CITY OF LEAVENWORTH

CHELAN COUNTY **WASHINGTON**

WTP ASSESSMENT AND RECOMMENDATION REPORT

G&O #18014
OCTOBER 2018

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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EXECUTIVE SUMMARY

The City of Leavenworth contracted with Gray & Osborne to perform a condition assessment for the existing Water Treatment Plant (WTP). The purpose of the assessment is to investigate the integrity of the existing WTP facilities from a structural, electrical, mechanical, and process perspective in order to guide the City's decisions on continued use of the water treatment plant.

The existing WTP is a direct rapid rate filtration plant that uses chlorine gas for disinfection. The plant was constructed in 1971 and has a rated capacity of 2.3 million gallons per day (mgd). The WTP treats surface water from Icicle Creek and is located on Icicle Creek Road approximately 4 miles from the intersection of US. Highway 2 and Icicle Creek Road.

An initial site visit was completed on April 19, 2018 by Gray & Osborne. During the visit, Gray & Osborne discussed the current operations, perceived deficiencies, and desired needs for the WTP with WTP operations staff, and also assessed the condition of all existing facilities at the WTP. After a preliminary data analysis was completed, two follow-up visits were conducted by select Gray & Osborne personnel to more thoroughly assess and investigate process and operational issues with the media filters.

The condition assessment found no significant structural, mechanical, or electrical deficiencies with either the WTP or the adjacent chlorine contact building. In general the facilities are in good condition and only require minor repairs and the completion of regular maintenance items in order to maintain their current function. In addition to minor repairs, the assessment has identified a number of proposed high-priority improvements that should be addressed to ensure the successful operation of the facility in the future. Table ES-1 provides a summary of the high priority repairs and improvements to the facility.

TABLE ES-1

High Priority WTP Recommendations Summary

Modification	Discipline(1)	Cost
High Priority Modifications		
Repair Deteriorated Wood Rafters at Eaves of Building	S	$15,000
Repair Corroded Structural Members in CCB	S	$30,000
Repair/Replace Corroded CCB Wall Fasteners	S	$10,000
Address Stair Tread/Rise Distances and Guard/Hand Rail	S	$25,000
Clean/Repair Icicle Ridge Reservoir Topping Slab	S	$32,000
Clean/Repair Icicle Ridge Reservoir Concrete Curb	S	$1,500
Assess Existing Water Main Piping and Connection Points	S	$15,000
Design and Install Auxiliary Generator	E	$105,000
Install Vacuum Pump Disconnect Switch	E	$10,000
Install Filter Backwash Pump Disconnect Switch	E	$10,000
Upgrade SCADA System Hardware/Software	E	$35,000
Provide Additional Ventilation in Basement	M	$40,000
Repair Chlorine Room Exhaust Fan Flashing	M	$1,000
Install Covered Grating Above Sedimentation Basins	BS	$18,000
Address Lack of Washup/Potable Water at WTP	BS	$6,000
Install Additional Shelving/Storage at Existing Workshop Area	BS	$1,000
Install Hand and/or Guardrail at the Intake Structure	BS	$8,000
Provide Confined Space Safety Equipment at the WTP	BS	$5,000
Replace Basement Piping, Fittings, and Appurtenances	P	$70,000
Repair/Replace Filter Inlet and Distribution Trough	P	$150,000
Assess Filter Surface Wash System and Replace Nozzles	P	$2,000
Reprogram Existing Secondary Clearwell Level Sensor	P	$2,000
Repair/Replace Existing CCB Mud Valves	P	$22,000
Design and Construct New, Larger, Backwash Storage Basin	P	$400,000
Add Additional Gas Cylinder Chain Restraints	P	$500
Replace Finished Water Flow Meter, Valve, and Actuator	P	$35,000

Subtotal $1,049,000
Contingency (30%) $315,000
Washington State Sales Tax (8.7%) $119,000
Design and Project Administration (25%) $371,000
Total $1,854,000

(1) S = structural, E = Electrical, M = Mechanical, BS = Building Systems, P = Process.

If the recommendations listed above are addressed, the WTP appears capable of successfully, effectively, and efficiently meeting the City's water treatment needs for at least the next 5 to 15 years. Although the original facility is nearly 50 years old, and the chlorine contact building is nearly 30 years old, the structures are in good overall condition and do not appear to need significant structural, electrical, mechanical or process modifications.

For potential longer term treatment of the Icicle Creek source, we identified and evaluated several potential alternatives. Technologies for successfully filtering 1,400 and 2,800 gpm from Icicle Creek were evaluated including utilizing the existing rapid rate media equipment, installing new rapid rate media equipment, and installing membrane filtration technology. An alternative to utilize groundwater sources was also presented.

The preferred treatment alternative will depend on the desired treatment capacity. If the City wishes to treat 1,400 gpm, then refurbishing and optimizing the existing equipment, and performing a majority of the maintenance/facility improvement items listed above would provide the most cost-effective solution. However, if the City wishes to treat 2,800 gpm – which is very nearly the City's current interruptible and uninterruptible water right from Icicle Creek – then expanding the existing filtration technology or installing membrane filtration technology at the existing WTP would be the most cost-effective alternative. Eliminating surface water treatment facilities completely and utilizing groundwater sources is also a technically feasible solution and could provide the lowest cost, long-term solution for the City – provided that the transfer of water rights could be successfully completed within the long-term planning period.

Depending on the ultimate treatment goals of the City, a more thorough, in depth analysis of select alternatives should be completed to more fully identify the full scope of improvements/modifications necessary. This analysis could also identify key design parameters and system requirements. Defining the full project scope will also help determine the overall project costs.

CHAPTER 1

INTRODUCTION AND EXISTING FACILITIES

INTRODUCTION

The City of Leavenworth contracted with Gray & Osborne to perform a condition assessment for the existing Water Treatment Plant (WTP) as part of a larger effort to analyze the City's water treatment and distribution facilities in order to prioritize funds for rehabilitation, modification, and/or replacement projects. The goal of the assessment is to identify potential improvements for the existing structures as well as the current treatment processes in an attempt to maximize efficiency and provide additional longevity for these facilities. The report can also be used to guide selection of feasible water treatment alternatives for longer term treatment of the Icicle Creek Source.

This report summarizes the findings of the WTP condition assessment, which was conducted on April 19, 2018. During this assessment, the structural, electrical, mechanical, process, and operations components for the WTP facility were investigated. Gray & Osborne personnel also briefly investigated the storage and pressure boosting facilities owned and operated by the City. Additional, follow-up visits by G&O personnel were also conducted and the findings from these visits are also incorporated.

This report includes a description of the existing facilities and processes, and summarizes the improvements that would be required for these facilities to meet current structural, mechanical, and electrical codes. The report also summarizes the modifications that may help to optimize the treatment process and provide a more efficient workspace for operations staff. A cost estimate is then provided for each of the proposed improvements. The report concludes with a description of the capacity of individual WTP treatment components and provides a brief description of alternatives that may be enacted to reach various treatment capacity goals in the long term.

BACKGROUND AND EXISTING FACILITIES

The City of Leavenworth is located along US Highway 2 approximately 25 miles west of Wenatchee in Chelan County, Washington. The City serves approximately 1,400 residential and commercial water system connections, and is heavily influenced by tourism during both the summer and winter months.

The City owns and operates a water system that includes a surface water source, water treatment facilities, groundwater sources, potable water storage, and water distribution facilities. Each of these groups of facilities is briefly described below and their locations are shown in Figure 1-1.

SURFACE WATER SOURCE

The City uses Icicle Creek as the primary water source for the WTP. Prior to the WTP, water flows through an intake structure and a screen house, both of which are described below.

Intake Structure

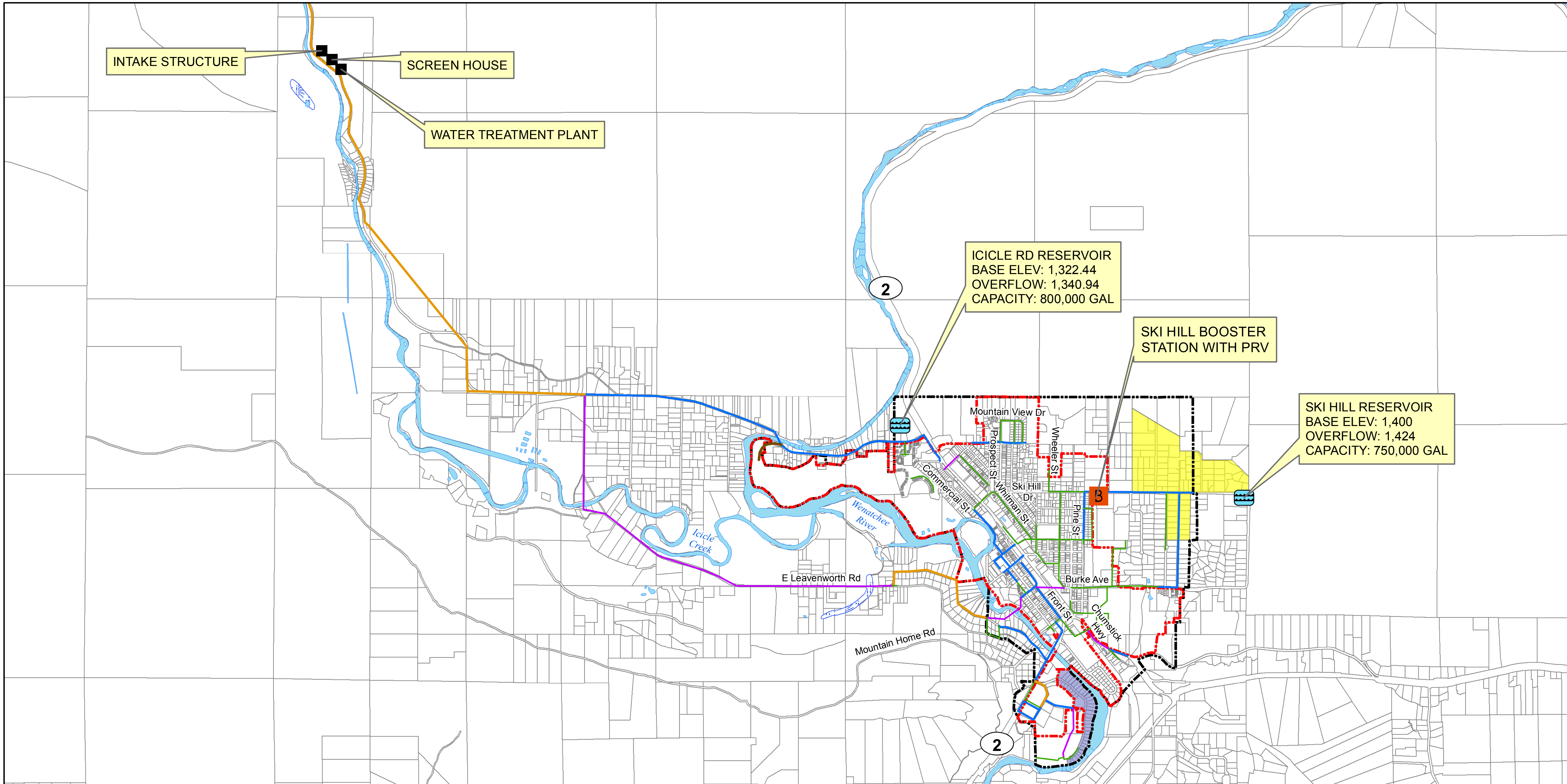
The intake structure is located approximately 1 mile west of the WTP on Icicle Creek and includes a creek diversion structure and settling caisson. The facility is accessed from Icicle Creek Road and is secured via chain link fencing. The intake structure contains a weave-mesh screen with 0.25-inch spaces that prevents leaves, sticks, and other large debris (including fish) from entering the intake caisson. This screen is cleaned manually as needed. The caisson is a concrete structure located adjacent to the screen and is designed to promote settling of larger particles prior to entrance to the intake piping. The caisson is also cleaned manually on an annual or semi-annual basis. Piping between the intake structure and screen house is 18-inch diameter while piping between the screen house (described below) and the WTP generally follows the rocky shoreline of Icicle Creek and is 16-inch diameter ductile iron. The intake structure was not assessed as part of this project; however, the intake structure and caisson are shown in Appendix A, Figure A-1 and A-2, respectively.

Screen House

The screen house is located between the intake structure and the WTP. The screen house is a concrete/CMU structure located at the edge of Icicle Creek. The screen house was originally intended to provide sediment filtration and screening for the WTP. The existing screen house and all associated screens, gates, and valves are in poor condition and no longer function as originally designed; however, it is currently slated for modification as part of a 2018 project to improve fish passage in Icicle Creek. The project will restore screening capabilities and provide a bypass for fish that enter the intake structure. The screen house was not assessed as part of this project; however, the screen house is shown in Appendix A, Figure A-3.

WATER TREATMENT PLANT (WTP)

The existing WTP is a direct rapid rate filtration plant with a rated capacity of 2.3 mgd. The WTP is a housed in a CMU building located on Icicle Creek Road approximately 4 miles south of US Highway 2. The facility was constructed in 1971 and has undergone several minor improvements since that time. A chlorine contact basin and other minor plant improvements/modifications were constructed in 1991. The WTP provides coagulation, flocculation, filtration, and disinfection before filtered, potable water flows by gravity to the distribution system that serves the City. Each of the individual components of the treatment process are described below.



LEGEND

UGA	WATERBODIES	**EXISTING WATERMAIN**
CITY LIMITS	MARSH, SWAMP, BOG	8" DIAMETER PIPE
RIVER BEND WATER ASSOCIATION	B BOOSTER STATION	10" DIAMETER PIPE
SKI HILL WATER ASSOCIATION	RESERVOIR	12" DIAMETER PIPE
PARCELS		16" DIAMETER PIPE
		24" DIAMETER PIPE

N

Feet
0 1,375 2,750 5,500

CITY OF LEAVENWORTH

WTP ASSESSMENT PROJECT

FIGURE 1-1
EXISTING WATER SYSTEM FACILITIES

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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Coagulation/Flocculation

The WTP adds Isopac 8662 coagulant to the raw water to assist with coagulation. Coagulant dose is monitored and automatically adjusted using a Chemtrac® current streaming monitor. Coagulant is injected to a static mixer, which is located immediately downstream from the raw water flow control valve. The static mixer is a TAH Industries Stata-Tube mixer that is designed for use with industrial adhesives. The coagulant injection and mixing equipment is shown in Appendix A, Figure A-4.

Once through the static mixer, raw water proceeds through a 90-degree bend and then proceeds into the first of four hydraulic flocculation basins operated in series (Basin 1→2→3→4). Each concrete flocculation basin is 5'-8" by 7'-6" (42.5 SF) and water flows through these basins in an under-over-under-over pattern. The first basin (Basin 1) contains a mud-valve used to drain both Basin 1 and 2. Basins 3 and 4 (in sequence) can flow back to Basin 1 by opening an existing sluice gate within Basin 4. The typical operational volume within each basin is approximately 5,460 gallons. These basins are located directly below the grating at the entrance to the WTP, and are covered by floormats to minimize the entrance of debris or other materials. Once through the fourth flocculation basin, water enters the media filter inlet trough. The flocculation basins are shown in Appendix A, Figure A-5.

Rapid Rate Filters and Backwash Basin

After coagulation and flocculation, water enters the dual media rapid rate filters through a steel inlet trough. The filter equipment is a package system manufactured by Infilco (now Suez® Industries) and includes an inlet trough, filter siphon, fixed filter level control weir, forebay, filter distribution trough, filter cells, vacuum system, dual media filtration system, and under-drain system. The filter system was constructed with the WTP in 1971 and has had very few modifications or improvements since its installation. While the filter walls are concrete, the central filter cylinder and distributing equipment is steel.

The inlet trough directs water to the forebay via a siphon tube and a fixed overflow weir at the center of the inlet trough. Once in the forebay, raw water then flows out the filter distribution trough and into the filter. Water then proceeds through the filter media, through the underdrain system, and then out the connecting piping to the primary clearwell. Critical design information for the rapid rate media filter unit is summarized in Table 1-1.

TABLE 1-1

Leavenworth WTP Infilco Media Filtration Design Information

Parameter	Value
Manufacturer	Infilco
Type	Gravity Rapid Rate Dual Media
Designation	B-4
Filter area (square feet, total)	476
Rate of Filtration, maximum (gpm/SF)	6.6[(1)(2)]
Rate of Filtration, 2.0 mgd (gpm/SF)	2.9
Rate of Filtration, 4.0 mgd (gpm/SF)	5.8
Rate of Backwash (gpm/sf)	10 - 14
Design Media Depth (inches) Anthracite (E.S. 0.9 mm – 1.2 mm, U.C 1.7 Max) Sand (E.S. 0.35 mm – 0.45 mm, U.C. 1.6 Max)	 18 9
Design Underdrain Gravel Depth (inches) Torpedo Sand 1/2" – 1/4" Gravel 3/4" – 1/2" Gravel 1-1/2" – 3/4" Gravel	 3 2.5 2.5 6
Vacuum Tank, High (psi)	7.4
Vacuum Tank, Low (psi)	0.9

(1) Taken from the Leavenworth WTP O&M Manual (1971) as provided by Infilco. Current code dictates that the maximum allowable areal flow rate for direct filtration, dual media filters is 6 gpm/SF (WAC 246-290-654).

(2) DOH currently assumes a maximum acceptable flow of 5.1 gpm/SF.

During normal filter operation, water is distributed to the filter cell and flows through the filter media and into a common underdrain chamber. As it passes through the filter media, sediment and small particles are trapped by the anthracite and sand media. As additional particles are trapped on the surface of the filter, both the headloss through the filter media and the turbidity of the filtered water increase. When the turbidity of the water leaving a filter cell reaches approximately 0.08 NTU, the filter is backwashed to remove the trapped particles and clean the filter media. During the backwash of a single filter cell, water from the primary clearwell and the other operating filters combine via the common underdrain chamber and reverses direction to flow *upward* through the filter that is being backwashed. This reverse flow is initiated by a vacuum system that is part of the media filter equipment package. Once the flow is reversed, the particle laden water then flows into the filter cell distribution trough, through the forebay into the central drain piping, and then through this piping to the backwash storage basin.

