLAN
CLIENT	CITY OF PASCO
PROJECT NUMBER	12011A00
REPORT BY	BRIAN REAM
REPORT DATE	7/17/2023 10:41 AM

EQUIPMENT INFORMATION

TAG	MCC-RAW WATER		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 3W, 65 KAIC KASC
LOCATION	RAW WATER PUMP STATION - SEPARATE FEED FROM WTP	**LARGEST MOTOR**	150HP
VOLTAGE	480	**COMMENTS**	
BUS AMPS	1200		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
518.2	623.3

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
647.8	779.1

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
555.6	668.3

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	RAW WATER PUMP-1	150	HP		DUTY / CONTINUOUS	NEW	149.6	180.0	
	RAW WATER PUMP-2	150	HP		DUTY / CONTINUOUS	NEW	149.6	180.0	
	RAW WATER PUMP-3	150	HP		DUTY / CONTINUOUS	NEW	149.6	180.0	
	RAW WATER PUMP-4	150	HP	VFD-18	STANDBY	NEW			
	DECANT PUMP STATION-1	60	HP	FVNR	DUTY / CONTINUOUS	NEW	64.0	77.0	
	DECANT PUMP STATION-2	60	HP	FVNR	STANDBY	NEW			
	BRUSH SCREEN-1	1	HP	FVNR	DUTY / CONTINUOUS	NEW	1.7	2.1	
	BRUSH SCREEN-2	1	HP	FVNR	DUTY / CONTINUOUS	NEW	1.7	2.1	
	BRUSH SCREEN-3	1	HP	FVNR	DUTY / CONTINUOUS	NEW	1.7	2.1	
	BRUSH SCREEN-4	1	HP	FVNR	STANDBY	NEW			
					OPERATING LOAD SUBTOTAL		518.2	623.3	

(Representative loads associated with raw water pump station and decant pumps. Representative of loads after completion of raw water pump station upgrades.)
(Raw water pump station and decant pumps to be fed from separate power feed to the Butterfield WTP site and have separate backup power supply source.)
(Loads include elements from CIP Project 3 - Raw Water Pump Station Improvements, CIP Project 14 - Backwash Lift Station Redundancy Improvements, and CIP Project 16 - Intake Screen Replacement)

Date/Time displayed in this report reflect time in PST