According to discussions with the WTP operations staff, the performance of the filters has declined in recent years. Although filter run times have decreased only slightly (perhaps due to decreased flow through the WTP), the time to return to active filtration after a backwash cycle has increased significantly. This would indicate that the backwash cycle is not effectively cleaning the filter, or that trapped particles are loosened and escape through the filter during backwash and during the period immediately following a backwash cycle.

The backwash storage basin is a large earthen basin south of the WTP. The original volume based on design drawings was approximately 100,000 gallons. Due to subsequent sediment accumulation and erosion since its construction, the current volume of the basin is unknown, but is estimated to be between 60,000 – 80,000 gallons. The backwash basin has a single, manually operated outlet valve located at the south end of the basin. Under normal operation, the backwash water within the basin is allowed to settle for approximately 24 hours at which point the basin drain valve is manually opened and the supernatant solution is allowed to drain to Icicle Creek. The drain valve is located approximately 6 feet below the upper rim of the basin. Sediment and particles that remain in the backwash basin are manually removed using an excavator approximately once each year.

Discussions with WTP operations staff suggest that backwash storage volume significantly limits the treatment capacity of the WTP. The issue of backwash storage volume is discussed later in this report. A schematic of the rapid rate filtration system is shown in Appendix A, Figure A-6, and the rapid rate dual media filters and backwash basin are shown in Appendix A, Figures A-7 and A-8, respectively.

Primary Clearwell

Once through the rapid rate dual media filters, water flows through 12-inch diameter piping to the primary clearwell. The primary clearwell is a concrete basin below the floor slab of the lower level of the WTP and is accessed via a 24-inch manhole within the floor. Both the primary and secondary clearwell should be considered as confined spaces. The clearwell is hydraulically connected to the filters via the underdrain chamber and the chlorine contact basin via ductile iron piping, but is separated from the adjacent secondary clearwell by a concrete wall and fixed overflow weir. The primary clearwell provides equalization volume for the WTP potable water system, provides a basin for the injection of ortho-phosphate solution which is used for corrosion control, and sets the hydraulic grade line for the backwash pressure for the filter units. The primary clearwell has a surface area of 36 SF and a typical operational volume of approximately 2,100 gallons. Once through the primary clearwell, water flows through 24-inch ductile iron pipe to the chlorine contact basin, which is described below. The primary clearwell is shown in Appendix A, Figure A-9.

Chlorine Disinfectant Injection System

Immediately downstream of the primary clearwell, disinfectant is injected to the filtered water piping. This disinfectant provides the necessary chlorine residual to meet the concentration and contact time (CT) requirements set forth by the Washington State

Department of Health (DOH). The WTP utilizes gaseous chlorine, which is mixed with a sidestream of water creating a hypochlorite solution that is then injected to the piping between the primary clearwell and the chlorine contact basin. The system is fully automated based on the desired chlorine residual, and adjusts automatically based on the flow through the raw water flow meter in order to maintain a target finished water chlorine concentration of 0.8 mg/L. Two active gas cylinders are stored on a scale which displays the pounds of gas remaining in each cylinder. The WTP keeps two to three backup cylinders onsite for redundancy.

While gaseous chlorine is a viable method for disinfection of potable water – especially for small-scale water treatment facilities – many municipalities are electing to disinfect using liquid sodium hypochlorite or other liquid based chemicals due to the inherent safety risks of chlorine gas. In the event of a leak, fire, or explosion, chlorine gas poses a significant health and safety risk to operations staff as well as residents near the WTP. Although the risk for the Leavenworth WTP is relatively low because of the small volume of gas used and stored onsite, it does exist. To help mitigate this risk, the chlorine room at the WTP contains a chlorine gas sensor, which will warn operations staff of a potential leak so that appropriate ventilation and safety procedures can be followed. The chlorine mixing and injection equipment is shown in Appendix A, Figure A-10.

Chlorine Contact Basin

Once chlorine is injected to the filtered water from the primary clearwell, water flows through the chlorine contact basin (CCB). The CCB was constructed in 1991 and consists of two baffled concrete basins covered by a metal-sided building. Each concrete basin is identical, and although it is possible to operate the basins in parallel (i.e., independently), the basins are typically operated in series such that water flows from Basin 1 to Basin 2 prior to exiting the CCB. Each basin contains HDPE baffles that further divide each basin into several long chambers. These chambers further lengthen the flowpath of the water within the basins. The CCB contains gates and valves that may be used to redirect flow and/or drain the basin for cleaning. The surface area of the CCB is approximately 1,846 square feet, and the operational volume at a sidewater depth of 10 feet is approximately 138,000 gallons.

Water enters the CCB, flows through a perforated HDPE sheet, continues down each chamber in a serpentine fashion, then exits the basin via a 24-inch ductile iron pipe. The CCB provides the necessary contact time for appropriate disinfection of the filtered water produced at the WTP. This contact time was verified as part of a Tracer Study project conducted in 2017 by Gray & Osborne. Given a typical operating volume and summertime flowrate of 138,000 gallons and 950 gpm, respectively, the hydraulic residence time of water within the CCB is 145 minutes. Also as part of the Tracer Study project, Gray & Osborne recommended a T_{10}/T, or baffling factor, of 0.6. This value is the ratio of the time for 10 percent of a tracer solution to make its way through the basin and be detected at the outlet divided by the total hydraulic residence time for the basin.

When the 0.6 baffling factor is applied to the CCB, the effective contact time of disinfection is 87 minutes for 950 gpm.

Although the CCB appears to be in good condition, discussions with the operations staff indicate that the existing 6-inch diameter mud valves are leaking. These valves are used to drain the basin during cleaning and the estimated leakage through these valves is between 1 to 10 gpm per valve. Water leaking from the CCB proceeds through 12-inch ductile iron drain piping directly to the backwash basin.

A plan view and photograph of the CCB are shown in Appendix A, Figures A-11 and A-12, respectively.

Secondary Clearwell

Once water exits the CCB, it flows back to the WTP through 24-inch piping and into the secondary clearwell. This clearwell consists of two separate but hydraulically connected concrete basins. The first basin has a surface area of 48 SF and a typical operational volume of approximately 2,700 gallons while the second basin has a surface area of 45 SF and a typical operational volume of approximately 2,500 gallons. The clearwell is used to provide equalizing storage for two existing pumps. The first is a 125-hp pump that is not longer used, but was originally installed to provide pressure and fire flow to the distribution system. The second is a 20-hp pump that is used at the conclusion of each backwash cycle to move a burst of chlorinated water from the secondary clearwell to each filter basin. This small volume of water is designed to limit algae growth within the individual filter cells. Water flows through the secondary clearwell and into the 12-inch diameter discharge pipe prior to flowing through the finished water flow meter vault.

The secondary clearwell is shown in Appendix A, Figure A-13.

Finished Water Flow Meter Vault

Once through the secondary clearwell, finished water flows through two buried vaults. The first vault contains a motor actuated butterfly valve that regulates the flow from the secondary clearwell in order to maintain a consistent volume within the CCB. The valve and actuator were installed prior to 2000 and are likely nearing the end of their useful life. This is evident by the apparent “stickiness” of the valve noted by WTP operations staff during our site visit. The second vault contains a magnetic flow meter and associated transmitter. The flow meter is a 12-inch Sparling meter and was also installed prior to 2000. The meter has not been recalibrated since its installation date. The finished water metering vault is shown in Appendix A, Figure A-14.

STORAGE RESERVOIRS

The City utilizes two storage reservoirs. The Icicle Ridge Reservoir is located immediately south of the intersection of US Highway 2 and Icicle Creek Road while the Ski Hill Reservoir is located at the intersection of Ski Hill Drive and Titus Road. The reservoirs are summarized in Table 1-2.

TABLE 1-2

City of Leavenworth Storage Reservoir Summary

Parameter	Icicle Ridge	Ski Hill
Year Constructed	2008	2006
Type	Cast in place concrete	Welded Steel
Shape	Rectangular	Round
Height (ft)	21	25
Diameter (ft)	-	74
Footprint (ft)	53 x 123	-
Base elevation (ft)	1,322.0	1,400.5
Overflow elevation (ft)	1,340.5	1,423.8
Volume (gal)	830,000	750,000
Gallons per foot	44,860	32,450

In 2008, the City demolished the Icicle Ridge Reservoir and rebuilt the existing structure on the same site. A 14-inch diameter ductile iron main installed in 1990 connects the Icicle Ridge Reservoir to the 12-inch transmission/distribution main on Icicle Road. The City put the Ski Hill reservoir into service in 2006 along with the accompanying Ski Hill Booster Station. These improvements established Zone 2 and allowed the City to serve higher elevation portions of the Ski Hill area unserviceable by the main zone. The transmission main between the Ski Hill booster and the Ski Hill reservoir consists of approximately 2,400 LF of 12-inch diameter and 1,900 LF of 16-inch ductile iron pipe.

BOOSTER STATIONS

The City owns and operates a single booster station – the Ski Hill Booster Station – which is located approximately 1.4 miles northwest along Ski Hill Drive west of US Highway 2. The booster station pumps water from Zone 1 to Zone 2, and additional information on the station is summarized in Table 1-3.

TABLE 1-3

City of Leavenworth Booster Station Summary

Parameter	Ski Hill BS
Year Constructed	2006
Enclosure Type	CMU Block
Suction Zone	Zone 1
Discharge Zone	Zone 2
No. of Pumps	2[(1)]
Pump Type	Close coupled end suction
Pump Size (hp)	10
Pump Speed (rpm)	3,600
Pump Control	Soft-start
Pump Capacity (gpm)	200

(1) Provisions exist for a third, similarly sized pump to be installed.

GROUNDWATER

The City maintains three groundwater sources that supplement the primary Icicle Creek surface water source. The sources are located on Icicle Creek Road approximately 0.9 miles south of the intersection of Icicle Road and US Highway 2, immediately west of the Leavenworth Golf Club. Information on these sources is provided in Table 1-4.

TABLE 1-4

City of Leavenworth Groundwater Source Summary

Parameter	Well 1	Well 2	Well 3
Year Constructed	1989	1989[(1)]	2014
Depth (ft)	106	94	115
Casing Size (in)	12	16	12
Screen Size (in)	12	16	12
Pump Type	Lineshaft	Submersible	Submersible
Pump Size (hp)	125	75	150
Pump Speed (rpm)	1,800	3,600	3,600
Pump Control	Soft Start	VFD	VFD
Pump Capacity (gpm)	1,200	750	1,300

(1) Well 2 was reconstructed in 2016.

The wellfield includes a chlorine gas injection system that provides continuous, flow-paced chlorination when any or all of the well pumps are in operation. A 24-inch diameter ductile iron transmission main connects the wells to the distribution system and provides the necessary chlorine contact time when the wells are in operation.

WATER RIGHTS

The City maintains adequate water rights for their existing demands as well as projected maximum day demands with one source offline through at least 2035. The City's water rights are fully detailed in the current Water System Plan (*Varela Engineers, 2018*), but are summarized below in Table 1-5. The City is currently working with the Washington State Department of Ecology (Ecology) to remedy a disagreement regarding several water right certificates, and a resolution on these disagreements is expected to be reached within the next 1 to 2 years.

TABLE 1-5

Water Rights Summary

Type	Number	Instantaneous		Annual[1] (acre-feet)	Annual[2] (acre-feet)
		Interruptible (gpm)	Un-Interruptible (gpm)		
Surface Water	4	-	682	1,100	-
	8105	-	673	1,086	-
	S4-28122	1,427	-	90[3]	546
Surface Water Subtotal		**1,427**	**1,355**	**2,276**	**546**
Groundwater	437-A	-	1,001	-	1,100
	G4-29958	2,000	-	90[3]	810
Groundwater Subtotal		**2,000**	**1,001**	**90**	**1,910**
TOTAL[4]		**3,427**	**2,356**	**2,276**	**2,456**

(1) Primary water rights.
(2) Supplementary water rights.
(3) A total of 90 acre-feet per year of new primary water rights were granted for both G4-29958 and S4-28122, and cannot be counted twice in the total annual quantity for the system.
(4) Rights 4, 8105, S4-28122, and G4-29958 are for Icicle Creek, while right 437-A is for the Wenatchee River.

Regardless of the outcome of this assessment with regards to water treatment plant operation and/or modifications, the City is interested in utilizing water from both Icicle Creek and the Wenatchee River in order to maintain some level of source redundancy.

CHAPTER 2

WTP CONDITION ASSESSMENT

INTRODUCTION

On Wednesday, April 19, 2018 engineers from Gray & Osborne visited the City of Leavenworth WTP to perform a condition assessment of the existing facilities. Russell Porter P.E., Aaron Pease P.E., Myron Basden P.E./S.E., Keith Stewart P.E., Adam Miller P.E., and Perry McKay from Gray and Osborne met City of Leavenworth WTP operators Arnica Briody and Tracy Valentine onsite at the WTP at approximately 10:45 a.m. The weather was clear with winds less than 2 mph and daytime high temperatures were approximately 65 degrees F.

Ms. Briody and Ms. Valentine described the treatment equipment and provided operations and technical information on all facets of the treatment plant. After becoming familiar with the WTP facilities, the assessment team split up and performed assessments on all of the facilities with a specific focus on their area of expertise.

Subsequent to our visit on April 19th, Adam Miller visited the WTP on April 25th in order to observe, witness, and document conditions immediately prior, during and immediately after a backwash cycle of all four filter cells.

Additionally, on May 10th, Adam Miller and Arnica Briody investigated and documented the existing condition of the filter media in one cell, including composition, depth, and attempted to identify the thickness of the various media layers.

Lastly, on June 29th, Adam Miller and Keith Stewart visited the WTP to investigate the filter cell performance. Water level measurements were collected at various times before, during, and after active filtration, as well as before, during, and after backwashing each of the filter cells. During this visit, some modifications were made to the settings of various filtration and hydraulic components in an attempt to optimize backwash performance and decrease the post-backwash filter-to-waste time for each filter cell.

An additional description of the results of these follow up visits is provided later in this report; however, the following sections include a summary of the issues identified by each discipline at our preliminary condition assessment conducted on April 19th.

STRUCTURAL CONDITION ASSESSMENT

The structural assessment includes the main building and chlorine contact building at the WTP. Information was collected from on-site observations as well as original drawings for the existing structures. The structural assessment includes review of the condition of structural members, compliance with current building code, adequacy of the structure for resisting earthquake forces, and potential structural modifications that may provide benefit for operation of the plant. The building code used for this evaluation is the International Building Code (IBC) 2015.

WTP Operations Building

The operations building consists of a metal roof over wood framing with a Glu-lam ridge beam running the length of the building. The perimeter wall of the building is masonry and is supported by below-grade concrete walls, many of which form the water-containing tanks within building. In general, the building is in serviceable condition. Specific items that were identified during the assessment are listed below.

- The original 1970 plans indicate that open cells of the masonry walls are filled with Zonolite insulation, which is a brand of vermiculite insulation that is known to contain asbestos. The presence of asbestos can be confirmed by drilling a hole in the masonry wall and extracting a sample of the insulation for testing. Construction plans and specifications for any proposed work affecting the masonry walls should identify the presence of asbestos so that contractors may account for this in their bids.

- The original 1970 plans indicate the existing 8-inch masonry walls have vertical reinforcing at 48-inches on center and no horizontal reinforcing except for the bond beam at the top of the wall. Current building codes require horizontal reinforcing at a maximum spacing of 48-inches on center. In addition, vertical dowels at the base of the wall appear to have insufficient lap length as required by the current building code. The above items are not expected to significantly affect the seismic performance of the walls because there is significant wall length on all four sides of the building.

- The roof diaphragm of the building consists of plywood sheathing with wood blocking installed below the sheathing at the ridge beam and the perimeter walls. The nailing pattern of the sheathing to supports, the attachment of the blocking to the sill plate at the top of the perimeter masonry wall, and the attachment of the sill plate to the masonry wall could not be verified while onsite. These items are critical to the seismic performance of the diaphragm and could be verified and retrofitted as needed when the roof is removed or replaced. The roof diaphragm of a building is an important component of the seismic force resisting system. It provides lateral support for the top of all walls to prevent toppling of the walls during an earthquake. The diaphragm also acts as a rigid plane to distribute earthquake loads to masonry shear walls.

- In several locations minor damage was observed on the underside of the plywood roof sheathing.

- Current building codes require that stairs providing egress out of a building have 11-inch treads and rises not more than 7 inches. The stairs to the main floor have insufficient tread length of 9.75 inches and a rise of 7 inches. Stairs to the basement have a tread length of 11 inches and a non-compliant rise of 9 inches.

- The metal roof of the building is in good condition and appears to have many years of service remaining.

- Some of the exposed wood rafters under eaves are slightly deteriorated due to exposure to weather.

- The stairs to the basement do not have a guard railing. Any stair providing egress from a building is required by the current building code to have handrail. Guardrail is also required where there is a vertical drop of more than 30 inches.

- No significant cracks were found in the masonry walls of the building. It appears the foundation has not experienced differential settlement, and has performed well over the life of the structure.

- Access to the existing filtration basins is currently only possible by placing an extension ladder into a metal trough in the tank and climbing over the guardrail at the platform to get to the ladder. A fixed ladder or other permanent means of access could be installed to improve access for staff.

- Currently there are no hoists located over the filtration basins. Steel beams could be added over the tanks to support trolley hoists to provide means for lifting, especially for removing/adding filtration media or to provide delivery of tools or equipment for cleaning.

- The buried water main between the WTP and the town's distribution system was not inspected as part of this assessment; however, much of the pipe between the WTP and the distribution system in Leavenworth is steel pipe which is in poor condition and is undersized. The pipe between the WTP and the wellfield was installed between 1955 and 1967 while the pipe on East Leavenworth Road was installed between 1930 and 1938. Leaks of the pipe are common and this old pipe is likely at a high risk of failure during a seismic event. Remaining sections of water main may be susceptible to damage during an earthquake if it has been compromised by corrosion damage or differential settling. Depending on the condition of the water main, it may have a higher risk of failure during an earthquake than the buildings at the treatment plant.

Chlorine Contact Building

The chlorine contact building is a prefabricated metal building supported by large structural steel frames spanning the width of the building with cold-formed Z-purlins framing the roof and walls. The frames are supported by concrete walls that also form the water containing tank within the building. The exterior is clad with metal roof and wall panels with occasional fiberglass relights. Observations noted during inspection of this structure include the following.

- The metal roof and wall panels on the exterior of the building are in good condition and appear to have many years of service life remaining. The tips of the fasteners that attach the metal panels to the Z-purlins are visible from the inside of the building and show light to mild corrosion.

- There are many failures of the white paint on the structural steel frames which has resulted in corrosion of the steel. The corrosion is not uniform but rather occurs in discrete spots along the steel, mostly along the top and bottom flanges of the I-beams. The steel appears to have lost thickness in some of the more severe spots of corrosion.

- The cold-formed Z-purlins framing the roof and walls are galvanized and are in good condition. No significant areas of corrosion were noted.

- X-bracing in the roof and walls of the metal building is galvanized and is in good condition. No significant areas of corrosion were noted.

- The access walkway is galvanized and in good condition. No significant areas of corrosion were noted.

- The earthquake force-resisting system of the building consists of cable X-bracing and two larger structural steel frames near the center of the building. An in-depth seismic analysis was not performed as part of this assessment; however, no deficiencies are expected in the earthquake force-resisting system based on a cursory review. Prefabricated metal buildings are historically proven to perform well in earthquakes, typically due to the relatively light weight of the structure and the ductility of the steel members.

Reservoirs

As previously mentioned, the Ski Hill Drive Reservoir is a 750,000-gallon steel ground-supported reservoir constructed in 2006. Although a full seismic analysis was not performed, Gray & Osborne personnel visited the reservoir site on April 19, 2018 and performed a brief visual analysis.

- Original drawings for the tank and observations during the site visit confirm that there is no concrete foundation ring wall under the perimeter shell of the tank. *AWWA D100 Welded Carbon Steel Tanks for Water Storage* allows five types of foundations for ground-supported flat-bottom tanks. Typically, a concrete ring wall is used per Type 1 of AWWA D100, however for this reservoir it appears the design used a granular berm with steel retainer ring per Type 5 in AWWA D100. Note N11 on Sheet 5 of the original plans indicates that the steel floor plate shall be designed such that the maximum soil bearing pressure below the wall is 5,000 psf. Preliminary calculations show that a 1/4-inch steel floor plate can span 3 to 4 inches from the wall before becoming overstressed by a soil bearing pressure of 5,000 psf. It appears this will be adequate for maximum static and seismic loads at the base of the wall.

The Icicle Ridge Reservoir holds approximately 830,000 gallons and is constructed of cast-in-place concrete foundation and walls and a pre-stressed concrete lid with cast-in-place prestressed concrete topping slab. Although a full seismic analysis was not performed, Gray & Osborne personnel visited the reservoir site on April 19, 2018 and performed a brief visual analysis.

- The topping slab has spots of deterioration across the entire roof, consisting of holes of 1/2 to 3 inches in diameter with chalky concrete within the hole that can easily be removed by hand. There are several possible causes for these defects, including impact from rocks or debris thrown over the security fencing. Regardless of the cause of these defects, it seems clear that the concrete does exhibit the strength and rigidity of typical prestressed concrete structures. It is likely that quality control issues during construction lead to portions of the slab that exhibit significantly less than the required compressive strength of 4,000 psi.

- A large section of concrete curb is missing at one side of the roof hatch.

- The gray paint on the metal guard railing around the roof is peeling due to poor adhesion. The railing appears to be corrosion-resistant metal (the original plans show aluminum) so it is not necessary for the railing to be painted.

- Grade has been dug down under the security fence in at least one location, comprising the security of the reservoir.

ELECTRICAL CONDITION ASSESSMENT

The electrical assessment includes the main building at the WTP. Information was collected from on-site observations as well as original drawings for the existing structures. The electrical assessment includes review of the condition of existing equipment, use of the existing equipment, current operational scheme and tactics, compliance with current electrical codes, and potential modifications that may benefit the operation of the plant. Furthermore, the existing telemetry/SCADA system was assessed by investigating the existing interface and discussions on the reliability of communications between the WTP alarm system and WTP operational staff.

Electrical

The existing utility service includes a pad mounted 150 kVA 480/277 VAC (180.5 full load amps) three phase electrical transformer installed by the Chelan County Public Utility District. The service feeds a 480 VAC motor control center (MCC) through a 400 amp main circuit breaker with 500 kCM conductors. The MCC originally supplied power for all the WTP loads including motors, heaters, and a sub panel for branch circuits for lighting, receptacles, and other general use loads. At some point after initial installation and startup of the WTP, a 480/277 VAC 125 amp panelboard was added, which was fed from the main circuit breaker. This additional panelboard supplies power to a unit heater and two motor operated valves. The main circuit breaker, 480 VAC panelboard, utility meter (including the metering current transformer (CT) enclosure) and the 480 VAC to 240/120 VAC transformer are located in the WTP basement while the MCC and the 240/120 VAC panelboard are located in the laboratory/office.

In general, a majority of the electrical components in service at the WTP are in good condition and do not require immediate attention. Furthermore, there were no significant safety or health risks noted during the WTP assessment. Recommendations for minor modifications to ensure code compliance are provided in subsequent sections of this report.

It was specifically noted that the WTP does not maintain a backup generator. As such, the WTP would not be operational during a loss of power event. This may be acceptable as the City maintains groundwater sources that are provided with a permanent auxiliary diesel generator that includes an automatic transfer switch.

Neither the filtration system vacuum pumps nor the filter backwash pump have circuit disconnect switches that meet current electrical codes.

An electrical power distribution diagram for the WTP was not available during the assessment, and a formal electrical capacity load study was not performed. However, based on the information gathered during our site visit, we do not anticipate any significant issues with electrical load for the existing equipment or potential future equipment. In 1990, the chlorine contact basin was constructed and several other modifications were completed at the WTP. Some of these modifications include removing an existing 125-hp pump from service. This reduced the overall load capacity of the WTP by approximately 155 amps. As such, it would be possible for the City to modify their existing electrical service; however, this modification would only be cost-effective and valuable if conducted as part of a larger project that affected the electrical equipment. Other specific recommendations are discussed later in this report.

Telemetry/SCADA

The existing supervisory control and data accusation (SCADA) system consists of a Wonderware computer-based human machine interface (HMI) that communicates with a programmable logic controller (PLC) using an ethernet communication protocol. In addition to monitoring and controlling activities at the WTP, this PLC also communicates with the City's groundwater facilities (near the intersection of Icicle Creek Road and Icicle Lane) as well as two Storage Reservoirs (Icicle Ridge and Ski Hill). Communication to these remote facilities is accomplished via radio based telemetry. Discussions with operations staff indicate that this type of communication is generally reliable; however, communication is lost several times each year due to weather conditions and the extremely rough, rugged, and hilly terrain. The existing SCADA system allows the operations staff to operate the WTP automatically based on the real time water system demand. The staff can also remotely connect to the HMI via a virtual private network (VPN) connection that allows them to view the system status, acknowledge alarms, and modify setpoints.

The existing SCADA system, which includes both hardware and software, was installed prior to 2007 and has had very few modifications since that time. Minor software upgrades have occurred, and the system is currently functional, but will likely not be supported within 3 to 5 years. Furthermore, the current license agreements are not compatible with Windows 10, and would require a license upgrade should the existing computer fail.

If significant upgrades occur at the WTP, the existing SCADA system (software and hardware) should be upgraded in order to more effectively operate and control the filtration process.

MECHANICAL/HVAC CONDITION ASSESSMENT

The mechanical/architectural assessment includes the main building and chlorine contact building at the WTP. Information was collected from on-site observations as well as original drawings for the existing structures. The assessment includes review of the condition of mechanical heating/cooling equipment, ventilation equipment, building system components, workspace analysis, and compliance with current mechanical codes. The mechanical code used for this evaluation is the International Mechanical Code (IMC) 2015.

Mechanical

- The basement room includes one electric, wall-mounted unit heater (capacity not verified due to limited access) and does not contain any ventilation. The room did not exhibit significant ambient moisture during the assessment; however significant signs of corrosion were present on most metal surfaces. Plant staff did not note any issues with temperature control in this room, indicating that the existing heater is sufficient for winter time freeze control and that summer time cooling is not required.

- The filter room includes one electric, ceiling-mounted unit heater (capacity not verified due to limited access) and has provisions for natural ventilation via screened louvers in each gable end. The screened louvers include interior blank-off plates that can be removed by plant staff, however it did not appear that they are air-tight in their closed position as day light was observed around the perimeter. Plant staff noted that additional ventilation, cooling, and heating, is desired in this space to provide a comfortable working environment during the extreme winter and summer months. The existing heating system is sufficient to prevent freezing of the equipment during the cold winter months.

- Based on a review of the original plant construction drawings, it appears that a portion of the interior cells of the masonry walls are filled with a loose-fill insulation, and the gable ends are framed 2x4 walls with fiberglass batt insulation. The roof structure is not insulated as the 2x10 roof joists are exposed to the interior and there does not appear to be any insulation installed above the sheathing, below the metal roofing.

- The office/laboratory includes an electric, wall-mounted space heater and a residential style, thru-wall air conditioner. Both of these units are in working condition but are not original to the plant. It does not appear that they were installed in a finished manner and are likely not of adequate capacity to provide proper heating and cooling within the space. Plant operators noted temperatures in this space are not able to be maintained within comfortable ranges during the winter and summer seasons. Within the office/laboratory there is a small bathroom that includes a lavatory, a water closet, an electric water heater, and some shelves and raingear storage. While functional, the space is constrained and access to the water heater is limited.

- The chlorine room includes an electric, wall-mounted space heater, a portable plug-in space heater and a thru-wall ventilation fan. Both heaters are controlled via integral thermostats and the fan is manually turned on whenever staff enter the room. It appears these systems are adequate for this space, however, some corrosion is apparent within the room and the exterior flashing on the exhaust fan should be reinstalled.

- The chlorine contact basin includes three small screened louvers in both the west and east ends of the building, and two roof mounted turbine vents to allow some amount of natural ventilation. The walls and roof are minimally insulated with approximately 1-inch rigid foam board and no heat is provided. Plant operators note that additional ventilation would be beneficial to reduce levels of humidity inside.

BUILDING SYSTEMS/WORKSPACE CONDITION ASSESSMENT

- The treatment plant building is constructed of painted CMU, with an exposed wood roof structure and mechanically fastened metal roofing. The painted CMU is in sound condition; however, this is likely to need repainting within the next 5 to 10 years.

- One location on the exterior south wall has plant growth coming out of the wall at a seam between the CMU and the concrete foundation.

- A small vinyl window has been added in the south wall and has been installed with exposed fasteners into an exposed wood frame. The rough opening around the wood frame and through the CMU wall has been roughly patched with cement grout.

- The metal roofing appears to be relatively new and is in good condition.

- Doors into the building are painted metal and are beginning to show signs of corrosion and paint delamination.

- The building above the contact basin is an engineered metal building with exposed fastener metal siding and roofing. The exterior of this building is in good condition, however, there are several translucent fiberglass wall panels on all four sides that are beginning to show signs of UV fatigue.

- The WTP does include a work area that contains a workbench, tables, and shelving for storage of equipment and materials. This work area is supported by grating directly above the flocculation basins that contain raw water. The aluminum grating is covered by cloth/rubber mats to provide a basic level of spill protection. While these mats do overlap at most seams, direct access through the grating to raw water is available at several locations, especially around the perimeter of the area. This represents a hazard as chemicals, cleaners, and other potentially harmful liquids/solutions may enter the raw water stream if spilled during use.

- As previously discussed, the WTP has a 125-hp pump formerly used to provide distribution system pressure and fire flow to the City. The 125-hp pump is no longer used, and occupies a considerable amount of floor space immediately north of the media filters. Furthermore, this area contains several pressure control valves, piping, fittings, and other components no longer used or necessary for the current method of operation and water delivery. This area is currently used for storage of miscellaneous material such as cleaning equipment, hoses, chemicals, and spare parts, and does not provide useful access to these items.

- The lab/office is a small space that contains laboratory, electrical equipment, office workspace, access to the basement, some storage for educational/operational materials, and a unisex restroom. While functional, this space is very cramped and there is no remaining space for additional storage, upgraded equipment, or additional operations personnel. While there is limited availability for expansion of the WTP footprint due to the steeply sloped terrain and its proximity to existing concrete structures, it may be possible to expand/upgrade the existing workspace within the existing WTP footprint.

    - One option may be to expand the existing lab/office to include the existing workbench/storage space. This would include extending the existing CMU wall and providing additional access doors to the filter space. This option would also likely require significant mechanical and electrical upgrades.

- Confined space safety equipment was not readily available at the WTP.

- The WTP does not have security fencing at or near the property lines. This is significant because the WTP is adjacent to a public trailhead and several private residences.

- No surveillance equipment or electronic security devices are currently installed at the WTP.

- Electrical boxes or equipment are often used to hang cables, tubing, extension cords; and the tops of these boxes are used to store various materials – including liquids,

- The WTP does not maintain sufficient potable water pressure for wash-up facilities or other operational uses when the WTP is not actively producing finished water.

TREATMENT/PROCESS CONDITION ASSESSMENT

The process condition assessment includes all of the components and processes used to generate potable water at the WTP including equipment, operations, maintenance, chemicals, and monitoring and controls. Information was collected from on-site observations, discussions with operations staff regarding system performance, previous experience at the WTP through the completion of other projects, and subsequent site visits and performance data analysis. The treatment equipment was described previously, and the assessments below correlate to the areas described in these previous sections.

Intake Structure

- The intake structure was not specifically assessed as part of this project; however, from a previous brief visual assessment by G&O personnel, the condition of the intake structure is sound and the structure remains relatively effective in providing raw water to the WTP. The structure does require frequent maintenance to remove debris, and represents a significant safety/confined space hazard during these maintenance operations.

- Access to the intake structure is precarious – especially during wet weather conditions. The access is along the surface of the riverine bedrock and does not contain hand or guardrail.

At a minimum, the proposed modifications to the intake structure currently in design should address the issues identified above.

Screen House

- The screen house is in poor condition. The structure has been neglected in recent years and shows significant signs of deterioration.

- The adjacent Icicle Creek has eroded away part of the supporting foundation along the northeast corner of the structure.

- All metal components show significant signs of corrosion and deterioration, and may not be operable in their current condition.

- While the screen house does contain adequate fish passage allowances to meet current Fish and Wildlife requirements, the existing fish passage allowance will not be sufficient when salmon are reintroduced to Icicle Creek in the near future.

- The screens and filters have accumulated significant volumes of sediment which will require removal.

- Access to the screen house is via a rutted, dirt road which requires a truck or high-clearance vehicle to access.

As with the intake structure, at a minimum the proposed modifications to the screen house currently in design should address the issues identified above.

Coagulation/Flocculation

- All existing piping in the basement of the WTP shows significant signs of corrosion. In several locations, the overall pipe thickness appears to be compromised.

- The existing magnetic flow meter was installed prior to 2000 and has not been calibrated since this date.

- The existing Rotork motorized actuator was installed prior to 2000 and may be near the end of its useful life.

- Access to the various equipment, storage tanks, and injection/sampling locations is poor.

- Finished grade of the basement floor is several feet below grade at the access door. This makes access with large, heavy equipment or chemicals extremely difficult.

- Access to the filter system vacuum pumps is poor, unstable, and does not provide sufficient working surface. These units are installed approximately 15 feet above the finished grade of the basement slab with no permanent access ladders or equipment, and as such, are difficult to maintain.

- The existing static mixer is not designed for use in potable water applications, but instead was designed for industrial adhesive applications. Furthermore, the installation location of the mixer does not likely promote coagulation of particles prior to entering the flocculation basins.

- The existing flocculation basins are covered with open aluminum grating and cloth mats which would allow chemicals or other small items such as tools, keys, or debris to enter the raw water.

- Access to the flocculation basins is limited and is only available using an extension ladder, which is difficult to maneuver within the WTP.

Rapid Rate Dual-Media Filters and Backwash Basin

- Access to the filtration basins is limited and is only available using an extension ladder, which is extremely difficult to maneuver within the WTP.

- The vacuum-assisted filtration system was installed in 1971 and may be nearing the end of its useful life. The technology utilized for this system is antiquated and replacement components are very likely to no longer be available or must be custom fabricated.

- The coating on the inlet distribution trough and associated siphon tubes has failed along the full expanse of wetted surfaces. This coating failure has led to corrosion of the trough as well as anchoring ears, anchor bolts, and adjoining equipment. Non-wetted surfaces appear to be in fair or poor condition – depending on their location.

- Turbidimeters throughout the WTP are Hach 1720E. Manufacturer's support for this equipment will be phased out over the next 5 years, and new laser-sensing turbidimeter technology will become standard industry practice. The existing turbidimeters will become obsolete or will no longer be supported within 5 years.

- Not all monitoring equipment such as turbidimeters, controllers, level sensors, have clear and precise labels.

- Surface wash nozzles appear to be corroded and ineffective at breaking up "mud-balls" that may form during active filtration. This may be hampering the effectiveness of filter backwash.

- Media depth, consistency, and particle size breakdown were not investigated during the assessment; however, were investigated in a follow up visit on May 10, 2018. Discussions with operations staff indicated that particle size was smaller than designed, and relative depths/volumes of components no longer matches original design. The original WTP design called for a media composition as defined below:

    - 18-inches Anthracite coal (09mm -1.2mm UC, 1.7mm max),
    - 9-inches sand (0.35mm – 0.45mm UC, 1.6mm max),
    - 3-inches torpedo sand,
    - 2.5-inches gravel (1/2" – 1/4"),
    - 2.5-inches gravel (3/4" – 1/2"), and
    - 6-inches gravel (1-1/2" – 3/4").

        - A filter media investigation was completed in May, 2017. The study found that the particle size distribution was typically below current design values, and also found that bed expansion during backwash was below ideal values.

        - A WTP operations staff added anthracite media to each filter unit during the annual shutdown in May, 2018.

        - From discussions with WTP operations staff, the media has only been fully replaced one time since WTP construction, and is typically supplemented with additional anthracite every 2 to 3 years.

- The underdrain system was not accessible during the WTP assessment, but was investigated during the spring shutdown. The underdrain system appears to be in good condition. Some penetrations in the concrete, the concrete and/or pipe coating system have corroded.

- From discussions with WTP operations staff, typical filter run times have remained at approximately 24 hours for several years. After filtered water turbidity from an individual cell reaches approximately 0.8 NTU, the filters are typically backwashed in an attempt to improve the filtration efficiency and reduce the filtered water turbidity. Filter backwash was not investigated during the initial assessment, but instead was investigated in a follow up visit to the WTP on April 19 and again on June 29, 2018.

    - Backwash flow and volume appears to be within the design range identified in the O&M manual; however, it does not appear sufficient to remove trapped sediments in order to "clean" the filter.

        - The design backwash flow is between 10-14 gpm/SF for 7 to 9 minutes. Currently, the estimated backwash flow is approximately 12 gpm/SF (average backwash discharge flow of 1,400 gpm divided by 119 SF per filter) for 11.5 minutes. However, no flow metering for backwash flow is available and these values are estimates based on the volume differential between the raw and finished water flow meters.

    - Backwash flow and volume is difficult to control/estimate due to the inherent design of the vacuum system, and is dependent on the level of water within the CCB and primary clearwell.

  - The backwash drain piping appears to be a mix of welded steel and corrugated metal. The piping conveys water from the backwash of the media filters to the backwash storage basin.

  - The backwash drain piping at the backwash basin is corroded and compromised. The poor condition of the bottom of the pipe has resulted in significant erosion below the piping which could compromise its structural integrity.

  - The backwash water is currently stored in an earthen holding pond located between the treatment building and Icicle Creek. This arrangement is inherently unstable and does not provide sufficient liquid storage volume or suitable access for solids handling. The backwash basin appears to be undersized. Under normal backwash operations, all four filters may be backwashed consecutively; however, the backwash storage basin must be fully drained prior to initiating the backwash sequence. This operation provides minimal settling time for backwashed sediments. The backwash basin is a natural bottomed basin that accumulates additional sediment with each backwash cycle. The natural bottom of this basin makes removal of these sediments difficult.

  - From discussions with the WTP operations staff, the backwash drain valve does not fully close.

  - Access to the backwash basin for heavy equipment or machinery is adequate.

  - Lack of backwash flow monitoring devices makes it extremely difficult to estimate the amount of water utilized for filter backwash operations.

- From discussions with operations staff, the WTP does not appear to be capable of successfully filtering the maximum filter media design capacity of 3,140 gpm (6.6 gpm/SF), as listed by Infilco in the WTP Operations Manual. Furthermore, it does not appear to be capable of successfully filtering the desired capacity of approximately 1,400 gpm (2 mgd) to fully utilize the City's uninterruptible water rights. Additional discussion on this topic is provided in Chapter 4.

Primary Clearwell

- The primary clearwell appears to be in good condition. The coatings for this basin show some staining and show only isolated signs of bubbling or delamination.

- The slide gate, access ladder, and pump bowls within the primary clearwell show significant signs of corrosion. The existing coatings on these items appear to have failed, and in several locations bare metal has been exposed. The gate frame and embedded wall sleeve also show significant signs of corrosion.

Chlorine Disinfectant Injection System

- The chlorine disinfection system appears to be functioning as desired. Piping, tubing, and equipment appear to be in good condition.

- Gaseous chlorine presents a significant health risk to WTP operations staff in the event of a leak, and a significant safety risk in the event of a fire or explosion.

    - While the existing chlorine gas disinfection facilities likely meet building code requirements in place at the time of their construction, the current chlorine gas storage facilities do not appear to meet current (2015) building code requirements. If chlorine gas will continue to be used as a disinfectant, the City should consider providing containment vessels such as Chlortainers to safely store chlorine gas cylinders.

    - The 2015 International Building Code defines the Maximum Allowable Quantities of hazardous materials that can be stored or used within a facility without triggering specific design and construction criteria. Gaseous chlorine is considered both an oxidizing gas (a physical hazard) and a toxic gas (a health hazard) and as such, the maximum allowable quantity is 150 pounds as a liquefied gas, or 810 cubic feet at NTP as a gas (both of which correspond to a single 150-pound cylinder). Several exceptions allow this maximum allowable quantity to be increased by 100 percent in buildings equipped throughout with an approved automatic sprinkler system and by an additional 100 percent when approved storage cabinets are used. Therefore in a building with a sprinkler system and if all the chlorine gas is stored within approved cabinets, a total of 600 pounds of chlorine gas, or four 150 pound cylinders can be used before triggering a hazardous, H-3 occupancy. A building with an H-3 occupancy incurs several additional safety and building protection systems including additional planning documents, ventilation system requirements, gas cabinets, smoke detection and alarm systems, emergency power supplies, and emergency alarm systems, among other requirements.

  - Any significant modifications to this system would require that the system be modified to meet current building code requirements for the use and storage of chlorine gas.

- The exhaust fan from the chlorine room does not have a protective screen.

- The spare gaseous chlorine cylinders have only one safety restraint chain near the top of the cylinder and are stacked two deep from the wall.

- Active gaseous chlorine cylinders have only one safety restraint chain near the top of the cylinder.

Chlorine Contact Basin

- The chlorine contact basin appears to be functioning as desired. The basin appears to be providing sufficient disinfection contact time according to DOH requirements – which was also confirmed during the recently completed tracer study project at the WTP.

- The HDPE baffles were inaccessible for close inspection, but appear to be in good working order.

- Discussions with WTP operations staff suggest that several of the CCB mud valves and diversion gates leak. The estimated leakage from these valves is between 1 to 10 gpm while the estimated leakage from the diversion gates is unknown.

- Slide gates within the CCB were not accessible during the assessment, but the gate seals appear to be in good condition.

Secondary Clearwell

- The secondary clearwell appears to be in good condition, however, the basin was inaccessible during the WTP assessment.

- During the tracer study conducted in 2017, we identified that the ultrasonic level sensor that measures the depth of water within the secondary clearwell, and correspondingly, the CCB, displayed a value that was 1.2 feet lower than the actual measured water depth. The depth of water within the CCB sets the position of the finished water butterfly valve in order to maintain a consistent volume for CT calculations. This level also sets the pressure available for backwash of the rapid media filters.

Finished Water Flow Meter Vault

- The finished water flow meter vault appears to be in good condition, however, the vault was inaccessible during the assessment and follow-up visit due to wasps and the lack of confined space safety equipment.

- The existing Sparling magnetic flow meter was installed prior to 2000 and has not been calibrated since this date. The piping and fittings in this vault show signs of corrosion. It appears as though sediment has entered the vault and partially buried the piping and fittings, thus reducing access for maintenance and promoting corrosion/deterioration.

- The existing Rotork motorized actuator was installed prior to 2000 and is likely near the end of its useful life. The existing finished water control valve shows significant signs of corrosion. Furthermore, sediment has entered the vault and partially buried this valve, thus reducing access to the valve and promoting corrosion/deterioration.

CHAPTER 3

TREATMENT IMPROVEMENTS

INTRODUCTION

The recommendations below are based on the assessment and findings for each discipline discussed in Chapter 2. The recommendations are divided in to both "high priority" and "recommended" improvements. High priority improvements should be addressed within 5 years and could affect the integrity of the WTP structure or operation. Recommended improvements should be addressed within 5 to 15 years and would provide additional convenience and efficiency to the WTP operations staff and would help ensure the long-term longevity of the WTP structure and components.

STRUCTURAL

High Priority Improvements

- Repair deteriorated wood rafters at eaves of building and apply stain or paint to protect wood from exterior exposure;

- Complete an assessment of the associated water main piping and connection points at the WTP to assess the level of corrosion damage or differential settlement that may have occurred since its installation;

- Complete an assessment of the associated water main piping and connection points between the WTP and the Icicle Ridge Reservoir to assess the level of corrosion damage or differential settlement that may have occurred since its installation;

- Address the corrosion of the structural members within the chlorine contact building. Members should be adequately prepared and recoated to provide additional service life;

- Replace the existing corroding metal wall panel fasteners with Type 304 or 316 stainless steel fasteners to ensure panel and building longevity. Alternatively, apply coating to corroded tips of the fasteners that attach the metal panels to the Z-purlins with cold galvanizing compound (minimum 95 percent zinc content in dried film);

- Address stair rise and tread distances that do not meet code by replacing/modifying existing stairs to comply with current building codes;

- Clean and repair areas of deterioration/damage in the topping slab at the Icicle Ridge Reservoir with structural, non-shrink grout; and

- Repair the damaged section of concrete curb at the Icicle Ridge Reservoir adjacent to the roof hatch with structural, non-shrink grout.

Recommended Improvements

- Repair depression in the grade at the base of the security fencing at the Icicle Ridge Reservoir to provide full security;

- Perform vermiculite insulation testing so that the results can be made available to contractors who may work at the plant;

- Verify and retrofit roof diaphragm connections the next time roofing modifications or repairs are necessary;

- Repair select damaged areas on the underside of the plywood roof sheathing during roof repair/replacement;

- Install handrail and guardrail on the stairs leading to the basement of the WTP;

- Additional access ladders and/or walkways should be provided and installed in order to improve access to each of the four filtration basins;

- Assess the need for trolley hoists or other lifting equipment within the WTP;

- Assess the current and desired level of security provided at both the Icicle Ridge and Ski Hill reservoir. Additions could include fencing modifications, landscape clearing to provide additional sightlines, and/or surveillance equipment.

ELECTRICAL

High Priority Improvements

- Remove paperwork, postings, and other materials from the front panel of the MCC and maintain working space in front of the MCC;

    - Per the National Electrical Code (NEC), a minimum of 42 inches is required in front of and equipment operating at 600 V or less which is likely to require examination, adjustment, servicing, or maintenance while energized.

- Install an auxiliary generator and automatic transfer switch at the WTP;
- Furnish and install a disconnect switch for the filter system vacuum pumps;
- Furnish and install a disconnect switch for the filter backwash pump; and
- Confirm that the disconnect switch for the finished water control valve actuator is in compliance with current codes as the vault was inaccessible during the assessment.

Recommended Improvements

- Schedule an inspection of the inside of the CT enclosure by the utility provider. The outside of the CT enclosure is extremely corroded and the interior of this enclosure should be inspected to determine if any of the components are corroded or damaged. The CT enclosure contains two power utility seals and should only be opened by the power utility;
- Fully inspect both the exterior and interior of the main circuit breaker to identify the level of exterior and interior corrosion, and whether or not the circuit breaker should be replaced;
- Locate a current power distribution diagram for the WTP electrical service and maintain both hard and digital copies of this diagram at the WTP. In the event that a distribution diagram cannot be located, the City should develop this diagram for future reference, repairs, maintenance, and modifications;
- Locate the current system control drawings for the WTP control system equipment and maintain both hard and digital copies of this diagram at the WTP. In the event that system control drawings cannot be located, the City should develop these files for future reference, repairs, maintenance, and modifications;
- If a new auxiliary generator is installed, consider installing a new electrical service to the WTP. The existing service is 400A; however, a new electrical service could be downgraded to 200A, which would then require a 200A ATS. This smaller ATS is significantly less expensive with a smaller footprint than a 400A ATS;

- Investigate the replacement of the existing MCC. The existing MCC is original to the WTP and likely utilizes antiquated technology or components. These components could be nearing the end of their useful life and replacement of these old components may become increasingly difficult;

- Investigate the loads currently slotted within the existing 240/120 VAC panelboard to identify circuit breakers that may actually be available for future electrical loads; and

- Replace florescent lighting with LED lighting. This replacement should provide a small reduction in energy consumption, but will require significantly less maintenance than current light fixtures.

MECHANICAL/HVAC

High Priority Improvements

- Provide additional ventilation in the basement to limit corrosion in this area due to moisture and exposure to chemical fumes; and

- Replace/repair existing flashing on the chlorine room exhaust fan to provide correct air flow and direction and to minimize the risk of moisture intrusion to the room.

Recommended Improvements

- Provide screen mesh for chlorine room exhaust fan to reduce the risk of human injury;

- Review the installation of the existing lab/office heater and air conditioning unit;

- Assess the need for additional HVAC equipment within the CCB to ensure a comfortable working environment and to minimize the humidity which will help to limit corrosion due to moisture;

- Assess the need for additional HVAC in the office/laboratory to ensure a more comfortable and consistent working environment;

- Assess the need for additional insulation for the underside of the roof within the WTP which will help reduce condensation and provide a more comfortable working environment; and

- Assess the need for additional HVAC in the filter room to ensure a comfortable working environment and to minimize the humidity which will help to limit corrosion due to moisture.

BUILDING SYSTEMS/WORKSPACE

High Priority Improvements

- Replace the existing mats and aluminum grating above the flocculation/sedimentation basins with solid-top, covered, fiberglass reinforced grating that will help prevent entrance of chemicals, solutions, or materials to the raw water within the sedimentation basins;

- Install additional shelving and storage above the existing workbench to minimize the amount of materials stored at grade level;

- Address the lack of wash-up/potable water available to the WTP when the WTP is not actively filtering;

    - One alternative is to provide a small, fractional horsepower pump operated continuously in conjunction with a pressure-sustaining valve that will recirculate water not used for washup, laboratory, or toilet flushing purposes back to the secondary clearwell.

    - Another alternative is to redesign the existing small pump and pressure tank system to provide a small volume of potable water during periods that the WTP is not in operation.

- Provide hand rail and or guard rail at the intake structure; and

- Provide the WTP with confined space entry equipment, or ensure that confined space entry equipment is maintained by the City and made available for specific WTP maintenance operations.

Recommended Improvements

- Remove the existing 125-hp pump and all unnecessary piping, valves, fittings, and appurtenances from the area immediately north of the media filters.

    - Consider installing additional shelving, workbenches, material storage, and/or equipment in this area to maximize the efficiency and effectiveness of the space

- Verify sufficient operation of the ventilation and safety equipment within the chlorine room;

- Remove excess/unnecessary materials from the lab/office in order to maximize the efficiency and effectiveness of the space;

- Plan for recoating of the WTP CMU structure within 5 to 10 years;

- Remove all plant growth between CMU and concrete foundation and fill any/all voids. Regularly, remove any and all plant growth, at the base of the building foundation to prevent intrusion to the building structure. This work should be completed by hand in lieu of applying herbicides;

- The vinyl window installed within the south wall should be trimmed out and weather sealed to ensure deterioration does not begin within the exposed wood frame;

- The exposed portions of the roof structure and the wood corbels should be refinished within the next 5 years prior to any deterioration occurring within the wood.

- Assess the current and desired level of security for each facility, particularly the WTP, the Icicle Ridge Reservoir, and the Ski Hill Reservoir. Additions could include fencing modifications, landscape clearing to provide additional sightlines, and/or surveillance equipment;

- Install chain-link security fencing and access gate at the WTP;

- Plan for recoating of the WTP access doors within 2 to 5 years; and

- Plan for replacement of translucent FRP panels on the CCB within 3 to 5 years.

TREATMENT/PROCESS

High Priority Improvements

- Replace the existing basement piping and fittings, including magnetic flow meter, motorized actuator, and static mixer;

- Recoat the existing inlet and distribution trough. The trough may be prepared according to SSPC-SP10 and recoated using a heavy-duty, commercial grade, NSF61-approved coating for metal structures.

Alternatively, the trough could be replaced in-kind by a custom metal fabrication shop;

- Initiate the planning and design for a new, larger, backwash storage basin, backwash supply pipe, and backwash flow meter. Because it drains directly to Icicle Creek, it is likely that this project would qualify for some level of state and/or federal financial assistance, either through grants or low-interest loans. Procurement of funding assistance should begin immediately in order to establish a level of financial responsibility for the City;

- Provide containment systems for two chlorine cylinders;

- Provide additional restraining chains for active and spare chlorine gas cylinders;

- Repair, replace, or reprogram the existing ultrasonic level sensor in the secondary clearwell;

- Assess all filter surface wash nozzles for operation/effectiveness, and replace nozzles that are ineffective or deficient;

- Drain the chlorine contact basin and repair/replace the existing mud valves;

- Replace the existing finished water magnetic flow meter and motorized actuator; and

- Identify the desired capacity for surface treatment facilities for at least the 20-year planning period.

Recommended Improvements

- Investigate possible methods to improve access to existing equipment, tanks, and components within the WTP basement. This would include providing additional access to the filter vacuum pumps, which are located at height on a small grated platform only accessible by ladder;

- Investigate possible methods to raise the finished floor in the WTP basement to provide for additional, easily accessible chemical storage;

- Provide permanent, FRP access ladders for each sedimentation basin;

- Initiate a phased replacement of existing turbidimeters, which will be phased out by manufacturers within 5 to 7 years;

- Provide consistent, clear labeling for all instrumentation at the WTP;

- Replace the existing primary clearwell access ladder and gate valve. Alternatively, the components may be prepared according to SSPC-SP10 and recoated using a heavy-duty, commercial grade, NSF61-approved coating for metal structures. Also, provide spot repair (preparation and recoating) for damaged wall areas within the primary clearwell;

- Provide a high-gap mesh protective screen on the chlorine room exhaust fan;

- Investigate project costs for replacement of the existing gas chlorine disinfection system. Alternatives include on-site hypochlorite generation as well as bulk hypochlorite storage and dosing;

- Drain the chlorine contact basin and fully inspect the HDPE baffles for evidence of leaks or damage;

- Inspect the secondary clearwell for paint/coating failure or corrosion.

Table 3-1 below provides a modification summary, discipline, and budgetary cost to complete the High Priority Improvements. The cost shown includes materials and installation, but does not include Washington State sales tax, contingency, or project design/administration. Table 3-2 provides this information for the Recommended Improvements.

TABLE 3-1

High Priority Leavenworth WTP Modifications Summary

Modification	Discipline(1)	Cost
Repair Deteriorated Wood Rafters at Eaves of Building +	S	$15,000
Repair Corroded Structural Members in CCB ** +	S	$30,000
Repair/Replace Corroded CCB Wall Fasteners ** +	S	$10,000(2)
Address Stair Tread/Rise Distances and Guard/Hand Rail	S	$25,000
Clean/Repair Icicle Ridge Reservoir Topping Slab ** +	S	$32,000
Clean/Repair Icicle Ridge Reservoir Concrete Curb ** +	S	$1,500
Assess Existing Water Main Piping and Connection Points +	S	$15,000
Design and Install Auxiliary Generator ** +	E	$105,000
Vacuum Pump Disconnect Switch	E	$10,000
Filter Backwash Pump Disconnect Switch	E	$10,000
Upgrade SCADA System Hardware/Software ** +	E	$35,000
Provide Additional Ventilation in Basement +	M	$40,000
Repair Chlorine Room Exhaust Fan Flashing +	M	$1,000
Install Covered Grating Above Sedimentation Basins +	BS	$18,000
Address Lack of Wash-up/Potable Water at WTP +	BS	$6,000
Additional Shelving/Storage at Existing Workshop Area +	BS	$1,000
Install Hand and/or Guardrail at the Intake Structure ** +	BS	$8,000
Provide Confined Space Safety Equipment at the WTP ** +	BS	$5,000
Basement Piping, Fittings, and Appurtenances +	P	$70,000
Repair/Replace Filter Inlet and Distribution Trough	P	$150,000(3)
Assess Filter Surface Wash System and Replace Nozzles	P	$2,000
Reprogram Existing Secondary Clearwell Level Sensor +	P	$2,000
Repair/Replace Existing CCB mud Valves ** +	P	$22,000(4)
Design and Construct New, Larger, Backwash Storage Basin	P	$400,000
Add Additional Gas Cylinder Chain Restraints +	P	$500
Replace Finished Water Flow Meter, Valve, and Actuator ** + (5)(6)	P	$35,000

Subtotal **$1,019,000**
Contingency (30%) $315,000
Washington State Sales Tax (8.7%) $119,000
Design and Project Administration (25%) $371,000
TOTAL **$1,854,000**

(1) S = Structural, E = Electrical, M = Mechanical, BS = Building Systems, P = Process/Operational.
(2) Price is for SSPC-SP10 surface preparation and recoating with high quality coating product.
(3) Price is for sanding and coating with high-zinc protective coating and includes accommodations to address the remediation and disposal of the existing lead-based paint.
(4) Price is for replacement of all four mud valves.
(5) All High Priority items listed in Table 3-1 are included in Alternative 2A and 2B. Items marked with ** are included in the cost estimate for Alternative 3 and are discussed in Chapter 4.
(6) Items marked with + are included in the cost estimate for Alternative 4 and are discussed in Chapter 4.

TABLE 3-2

Recommended Leavenworth WTP Modifications Summary

Modification	Discipline(1)	Cost
Repair Grade Depression at Icicle Ridge Reservoir ^	S	$500
Perform Vermiculite Insulation Testing	S	$1,500
Verify and Retrofit Roof Diaphragm Connections	S	$20,000
Repair Roof Sheathing	S	$4,000
Install Handrail/Guardrail on Basement Stairs	S	$3,000
Install Filter Cell Access Ladders **	S	$20,000
Assess Needs for Lifting Beams and Devices in Filter Cells **	S	$5000
Inspect the Interior of the Existing CT Enclosure ** +	E	$500
Inspect the Interior of the Main Circuit Breaker ** +	E	$500
Construct Power Distribution Diagram ** +	E	$2,400
Construct System Control Diagram Including Field Devices ** +	E	$4,200
Replace Existing Fluorescent Lighting with LED Lighting	E	$7,500
Provide Chlorine Room Exhaust Fan Mesh Screen	M	$500
Remove Existing 125-hp Pump and Superfluous Fittings ** +	BS	$15,000
Provide Additional Workspace and Shelving at 125-hp Pump ** +	BS	$10,000
Remove Plant Growth from Building	BS	$500
Provide Trim and Finish Work for South Wall Vinyl Window	BS	$1,000
Recoat WTP Access Doors	BS	$8,000
Replace CCB Relight Panels ** + ^	BS	$8,000
Prepare and Recoat WTP Corbels and Ext. Wood surfaces ** +	BS	$12,000
Assess Needs for Additional Security at Each Facility ^	BS	$1,000
Install Chain Link Security Fencing with Access Gate at WTP ^	BS	$50,000
Install Basement Modifications to Provide Chemical Storage ** +	P	$80,000(2)
Provide FRP Ladders within Each Filter Cell **	P	$15,000
Provide FPR Ladders within Each Sedimentation Basin **	P	$15,000
Replace Existing Turbidimeters ** +	P	$64,000(3)
Provide Equipment Labels and Tags ** +	P	$500
Repair/Replace Primary Clearwell Ladder and Valve ** +	P	$35,000(4)
Provide Mesh Screen on Chlorine Room Exhaust Fan ** +	P	$500
Complete Alternatives Analysis for Chlorine Disinfection ** + (5)(6)	P	$12,000

Subtotal..**$397,000**
Contingency (30%)..$119,000
Washington State Sales Tax (8.7%) $45,000
Design and Project Administration (25%) $140,000
TOTAL...**$701,000**

(1) S = Structural, E = Electrical, M = Mechanical, BS = Building Systems, P = Process/Operational.
(2) Also includes electrical modifications to raise existing panels to appropriate height per current NEC codes.
(3) Assumes eight turbidimeters.
(4) Price is for replacement of valve and ladder, and recoating of pump bowls.
(5) Items marked with ** are included in the cost estimate for Alternative 2B discussed in Chapter 4.
(6) Items marked with ^ are included in the cost estimate for Alternative 3B and are discussed in Chapter 4.
(7) Items marked with a + are included in the cost estimate for Alternative 4B and are discussed in Chapter 4.

CHAPTER 4

SYSTEM ALTERNATIVES ANALYSIS

INTRODUCTION

The City's goals for this condition assessment are to identify and prioritize modifications to the WTP that would be required to maintain or improve the treatment capacity of the WTP, but also to identify other feasible treatment alternatives that may be more cost-effective in both the short-and long-term planning periods. For this evaluation, Gray & Osborne has identified several feasible treatment alternatives. A brief description of these alternatives and a preliminary, budgetary cost estimate are included below.

First, a brief discussion on water rights as well as the capacity of the WTP and its individual components is included below.

WATER RIGHTS

As mentioned in Chapter 1, the City maintains a combination of both surface water rights and groundwater rights. Within these designations, there are both un-interruptible and interruptible water rights, as well as primary and supplementary water rights. A complete synopsis of the City's current water rights situation is provided in the City of Leavenworth Water System Plan (*Varela Engineers, 2018*); however, the City currently possesses 1,355 gpm (Certificate No. 4 and Certificate No. 8105) of un-interruptible and 1,427 gpm (Surface Water Permit #S4-28122) of interruptible water rights from Icicle Creek. In addition, the City is in the process of trying to obtain additional water rights from Icicle Creek.

The City currently maintains a total instantaneous surface water right from Icicle Creek of 2,782 gpm (including both uninterruptible and interruptible rights). For this evaluation, a maximum treatment capacity of 2,800 gpm (4.03 mgd) will be used for evaluating and estimating the cost of various treatment alternatives. In addition to this flow rate, a minimum treatment plant capacity of 1,400 gpm (2.01 mgd) will be evaluated. This is the amount of the City's current un-interruptible water rights.

WTP CAPACITY

In conjunction with the City's water rights, the capacity of the existing WTP and its individual subcomponents are critical in determining the ultimate selection of treatment equipment at the WTP. Within a WTP, each individual treatment component has a design capacity, and the overall treatment plant capacity is limited to the capacity of the lowest individual component. For the purposes of analyzing the capacity of these individual components, the WTP will be broken down as follows:

- Intake structure, screen house, and raw water intake piping;
- Coagulation/Flocculation system;
- Filtration system;
- Backwash system;
- Chlorine disinfection system; and
- Downstream distribution

Intake Structure, Screen House, and Raw Water Piping

The existing intake structure, screen house, and raw water intake pipe were constructed in 1971 and are in fair to poor condition. Modifications to these facilities are currently underway and will be designed to accommodate a proposed projected flow of 2,800 gpm. Once these facilities are constructed, it is not anticipated that they will limit the treatment capacity of the WTP.

Coagulation/Flocculation System

The coagulation/flocculation system includes three main components: coagulation addition, mixing, and flocculation. Coagulant is added from a plastic storage tank via a diaphragm metering pump, both of which are located in the basement of the WTP. Mixing is provided by a flow-through static mixer. The existing mixer was designed for use in an industrial adhesive application and was not designed for potable water applications. Although the existing style of mixer does have applications to potable water treatment, other, smaller options exist and new technology likely provides better mixing efficiency. Once through the static mixer, raw water enters the flocculation basins. There are four basins, each with a surface area of 42.5 square feet. The total flocculation basin surface area is 170 square feet and at a typical operational water depth of 17.2 feet the total volume of the flocculation basin is 21,830 gallons. Based on this estimated operational volume, the residence time within the flocculation basin for flows of 700 gpm, 950 gpm, 1,400 gpm, and 2,800 gpm is 31.2, 23.0, 15.6, and 7.8 minutes, respectively.

Flocculation basins are typically designed based on two criteria: retention time and mixing energy. Since flocculation is the conglomeration of many small particles into fewer large particles, successful flocculation basins typically provide long time periods for this accumulation to occur, and the correct amount of energy to promote the interaction/collision of small particles.

Hydraulically mixed flocculation basins are typically designed to achieve a detention time between 30 to 45 minutes with a mixing energy value of 10 to 50. Given the short retention times calculated above and the lack of mechanical mixing within the basins, it appears that the flocculation basin is undersized for flows greater than approximately 700 gpm.

Filtration System

As discussed above, the design capacity of the filtration system is 6.6 gpm per square foot (as listed in the WTP O&M manual provided by Infilco) which is equivalent to an overall flow of 3,141 gpm, or 4.52 million gallons per day (mgd). As previously mentioned WAC 246-290-654 lists the maximum areal surface flowrate for direct filtration facilities using dual media as 6 gpm/SF, which is less than the current design value. The design value likely represents an instantaneous capacity limit, and is not sustainable over long periods. The areal flow at the projected maximum instantaneous water right (2,800 gpm) is equivalent to 5.9 gpm per square foot, which is below both the maximum design capacity of 6.6 gpm/SF as well as the allowable areal flowrate of 6.0 gpm/SF as listed in the WAC. As such, the existing filtration system appears to have sufficient design capacity to treat flows up to 2,800 gpm.

In reality, there appears to be a difference between the design and the actual operating capacity of the filtration system. Some of this may be a result of the desired filter run times, the long filter-to-waste times that occur immediately post backwash, as well as the limited backwash storage capacity available at the WTP. Given the smaller size of filtration media, the low thickness of the media layers, the limitations of the flocculation system, and the sporadic, sudden increases in raw water turbidity, a conservative estimate for the current filter system capacity would be between 3.5 to 4.5 gpm/SF, which equates to between 1,666 to 2,140 gpm (2.4 to 3.08 mgd).

During a site visit on June 29, 2018, Adam Miller and Keith Stewart from Gray & Osborne modified the position of several gates within the treatment process to increase the level in the clearwell and allow for increased backwash flow. These adjustments appear to have increased filter run times, decreased filter-to-waste times, and improved the backwash cycle for the media filters. It is possible that additional modifications to the standard operating procedures could provide additional benefits and further improve WTP performance.

Backwash System

The volume of the existing backwash storage basin is between 60,000 to 80,000 gallons. Because all four existing filters cannot be backwashed unless the backwash storage basin is fully drained, it is clear that the existing basin is undersized. If the City wished to expand the treatment capacity up to the target flow rate of 2,800 gpm, additional daily backwash cycles may be necessary to treat the full range of annual flows, which would necessitate additional backwash storage volume.

Ideally, a storage basin should be able to handle between 2.5 to 3 complete backwash cycles – a total volume of approximately 150,000 to 160,000 gallons. This volume typically provides for sufficient solids storage volume as well as sufficient supernatant storage volume. These additional volumes will help ensure that water backwash water with low solids content is returned to Icicle Creek.

Chlorine Disinfection System

The chlorine disinfection system includes the chlorine injection equipment as well as the chlorine contact basin. The basin was constructed in 1991 and was added in order to provide additional contact time for the filtered water after chlorine injection. In order to confirm that an appropriate level of disinfection is being provided, a CT value is calculated by WTP staff on a daily basis. The CT value is the product of the hydraulic residence time – or the average length of time a parcel of water takes to travel through a basin – and the chlorine concentration in the water as it enters/leaves the basin. The CT provided by a treatment plant must be greater or equal to a theoretical value that is defined by pH, temperature, and the required log-removal.

Given the historical range of temperatures for raw water from Icicle Creek in the winter (0 deg-C) and summer, (65 deg-C) an average raw water pH of 7.2, and a historical target chorine concentration of 0.8 mg/L, the range of CT values required by the WTP is between 71 (winter) and 22 (summer).

The basin has a surface area of 1,846 square feet and a typical water depth of 10.0 feet, which results in an operational volume of 138,000 gallons. The effective volume is 82,800 gallons, which is the product of the total volume and the empirically determined baffling factor of 0.6. Flow through the WTP of 700, 1,400, and 2,800 gpm results in hydraulic residence times through the chlorine contact basin of 118, 59, and 30 minutes, respectively. The WTP has historically had a target chlorine dose level of 0.8 mg/L, which would result in an effective CT value of 94, 47, and 24, respectively.

Historical Daily Monitoring Reports (DMR) completed by WTP staff show that the WTP does not have difficulty meeting CT requirements; however, flows during this same period have not exceeded 1,000 gpm. Since 2016, the maximum CT required based on raw water temperature and pH has been 79, which occurred in December of 2016. CT requirements are typically highest during the cold winter months due to a drop in the raw water temperature. Also, since 2016, the average CT requirement for the warmer summer months (June - September) has been 36. Based on these values, the WTP appears capable of providing sufficient CT for flows up to 2,800 gpm during the summer months; however, the target chlorine residual would likely need to be increased from 0.7 mg/L to at least 1.3 mg/L to reliably provide sufficient disinfection contact time. During the cold winter months, the WTP should be able to successfully and reliably disinfect a flow of approximately 1,250 gpm provided that the target chlorine residual is raised to 1.3 mg/L. At the existing target chlorine residual of 0.7 mg/L, the WTP should be able to reliably treat and disinfect flows up to approximately 750 gpm.

Downstream Distribution System

The City's distribution system is a mix of steel, cast iron, ductile iron, and PVC pipe materials ranging in size from 4-inch to 16-inch diameter. A 16-inch transmission main runs along Icicle Creek Road between the WTP and East Leavenworth Road where it splits into a 10-inch main along East Leavenworth Road and a 12-inch main along Icicle Creek Road. A majority of the distribution system piping within the City limits is a mix of 4-, 6-, and 8-inch piping in various physical condition. The total length of piping owned and maintained by the City is estimated to be 123,000 linear feet. Additional information on distribution system piping is provided in the City's Water System Plan (*Varela Engineers, 2018*).

The City provides maintenance and service for its distribution system piping on an as needed basis. The existing 16-inch transmission main leaving the WTP is known to be in fair to poor condition, is undersized for future water system demand projections and requires frequent maintenance. Additionally, both the 10-inch and 12-inch transmission mains along E. Leavenworth Road and Icicle Creek Road are known to be in fair to poor condition and require frequent maintenance.

For design purposes, the ideal range of pipe velocities to prevent scaling, prevent bioaccumulation, and limit headloss and pressure surges is between 2 to 8 feet per second for water distribution piping. For the target flow range of 2,800 gpm, water velocities within the 16-inch, 12-inch, and 10-inch main are 4.6, 8.3, and 12.0 fps – most of which are within the desired range. If the City wishes to provide treatment up to 2,800 gpm, sections of the existing 10-inch main between the WTP and the distribution system should be replaced with larger diameter piping which will reduce the overall water velocities through the piping.

The analysis above shows that the existing backwash and coagulation/flocculation treatment components are the limiting factors for determining the ultimate filtration capacity of the existing WTP.

TREATMENT ALTERNATIVES

Given the limitations of the individual treatment components listed above, the alternatives presented below briefly highlight the modifications that may be necessary in order to meet the stated treatment goals. The alternatives listed below do not include any of the structural, electrical, process, or building/mechanical modifications recommended in Chapter 3 unless explicitly required to provide the modification listed in the individual alternatives.

With the exception of Alternative 1, each of the following alternatives would be designed to provide filtration of raw water with turbidity up to 75 NTU, which is two or three times higher than the historical high turbidity value seen in Icicle Creek during turbid spring snow-melt period. While Alternative 1 may be able to successfully filter raw water with a turbidity up to 75 NTU, historically, the WTP has experienced operational difficulties trying to operate during these high turbidity periods. Specifically, the backwash system is not large enough to provide storage for the frequent filter backwash cycles that are required to meet treatment goals.

Alternative 1 – Status Quo

This alternative includes providing water treatment at the current flowrate of approximately 950 gpm while balancing additional demands using existing groundwater sources. To ensure that the WTP facility maintains its structural and functional integrity, several high priority recommendations listed in Chapter 3 and Table 3-1 should be completed.

Since the WTP currently operates at this flowrate with the existing backwash system, no additional modifications to the backwash system are included.

Select high priority improvements listed in Table 3-1 in Chapter 3 has been included in order to ensure WTP facility functionality and longevity. Specifically, the backwash storage basin and modifications to the existing filter system are not included.

The cost for this proposed alternative is $927,000, which includes contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 2A – Upgrade Existing Treatment Equipment – 1,400 gpm

This alternative would upgrade the existing treatment equipment in order to filter 1,400 gpm. Although the existing coagulation/flocculation basins are theoretically undersized, they may be sufficient given the high clarity found in Icicle Creek source water for a majority of the year. The existing backwash system is undersized and would require modification in order to provide adequate capacity. Modifications to the existing backwash system could include a new, below-grade concrete basin or above grade concrete tank that would allow for solids separation within the backwash wastewater. Supernatant water would continue to be directed to Icicle Creek.

For the purposes of this analysis the new backwash storage basin was assumed to consist of an above-grade, circular, concrete storage reservoir approximately 35 feet high, 20 feet in diameter with an approximate volume of 150,000 gallons. New 24-inch ductile iron backwash supply piping from the WTP would also be provided, and new discharge piping would be connected to the existing discharge piping at or near the WTP property line. The upgrades would also include backwash flow monitoring equipment and the new storage basin would be installed at grade in the same location as the existing backwash storage basin. It is assumed that the existing site would provide enough elevation difference for this facility; however, a full analysis would be required prior to formal design. If an elevated tank is not feasible, a below grade, open concrete basin could be constructed and provide similar functionality.

The filtration media in all four filter cells should be replaced and returned to design thickness and particle size distribution. For the purposes of this analysis, the underdrain gravel is assumed to be in good condition and may remain in place. Furthermore, the surface wash system should be restored to good working order.

Modifications to the existing coagulation/flocculation basins would include the addition of new mechanical mixers in both Basin 1 and Basin 2.

Select high priority improvements listed in Table 3-1 in Chapter 3 has been included in order to ensure WTP facility functionality and longevity.

The modifications necessary to successfully and reliably treat raw water at a flow of 1,400 gpm using the existing WTP facilities would cost approximately $2,326,000, which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 2B – Upgrade Existing Treatment Equipment – 2,800 gpm

This alternative would upgrade the existing filtration system in order to filter the current maximum potential water right of 2,800 gpm. To successfully and reliably filter this flowrate, the existing coagulation/flocculation basins would need to be expanded to provide additional retention time. To provide a minimum retention time of 20 minutes, the required total volume of the coagulation/flocculation basins should be approximately 58,000 gallons, which is 3 times larger than the existing basins. Another option is to convert the existing basins to a contact adsorption clarifier (CAC) which uses specialized media to filter flocculated particles prior to entrance to the filter inlet trough. Typically, water flows upwards through a CAC prior to flowing to the filter units. A CAC system could be retrofitted to the existing coagulation/flocculation basin(s), but would require structural modifications as well as additional pumps and equipment to backwash/clean the media on a regular basis. This backwash waste could be directed to the proposed backwash basin discussed below.

The filtration media in all four filter cells should be replaced and returned to design thickness and particle size distribution. For the purposes of this analysis, the underdrain gravel is assumed to be in good condition and may remain in place. Furthermore, the surface wash system should be restored to good working order.

The capacity of the backwash system would need to be increased as described in Alternative 2A.

It is unlikely that mechanical mixers would be able to provide sufficient mixing energy at this higher flow, and as such, a CAC is included with this alternative. The coagulation/flocculation system would be retrofitted with a new CAC and would also be provided with new supply, backwash, and interconnecting piping, valves, and appurtenances. The system would be designed with parallel trains which would allow for continuous filtration during CAC backwash.

Select high priority improvements listed in Table 3-1 in Chapter 3 has been included in order to ensure WTP facility functionality and longevity. Also, selected recommended improvements listed in Table 3-2 have also been included to improve the working facilities at the WTP and to further upgrade the filtration equipment so that it can treat the required flow of 2,800 gpm.

The modifications necessary to successfully and reliably treat raw water at a flow of 2,800 gpm using the existing WTP facilities would cost approximately $4,001,000, which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 3A – Install New Filtration Equipment – 1,400 gpm

This alternative would replace the aging Infilco filtration system with a new rapid sand package filtration system sized to effectively treat up to 1,400 gpm.

Rapid sand package filtration systems include a CAC pre-filtration system, flow troughs, internal piping, underdrain system, and filtration media – all of which are contained within an open-top coated steel basin. The systems can also include meters, flow control valves, and valve actuators at the Owner's discretion in order to provide a complete, turn-key filtration system requiring minimal additional work for installation.

To provide a consistent flow through the filter units, the existing coagulation/flocculation basins would likely be converted to a single equalization basin for raw water. This would require removing or modifying the orientation of the basin's internal walls.

The footprint of a typical 700 gpm filtration units is approximately 28-feet by 9-feet, which does not include adjacent supply and backwash piping, valves, or appurtenances. It is advantageous to provide two, 700 gpm units in lieu of a single, larger unit so that the WTP could still operate if one filter needed to be taken offline for maintenance or repairs. The footprint of the existing WTP is approximately 52 feet by 27 feet, which does not provide adequate space and clearance for the proposed filtration units. Although it may be possible to physically fit the proposed filtration units within the existing building, it would not likely be cost-effective to remove/replace the roofing, modify the existing footings and wall supports, and bring the entire building up to current seismic codes in order to install the proposed filter units. Furthermore, the resulting workspace around the proposed units once installed would severely hinder daily functions and filter maintenance operations. As such, a new, 3,000 square foot WTP building is included with this alternative. The building would be constructed at the same site and could be located in the same location as the existing WTP or could be relocated to the location of the existing backwash basin. It may also be possible to construct the new facility above the existing CCB, but a full seismic structural analysis must be completed to confirm that the CCB is able to support the additional loading.

The capacity of the backwash system would need to be increased as described in Alternative 2A.

Electrical and telemetry programming modifications would also be required due to the significant increase in the number of valves, monitoring devices, and control valves required.

Select high priority improvements listed in Table 3-1 in Chapter has been included in order to ensure WTP facility functionality and longevity.

The modifications necessary to successfully and reliably treat raw water at a flow of 1,400 gpm using new WTP filtration equipment would cost approximately $6,069,000 which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 3B – Install New Filtration Equipment – 2,800 gpm

This alternative would replace the aging Infilco filtration system with a new rapid sand package filtration system sized to effectively treat up to 2,800 gpm.

As described in Alternative 3A, the existing coagulation/flocculation basins would likely be converted to an equalization basin for the filter inlet.

The scope for this alternative is similar to Alternative 3A with the exception that larger filter units would be utilized. The footprint of a typical 1,400 gpm filtration unit is approximately 40-feet by 12-feet which does not include the adjacent supply and backwash piping, valves, or appurtenances. Two 1,400 gpm filter units would be recommended to provide continuous service (although at a lower flowrate) in the event that one filter unit must be taken offline for maintenance or repairs. Because these units are larger than those listed in Alternative 3A, there is likely not enough space within the existing WTP to accommodate the new filter units. As such, a new WTP building as described in Alternative 3A above is included with this alternative.

The capacity of the backwash system would need to be increased as described in Alternative 2A.

Electrical and telemetry programming modifications would also be required due to the significant increase in the number of valves, monitoring devices, and control valves required.

Select high priority improvements listed in Table 3-1 in Chapter 3 has been included in order to ensure WTP facility functionality and longevity. Also, selected recommended improvements listed in Table 3-2 have also been included to improve the working facilities at the WTP so that it can treat the required flow of 2,800 gpm.

The modifications necessary to successfully and reliably treat raw water at a flow of 2,800 gpm using new WTP filtration equipment would cost approximately $7,137,000 which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 4A – Install Membrane Filtration Equipment – 1,400 gpm

This alternative would replace the aging Infilco filtration system with a new membrane filtration system to effectively treat up to 1,400 gpm.

Treatment of surface and/or groundwater for potable water applications utilizing membrane filtration media is becoming more common the municipal treatment industry. This technology utilizes modular cartridges filled with hundreds of thin, cylindrical, polyvinylidene difluoride (PVDF) fibers that provide filtration down to 0.1 micron. Water typically flows through the membrane fibers (outside to inside), and particles are trapped on the outer surface of the membrane fiber. These particles are then removed through regular finished water backwashing, air scouring, and sporadic chemical cleaning. While effective at producing high quality finished water, membrane systems typically require significant additional chemical injection and cleaning equipment, additional maintenance work, and incur additional operations costs due to chemicals and replacement membranes. The expected lifetime of a single membrane cartridge, if maintained according to the manufacturer's instructions, is between 3 to 7 years and the cost to replace an individual membrane cartridge is between $2,000 to $4,000.

Membrane filtration units can be provided on a stand-alone skid – which incurs additional capital cost but simplifies the installation, startup, and testing process – or can also be retrofitted to existing basins. For the purposes of this analysis membrane cartridges compatible with the WTP's existing filter basins were considered. These filter units would be installed within the existing filter basins once the existing Infilco equipment is removed. These filter units are designed to function via gravity and rely on a differential head pressure of 10 feet to drive water through the membrane cartridges. This head differential is not available at the Leavenworth WTP in its current configuration, so additional pumping equipment will be necessary.

Interconnecting piping, control valves, monitoring devices, air scouring equipment including blowers, lifting and rigging equipment, and chemical cleaning equipment would also be required.

The capacity of the backwash system would need to be increased as described in Alternative 2A.

The existing coagulation/flocculation system would be revised to include an automated pre-filter system that will provide the necessary pre-filtration prior to contact with the membrane filters. This pre-filtration system is critical to maintaining the functionality of the membrane system and could be provided by the membrane manufacturer.

Electrical and telemetry programming modifications would also be required due to the significant increase in the number of valves, monitoring devices, and control valves required.

Select high priority improvements listed in Table 3-1 in Chapter 3 has been included in order to ensure WTP facility functionality and longevity.

The modifications necessary to successfully and reliably treat raw water at a flow of 1,400 gpm using new membrane filtration equipment would cost approximately $7,653,000 which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 4B – Install Membrane Filtration equipment – 2,800 gpm

This alternative would replace the aging Infilco filtration system with a new membrane filtration system to effectively treat up to 2,800 gpm.

The scope for this alternative is similar to Alternative 4A. The equipment proposed in Alternative 4A also has the capacity to successfully filter up to 2,800 gpm from Icicle Creek. With this larger flow, slightly larger chemical cleaning equipment and air scouring equipment would be required.

The capacity of the backwash system would need to be increased as described in Alternative 2A.

The existing coagulation/flocculation system would be revised to include an automated pre-filter system that will provide the necessary pre-filtration prior to contact with the membrane filters. This pre-filtration system is critical to maintaining the functionality of the membrane system.

Electrical and telemetry programming modifications would also be required due to the significant increase in the number of valves, monitoring devices, and control valves required.

Select high priority improvements listed in Table 3-1 in Chapter 3 has been included in order to ensure WTP facility functionality and longevity. Also, selected recommended improvements listed in Table 3-2 have also been included to improve the working facilities at the WTP so that it can treat the required flow of 2,800 gpm.

The modifications necessary to successfully and reliably treat raw water at a flow of 2,800 gpm using new membrane filtration equipment would cost approximately $9,873,000 which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 5 – New WTP – 3,600 gpm

This alternative includes providing potable water treatment and delivery for the ultimate potential water right of 3,600 gpm.

This alternative is meant to provide a comparison between a new water treatment facility and implementing modifications to the existing facility. Although new filtration technology is highly variable and the optimal treatment technology has not been selected, for the purposes of this comparison, a new WTP facility is assumed to be located at a completely new location off Icicle Creek near the existing Fish Hatchery or Cemetery and will include the following components:

- 1,000 LF of new 16-inch ductile iron intake piping connected to Icicle Creek;
- Intake facilities;
    - Raw water monitoring equipment;
    - Magnetic flow meter with modulating actuator;
    - Two duplex chemical injection systems with chemical storage;
    - Static mixing for chemical injection systems.
- Filtration facilities;
    - Package rapid sand treatment equipment with CAC (3x @ 1,400 gpm each);
    - Associated piping, pumps, valves, and appurtenances.
- Backwash facilities;
    - Above grade concrete storage tank (150,000 gallon, 25-foot diameter);
    - 300 LF of 12-inch interconnecting piping, valves, and appurtenances.

- Disinfection facilities;
    - Duplex chemical injection systems with chemical storage;
    - Concrete, baffled contact tank located below the main floor of the WTP;
    - Finished water monitoring equipment;
    - Finished water vertical turbine pumps w/VFDs, (5x 1,000 gpm @ 100 feet TDH).
- Electrical;
    - New 400A electrical service from existing overhead power;
    - New electrical room for MCCs and other equipment;
    - New, Ethernet based telemetry system;
    - New HMI and PLC control scheme with updated software package.
- An additional 1,000 LF of 16-inch diameter distribution system connection piping between the WTP outlet and the existing distribution system; and
- 1,000 LF of new, ductile iron backwash discharge piping from the WTP to Icicle Creek.

The facilities listed above would cost approximately $10,541,000 which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternative 6 – Additional 1,000 gpm Groundwater Well at Existing Wellfield

Because of the capital expense for Alternatives 1 – 5, Alternative 6 is presented in order to compare the cost of surface water improvements to the cost of additional groundwater system capacity.

Treatment requirements for surface water are significantly more stringent than for groundwater, and these additional treatment requirements incur additional capital and operational costs when compared to typical groundwater facilities.

As listed previously, the City maintains 3,250 gpm of existing groundwater sources (1,200 gpm, 1,300 gpm, and 750 gpm). This existing capacity is sufficient to meet the projected maximum day demand until at least 2035 and is only slightly deficient at the projected *ultimate* maximum day demand of 3,870 gpm. If the City were able to transfer their existing water rights from Icicle Creek used at the WTP to a new groundwater extraction facility also located on Icicle Creek, this would provide an additional 1,400 gpm and would provide enough source capacity to serve the projected ultimate maximum day demands for the City. The City could then decommission the existing WTP and remove it from service.

This alternative includes transferring existing water rights from Icicle Creek downstream to a new groundwater extraction facility also located on Icicle Creek. One potential location for this new groundwater extraction site is near the existing State fish hatchery or cemetery. Although additional hydrogeological studies would need to be completed prior to installing a new well, for the purposes of this analysis, the well is assumed to be located near these existing facilities and would provide additional source capacity suitable to meet the City's projected ultimate maximum day demands.

Currently, there are many existing service connections served directly from the water main between the WTP and the Icicle Ridge Reservoir. If the WTP was removed from service in order to fully utilize the existing and proposed groundwater facilities, these existing connections would be left without water service. As such, a new water booster station would be required to provide service to these existing connections. A new booster station would be provided with three duty pumps (two operational, one standby), and two larger, fire suppression pumps (one duty, one standby). These pumps would be located near the Icicle Ridge Reservoir and would be located inside a CMU or wood building that would include monitoring instrumentation, electrical connection, standby power generation, and site security.

In addition to a new pump building, some modifications to the existing distribution system piping would be required.

Electrical and telemetry programming modifications would also be required to connect the new system and allow for successful control and monitoring.

Because the WTP would be removed from service, this alternative does not include any of the high priority or recommended modifications listed in Table 3-1 or Table 3-2.

The modifications necessary to install this alternative using new groundwater facilities would cost approximately $3,468,000 which includes equipment, construction, contingency (30%), Washington State sales tax (8.7%), and project design and administration (25%). A preliminary budgetary project cost estimate is provided in Appendix B.

Alternatives Summary

Table 4-1 summarizes the target capacity and the estimated project costs for all of the alternatives discussed above. The table shows that Alternatives 1, 2A, 2B, and 6 have a significantly lower capital cost than the remaining alternatives.

TABLE 4-1

WTP Treatment Alternatives Summary

Alternative No.	Target Capacity (gpm)	Description	Estimated Project Cost
1	950	Status Quo	$927,000
2A	1,400	Existing Equipment	$2,326,000
2B	2,800	Existing Equipment	$4,001,000
3A	1,400	New Rapid Rate Filtration Equipment	$6,069,000
3B	2,800	New Rapid Rate Filtration Equipment	$7,137,000
4A	1,400	New Membrane Filtration Equipment	$7,653,000
4B	2,800	New Membrane Filtration Equipment	$9,873,000
5	3,600	New WTP Facility	$10,541,000
6	4,650	Additional groundwater wells	$3,468,000

Major advantages and disadvantages for each alternative discussed above are summarized in Table 4-2. Each alternative has advantages and disadvantages that may be weighted differently by the City depending on their desire for additional treatment capacity at the WTP. This table is also included as Appendix D and includes some additional information on assumptions, and items not included in the cost estimate.

TABLE 4-2

Alternatives Advantages/Disadvantages Summary

Alternative No.	Description	Advantages	Disadvantages
1	Status Quo	• low capital cost • low operational complexity	• low filter capacity • continued deterioration of filter equipment
2A	Existing Equipment	• low capital cost • operational familiarity • utilize existing equipment	• cost of ongoing maintenance • continued deterioration of filter equipment
2B	Existing Equipment	• low capital cost • higher filtration capacity • operational familiarity • utilize existing equipment	• additional optimization testing required • uncertain final filter capacity
3A	New Rapid Rate Media Filtration Equipment	• operational familiarity	• loss of work/storage space • building expansion required
3B	New Rapid Rate Media Filtration Equipment	• higher filtration capacity • operational familiarity	• high capital cost • building expansion required • loss of work/storage space
4A	New Membrane Filtration Equipment	• utilize existing filter cells	• high capital cost • high operational cost • increased operational complexity
4B	New Membrane Filtration Equipment	• higher filtration capacity • utilize existing filter cells	• high capital cost • high operational cost • increased operational complexity
5	New WTP Facility	• higher filtration capacity • utilize new technology and equipment	• highest capital cost • would require new site, permitting
6	Additional Groundwater Facilities	• low capital cost • reduced operational cost • reduced staffing requirements • low operational complexity	• decreased source redundancy • must pump to serve upper Icicle Creek Road • difficulty in transferring water rights

To determine which alternative may provide the highest value for the City, a decision matrix is a useful tool that will weigh the City's critical factors and rank each alternative according to these factors. The decision matrix shown in Table 4-3 below ranks each alternative according to the following factors:

- Capital cost
  - 1 = high cost, 10 = low cost
- Operational cost
  - 1 = high cost, 10 = low cost
- Operational complexity
  - 1 = significantly more complex than current WTP, 10 = similar complexity to current WTP
- Potential filtration capacity
  - 1 = low potential capacity, 10 = high potential capacity
- Constructability
  - 1 = not easily constructible, 10 = easily constructible
- Risk for Implementation, and
  - 1 = potential legal, logistical, or physical risks for installation, 10 = minimal legal, logistical, or physical risks for installation
- Environmental impact
  - 1 = highly negative impact, 10 = low negative impact

A score between 1 and 10 was give to each alternative for each factor, then the sum of all scores for all factors was tallied. For all factors, a higher score indicates that an alternative is more likely to successfully address the City's goals for each factor. A score of 10 was assigned to the alternative the best suited a specific critical factor, and scoring for the remaining alternatives was made relative to the highest scoring alternative.

TABLE 4-3

Alternatives Decision Matrix Summary

Alternative No.	Capital Cost	Operational Cost	Operational Complexity	Filtration Capacity	Constructability	Risk for Implementation	Environmental Impact	Total	Rank
1	10	10	10	2	10	10	10	62	**1**
2A	8	9	9	5	9	9	8	57	**2**
2B	7	8	8	6	6	5	8	48	**4**
3A	5	7	7	5	5	2	5	36	**9**
3B	5	6	7	8	5	2	5	38	**7**
4A	4	5	5	5	8	6	8	41	**6**
4B	3	5	5	8	8	6	8	43	**5**
5	2	7	7	10	4	4	4	38	**7**
6	8	9	10	10	8	5	6	56	**3**

The results from Table 4-3 suggest that if the City wishes to utilize the existing WTP, Alternative 1 will most successfully address the City's needs. However, both Alternative 2A and Alternative 6 provide excellent alternatives that may address both the City's short- and long-term goals for water system operation.

RECOMMENDATIONS

FUNDING

The following funding opportunities are available to help the City provide design and construction funds to complete any potential project.

Public Works Board Design/Construction Loan (PWB)

The PWTF is a revolving loan fund designed to help local governments finance public works projects through low-interest loans and technical assistance. The PWTF, established in 1985 by legislative action, offers loans substantially below market rates, payable over periods ranging up to 20 years. To be eligible for the PWTF programs, an applicant must be a local government such as a city, county, or utility district. PWTF has four loan programs including Construction, Preconstruction, Planning, and Emergency.

There is currently no Construction Funding available from the Public Works Board; however, applications are typically due in April/May of the financing year.

Preconstruction funding is generally limited to $1 million/jurisdiction/biennium and construction funding is usually limited to $10 million if funds are available.

Drinking Water State Revolving Fund (DWSRF)

In 1996, Congress established the DWSRF through the reauthorization of the federal Safe Drinking Water Act. The program is managed by both DOH and the Washington State Public Works Board. The purpose of the program is to provide low-interest loans to assist publicly- and privately-owned water systems improve drinking water and protect public health.

Eligible publicly owned water systems include city and county governments, public utility districts, and special purpose districts. Privately owned systems are eligible as long as they are Group A systems. Maximum award per single water system is $12,000,000 and for combining systems an award of $24,000,000 is available. These loans are often allowed a high level of forgiveness if the system is consolidated due to water quality issues.

DWSRF puts its greatest emphasis on communities and projects with significant water quality issues. Applications are generally available in September and due at the end of November.

Community Development Block General Purpose Grants (CDBG)

The CDBG program is a competitive source of federal funding for a broad range of community development projects. A primary requirement of the CDBG program is that the project must principally benefit at least 51 percent of the low-to-moderate income residents of the project area. CDBG has two programs including General Purpose and Planning Only. The General Purpose program provides grant funds for the design, construction, or reconstruction of water and sewer systems up to the amount of $750,000. The Planning Only program includes projects such as comprehensive plans and capital improvement plans and has an upper limit of $24,000 for a single applicant or $40,000 for a joint applicant. Eligible applicants for the CDBG programs include cities and towns with less than 50,000 people or counties with populations less than 200,000.

This funding source just closed for this year, however, applications would be due in the spring of 2019. It is a state-wide program for low-income communities with a total budget of around $10 million each year.

USDA Rural Development Water and Waste Loan Funding (USDARD)

The USDA Rural Development Administration provides funding for water and waste infrastructures for communities with a population under 10,000 and who are unable to obtain funding from other sources at reasonable rates. Projects can include both residential and commercial activities. Applications are accepted year-round and interest rates vary with the federal prime rate (currently ranging from 2.125 percent for severe low-income communities to a standard loan rate of 3.5%); rates are updated quarterly. Loan terms can be as long as 40-years or for the life of the facility. As this program provides funds on a reimbursement basis, interim financing is often required. Interim funding can be obtained from another funding agency. Evergreen Rural Water Assn. and the Rural Community Assistance Corporation (RCAC) provide short-term interim finance loans and frequently work with USDA Rural Development.

Fish Restoration Funding Opportunities

Funding from fish restoration programs may be available for some of the alternatives which reduce the amount of water which is withdrawn from Icicle Creek as water availability in Icicle Creek is deficient during important fish windows.

APPENDIX A

EXISTING FACILITY PHOTOGRAPHS

Figure A-1: Existing Intake Structure

Figure A-2: Existing Intake Caisson

Figure A-3: Existing Screen House

Figure A-4: Polymer Injection and Mixing Equipment

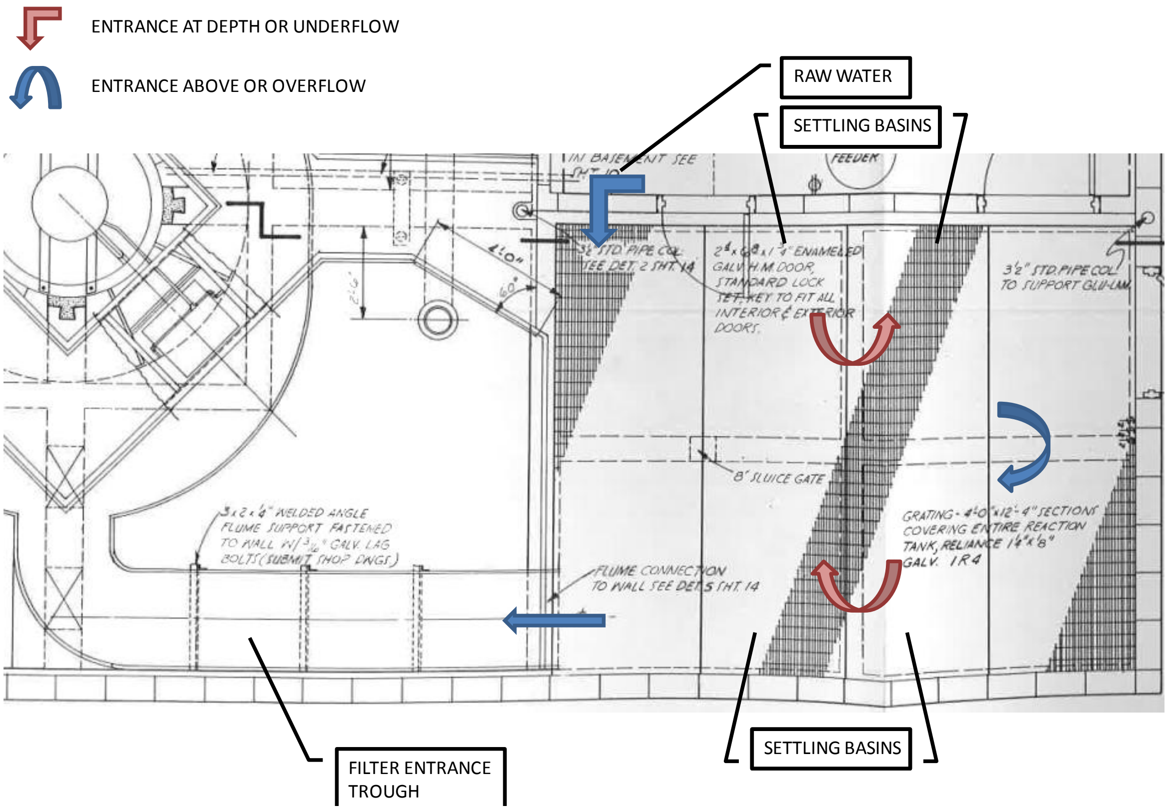

Figure A-5: Raw Water Settling Basins

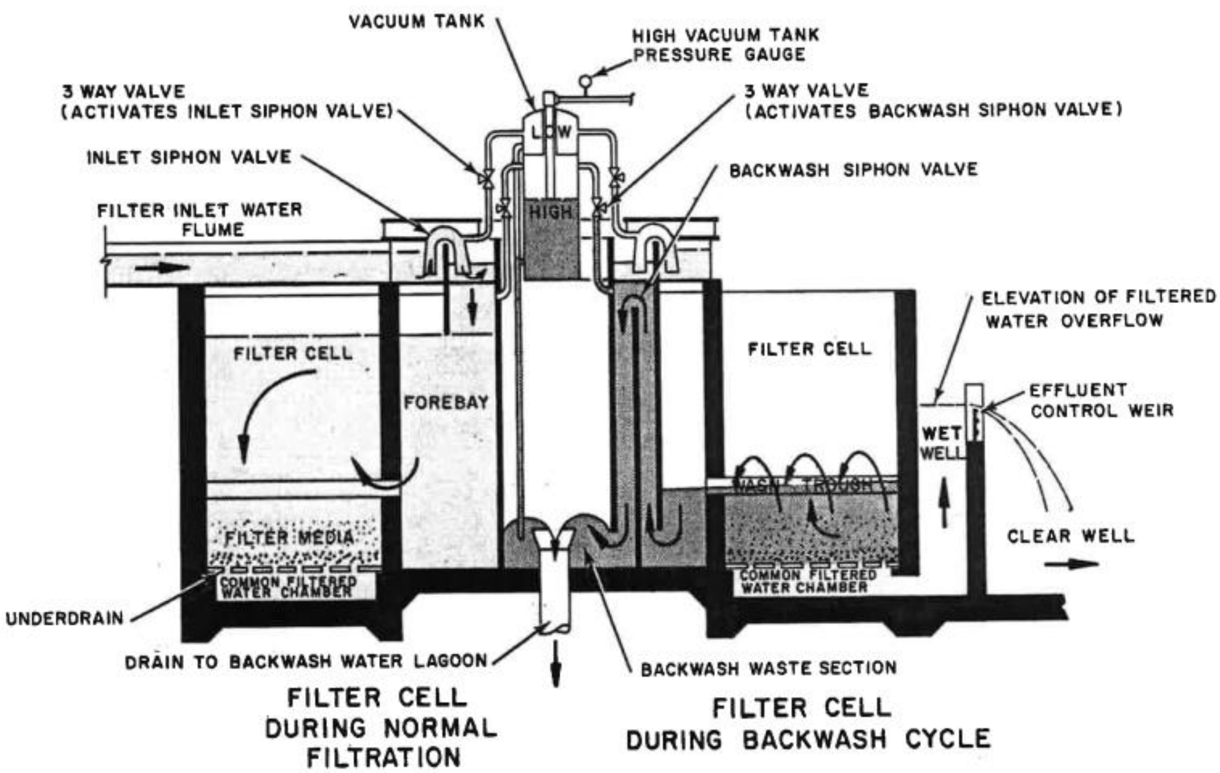

Figure A-6: Rapid Media Filter System Schematic Drawing

Figure A-7: Rapid Media Filtration System

Figure A-8: Filter Backwash Basin

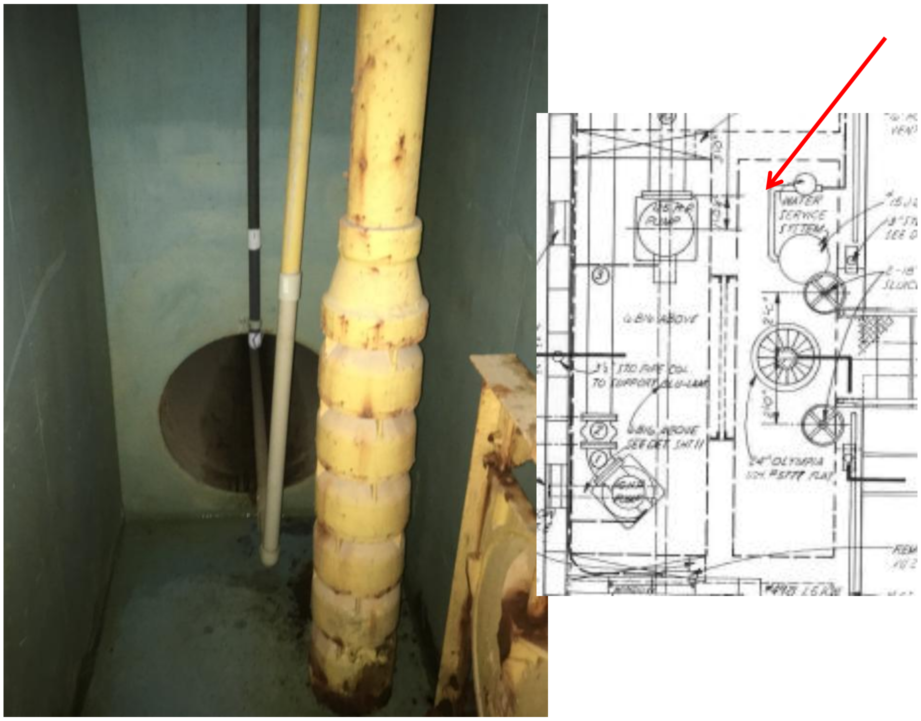

Figure A-9: Primary Clearwell

Figure A-10: Chlorine Mixing and Injection Equipment

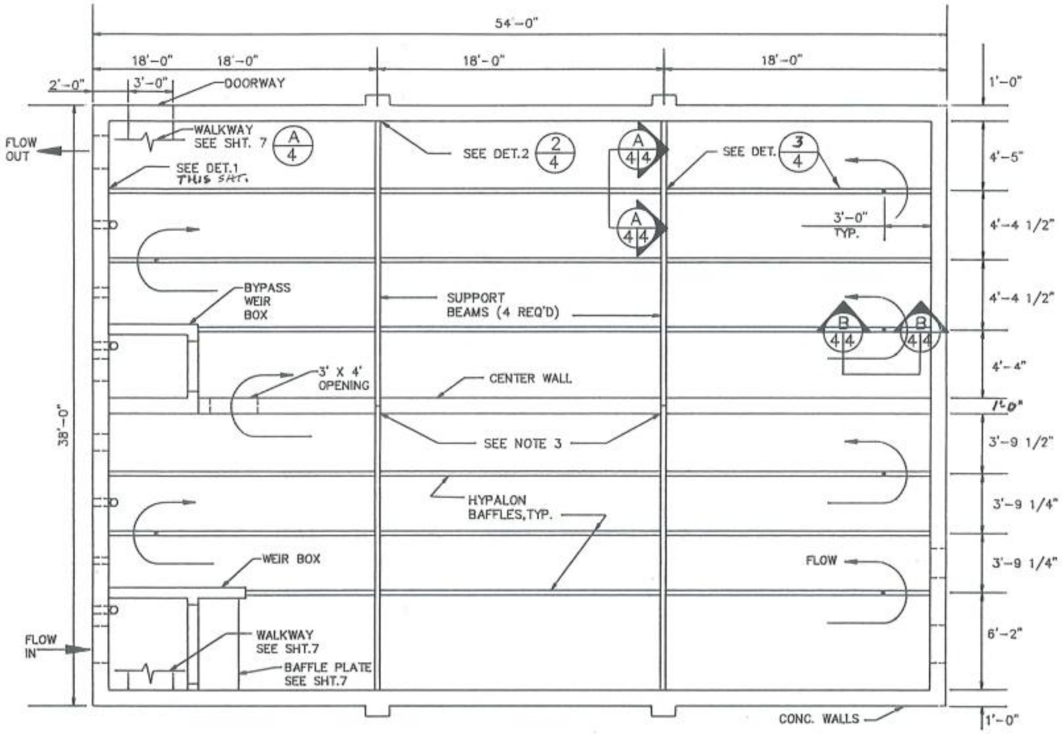

Figure A-11: Chlorine Contact Basin Plan

Figure A-12: Chlorine Contact Basin

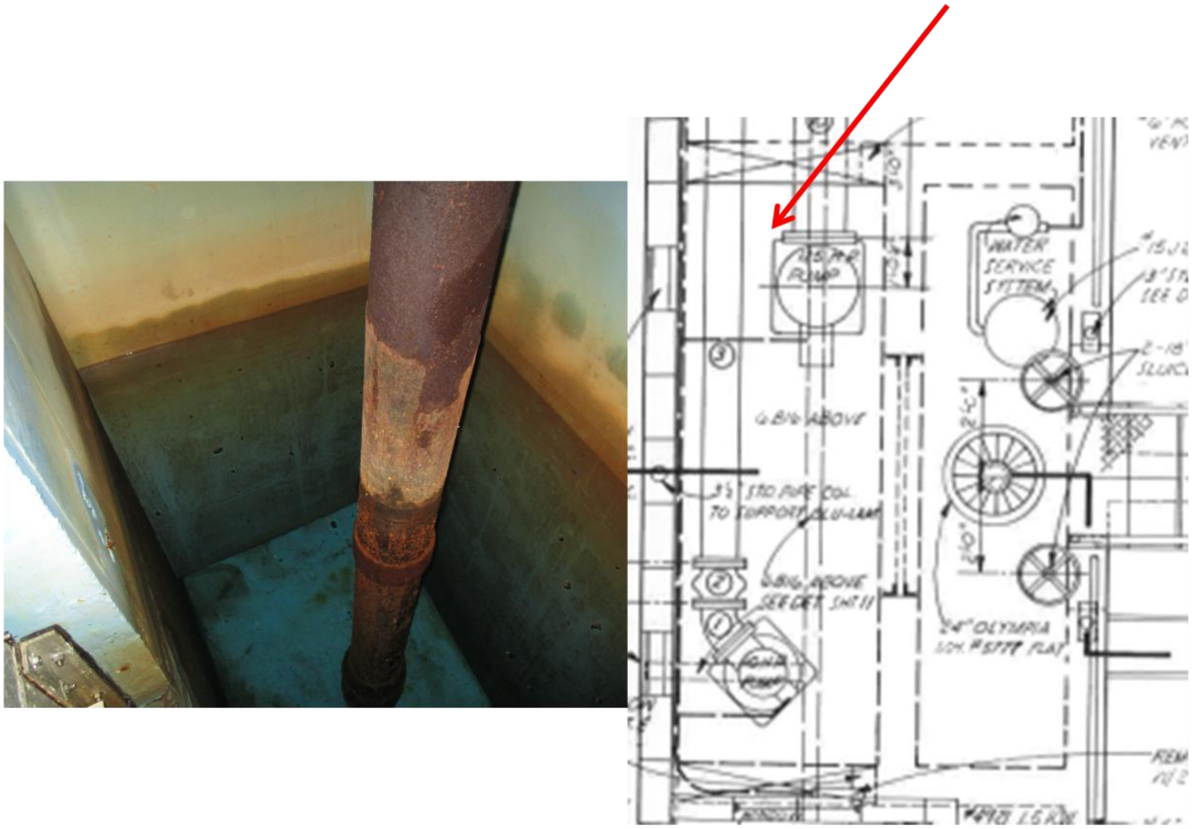

Figure A-13: Secondary Clearwell

Figure A14: Finished Water Flow Vault

APPENDIX B

BUDGETARY ALTERNATIVE COST ESTIMATES

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 1 - STATUS QUO

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 48,000	$ 48,000
2	High Priority Assessment Improvements	1	LS	$ 477,000	$ 477,000
				Subtotal	**$ 525,000**
				Contingency (30%)	$ 157,500
				Subtotal	**$ 682,500**
				Washington State Sales Tax (8.7%)	$ 59,400
				Subtotal	**$ 741,900**
				Design and Project Administration (25%)	$ 185,500
				TOTAL CONSTRUCTION COST	**$ 927,400**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 2A - 1,400 GPM WITH EXISTING EQUIPMENT

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 120,000	$ 120,000
2	Demolition / Sitework	1	LS	$ 50,000	$ 50,000
3	Backwash System Modifications	1	LS	$ 400,000	$ 400,000
4	Flocculation System Modifications	1	LS	$ 50,000	$ 50,000
5	Filtration System Modifications	4	EA	$ 7,000	$ 28,000
6	Electrical Modifications	1	LS	$ 15,000	$ 15,000
7	Telemetry, Programming & Integration	1	LS	$ 5,000	$ 5,000
8	High Priority Assessment Improvements	1	LS	$ 649,000	$ 649,000

Subtotal	**$ 1,317,000**
Contingency (30%)	$ 395,100
Subtotal	**$ 1,712,100**
Washington State Sales Tax (8.7%)	$ 149,000
Subtotal	**$ 1,861,100**
Design and Project Administration (25%)	$ 465,300
TOTAL CONSTRUCTION COST	**$ 2,326,400**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 2B - 2,800 GPM WITH EXISTING EQUIPMENT

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 206,000	$ 206,000
2	Demolition / Sitework	1	LS	$ 50,000	$ 50,000
3	Flocculation System Modifications	1	LS	$ 350,000	$ 350,000
4	Backwash System Modifications	1	LS	$ 400,000	$ 400,000
5	Filtration System Modifications	4	EA	$ 70,000	$ 280,000
6	Electrical Modifications	1	LS	$ 20,000	$ 20,000
7	Telemetry, Programming & Integration	1	LS	$ 10,000	$ 10,000
8	High Priority Assessment Improvements	1	LS	$ 649,000	$ 649,000
9	Recommended Assessment Improvements	1	LS	$ 300,000	$ 300,000

Subtotal	**$ 2,265,000**
Contingency (30%)	$ 679,500
Subtotal	**$ 2,944,500**
Washington State Sales Tax (8.7%)	$ 256,200
Subtotal	**$ 3,200,700**
Design and Project Administration (25%)	$ 800,200
TOTAL CONSTRUCTION COST	**$ 4,000,900**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 3A - 1,400 GPM WITH NEW RAPID RATE FILTRATION EQUIPMENT

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 312,000	$ 312,000
2	Demolition / Sitework	1	LS	$ 50,000	$ 50,000
3	Rapid Sand Package Filtration System	2	EA	$ 275,000	$ 550,000
4	Supporting Pumps, Piping, and Equipment	1	LS	$ 150,000	$ 150,000
5	Piping, Valves, and Appurtenances	1	LS	$ 50,000	$ 50,000
6	Site Piping and Connections	1	LS	$ 25,000	$ 25,000
7	WTP Building	3,000	SF	$ 500	$ 1,500,000
8	Backwash System Modifications	1	LS	$ 400,000	$ 400,000
9	Electrical Modifications	1	LS	$ 100,000	$ 100,000
10	Telemetry, Programming & Integration	1	LS	$ 15,000	$ 15,000
11	High Priority Assessment Improvements	1	LS	$ 284,000	$ 284,000

Subtotal	**$ 3,436,000**
Contingency (30%)	$ 1,030,800
Subtotal	**$ 4,466,800**
Washington State Sales Tax (8.7%)	$ 388,600
Subtotal	**$ 4,855,400**
Design and Project Administration (25%)	$ 1,213,900
TOTAL CONSTRUCTION COST	**$ 6,069,300**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 3B - 2,800 GPM WITH NEW RAPID RATE FILTRATION EQUIPMENT

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 367,000	$ 367,000
2	Demolition / Sitework	1	LS	$ 100,000	$ 100,000
3	Rapid Sand Package Filtration System	2	EA	$ 450,000	$ 900,000
4	Supporting Pumps, Piping, and Equipment	1	LS	$ 175,000	$ 175,000
5	Piping, Valves, and Appurtenances	1	LS	$ 65,000	$ 65,000
6	Site Piping and Connections	1	LS	$ 25,000	$ 25,000
7	WTP Building	3,000	SF	$ 500	$ 1,500,000
8	Backwash System Modifications	1	LS	$ 400,000	$ 400,000
9	Electrical Modifications	1	LS	$ 150,000	$ 150,000
10	Telemetry, Programming & Integration	1	LS	$ 15,000	$ 15,000
11	High Priority Assessment Improvements	1	LS	$ 284,000	$ 284,000
12	Recommended Assessment Improvements	1	LS	$ 59,500	$ 59,500

Subtotal	**$ 4,040,500**
Contingency (30%)	$ 1,212,200
Subtotal	**$ 5,252,700**
Washington State Sales Tax (8.7%)	$ 457,000
Subtotal	**$ 5,709,700**
Design and Project Administration (25%)	$ 1,427,400
TOTAL CONSTRUCTION COST	**$ 7,137,100**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 4A - 1,400 GPM WITH NEW MEMBRANE FILTRATION EQUIPMENT

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 285,600	$ 285,600
2	Demolition / Sitework	1	LS	$ 50,000	$ 50,000
3	Membrane Filtration System	4	EA	$ 700,000	$ 2,800,000
4	Supporting Pumps, Piping, and Equipment	1	LS	$ 50,000	$ 50,000
5	Piping, Valves, and Appurtenances	1	LS	$ 50,000	$ 50,000
6	Site Piping and Connections	1	LS	$ 25,000	$ 25,000
7	Backwash System Modifications	1	LS	$ 400,000	$ 400,000
8	Electrical Modifications	1	LS	$ 175,000	$ 175,000
9	Telemetry, Programming & Integration	1	LS	$ 20,000	$ 20,000
10	High Priority Assessment Improvements	1	LS	$ 477,000	$ 477,000

Subtotal	**$ 4,332,600**
Contingency (30%)	$ 1,299,800
Subtotal	**$ 5,632,400**
Washington State Sales Tax (8.7%)	$ 490,000
Subtotal	**$ 6,122,400**
Design and Project Administration (25%)	$ 1,530,600
TOTAL CONSTRUCTION COST	**$ 7,653,000**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 4B - 2,800 GPM WITH NEW MEMBRANE FILTRATION EQUIPMENT

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 442,500	$ 442,500
2	Demolition / Sitework	1	LS	$ 50,000	$ 50,000
3	Membrane Filtration System	4	EA	$ 900,000	$ 3,600,000
4	Supporting Pumps, Piping, and Equipment	1	LS	$ 65,000	$ 65,000
5	Piping, Valves, and Appurtenances	1	LS	$ 65,000	$ 65,000
6	Site Piping and Connections	1	LS	$ 25,000	$ 25,000
7	Backwash System Modifications	1	LS	$ 400,000	$ 400,000
8	Electrical Modifications	1	LS	$ 200,000	$ 200,000
9	Telemetry, Programming & Integration	1	LS	$ 20,000	$ 20,000
10	High Priority Assessment Improvements	1	LS	$ 477,000	$ 477,000
11	Recommended Assessment Improvemetns	1	LS	$ 245,000	$ 245,000

Subtotal	**$ 5,589,500**
Contingency (30%)	$ 1,676,900
Subtotal	**$ 7,266,400**
Washington State Sales Tax (8.7%)	$ 632,200
Subtotal	**$ 7,898,600**
Design and Project Administration (25%)	$ 1,974,700
TOTAL CONSTRUCTION COST	**$ 9,873,300**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 5 - 3,600 GPM WITH NEW WATER TREATMENT FACILITY

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 542,500	$ 542,500
2	Demolition / Sitework	1	LS	$ 250,000	$ 250,000
3	Intake Piping	1,000	LF	$ 210	$ 210,000
4	Intake Facilities	1	LS	$ 400,000	$ 400,000
5	WTP Building	3,000	SF	$ 500	$ 1,500,000
6	Site Piping, Valves, and Appurtenances	1	LS	$ 650,000	$ 650,000
7	Filtration Equipment	3	EA	$ 250,000	$ 750,000
8	Backwash Facilities	1	LS	$ 400,000	$ 400,000
9	Backwash discharge piping (8-inch)	1,000	LF	$ 160	$ 160,000
10	Disinfection Facilities	3,000	SF	$ 100	$ 300,000
11	Connection to Existing System	2	EA	$ 10,000	$ 20,000
12	Distribution system piping (16-inch)	1,000	LF	$ 210	$ 210,000
13	Electrical	1	LS	$ 500,000	$ 500,000
14	Telemetry, Programming & Integration	1	LS	$ 75,000	$ 75,000
				Subtotal	**$ 5,967,500**
				Contingency (30%)	$ 1,790,300
				Subtotal	**$ 7,757,800**
				Washington State Sales Tax (8.7%)	$ 674,900
				Subtotal	**$ 8,432,700**
				Design and Project Administration (25%)	$ 2,108,200
				TOTAL CONSTRUCTION COST	**$ 10,540,900**

CITY OF LEAVENWORTH

2018 WATER TREATMENT PLANT ASSESSMENT
PRELIMINARY PROJECT COST ESTIMATE

ALTERNATIVE 6 - 4,650 GPM WITH NEW GROUNDWATER FACILITIES

WTP MODIFICATIONS
October 23, 2018
G&O# 18014.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization / Demobilization	1	LS	$ 178,500	$ 178,500
2	Demolition / Sitework	1	LS	$ 50,000	$ 50,000
3	Decommission Existing WTP	1	LS	$ 100,000	$ 100,000
4	Groundwater Well	1	LS	$ 230,000	$ 230,000
5	Supporting Facilities	1	LS	$ 250,000	$ 250,000
6	Booster Pump Station	1,000	SF	$ 550	$ 550,000
7	Distribution System Modifications	1	LS	$ 250,000	$ 250,000
8	Connection to Existing System	3	EA	$ 10,000	$ 30,000
9	Electrical	1	LS	$ 250,000	$ 250,000
10	Telemetry, Programming & Integration	1	LS	$ 75,000	$ 75,000

Subtotal	**$ 1,963,500**
Contingency (30%)	$ 589,100
Subtotal	**$ 2,552,600**
Washington State Sales Tax (8.7%)	$ 222,100
Subtotal	**$ 2,774,700**
Design and Project Administration (25%)	$ 693,700
TOTAL CONSTRUCTION COST	**$ 3,468,400**

APPENDIX C

ICICLE CREEK WATER QUALITY ASSESSMENT

Gray & Osborne, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM

TO:	HERB AMICK, PUBLIC WORKS DIRECTOR JOEL WALINSKI, CITY ADMINISTRATOR ARNICA BRIODY, WTP OPERATOR
FROM:	KEITH STEWART, P.E. ADAM MILLER, P.E.
DATE:	AUGUST 24, 2018
SUBJECT:	WATER QUALITY ASSESSMENT AT WATER TREATMENT PLANT CITY OF LEAVENWORTH, CHELAN COUNTY, WASHINGTON G&O #18014.00

INTRODUCTION

The City of Leavenworth (City) has contracted with Gray & Osborne to perform a water quality assessment of both raw and finished water at the City's Water Treatment Plant (WTP). The goal of this water quality assessment is to compile and present historic water quality data in order to highlight trends, identify parameters that may negatively affect WTP performance, and to provide recommendations on process modifications that may positively affect WTP performance. The memorandum could also be used to guide selection of feasible water treatment alternatives.

This memorandum summarizes the findings of the water quality assessment, including key parameters and their historical trends. It also provides a brief interpretation of the data and some recommendations for additional testing and WTP operations.

BACKGROUND AND EXISTING FACILITIES

The City is located along U.S. Highway 2 approximately 25 miles west of Wenatchee in Chelan County, Washington. The City serves approximately 1,400 residential and commercial water system connections. The City is heavily influenced by tourism, leading to a significant increase in population and water demand during both summer and winter months.

The City owns and operates a water system that includes groundwater sources, a surface water source, a water treatment facility, water storage facilities, and water distribution facilities.

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This assessment focuses on the water quality of Icicle Creek, which is the City's primary water source and the sole source of raw water for the WTP. The WTP treatment process includes coagulation and flocculation, sedimentation, rapid media filtration, and chemical disinfection. According to the WTP Operation and Maintenance Manual (1981), the design capacity of the filters is 3,100 gallons per minute (gpm), which equates to 6.6 gpm per square foot (gpm/sf). A more typical operational flow rate is 1,000 gpm, which equates to approximately 2.2 gpm/sf.

Raw water from Icicle Creek proceeds through a concrete caisson at the intake structure, which is located approximately 1 mile upstream of the WTP along Icicle Creek Road. Raw water then flows through a screen house, then through 0.8 mile of 16-inch ductile iron piping to the WTP where coagulant is added. At the WTP, water flows through a static mixer then into four square, sequential settling basins where solids are flocculated and settled. Next, water flows into a distribution structure where it is evenly divided between four concrete filter basins filled with filtration media consisting of gravel, several layers of sand, and approximately 18 inches of anthracite. The filtered water is collected in a common chamber under the filters and directed to a primary clearwell. The water is disinfected with gaseous chlorine, then directed through a serpentine contact basin before flowing by gravity to downstream connections and the Icicle Creek Reservoir.

At regular intervals, the media filters must be backwashed in order to remove trapped particles and sediment. During a backwash, filtered water from the forebay flows back (upward) through the media in order to remove trapped particles. These particles are then transported with the backwash water through the backwash drain piping to the backwash storage basin which is located adjacent to the WTP.

During a majority of the year, the WTP is operated approximately 5 days per week for 4 to 8 hours each day at a flow rate between 400 and 750 gpm. The WTP is typically taken offline each spring (late May or early June) for 2 to 4 weeks due to high raw water turbidity. During this shutdown period, routine and preventive maintenance is performed on the WTP equipment as required. A shorter, 1- to 2-week shutdown period may also occur during the fall rainy season when the raw water turbidity increases, and additional short-term shutdowns (1 to 2 days) occur as needed based on weather conditions and raw water turbidity.

HISTORICAL WATER SUMMARY

Historical water quality data were gathered and compiled from the Washington State Department of Health (DOH) Daily Monitoring Reports (DMRs) as well as the City. Parameters analyzed included the following:

- Average Daily Flow
- Peak Flow
- Backwash Volume
- Temperature
- Turbidity
- pH
- Alkalinity

In an attempt to summarize the seasonal variation in raw water quality, the data was combined into winter (October through April) and summer (May through September) seasons. The sections below highlight the compiled data.

WTP Flow

Average daily, minimum daily, and maximum daily flows through the WTP are summarized in Table 1 and are plotted on Figure 1. These values are as measured by the raw and finished water flow meters and recorded in the WTP's DMRs from which the data are taken.

Peak hour flows through the WTP are summarized in Table 2 and are plotted on Figure 1. Peak hour flows are as measured through the WTP raw and finished water flow meters.

TABLE 1

Daily Flow Summary

Year	Average Daily Flow (gpd)	Minimum Daily Flow (gpd)	Maximum Daily Flow (gpd)
Winter			
2016	197,810	98,000	429,000
2017	256,238	69,000 (1)	748,000
2018	290,163	26,600 (2)	920,000
Summer			
2016	592,444	13,500	1,130,000
2017	923,550	56,000	1,402,000

(1) Low values of less than 1,000 have been omitted as they represent startup and testing totals.
(2) Includes data through March 31, 2018.

TABLE 2

Peak Hour Flow Summary

Year	Avg. Peak Hour Flow (gpm)	Min. Peak Hour Flow (gpm)	Max. Peak Hour Flow (gpm)
Winter			
2016	260	246	268
2017	286	178 (1)	570
2018	455	414 (2)	689
Summer			
2016	508	219	778
2017	758	257	1,046

(1) Includes some select low values which are estimated to be values during startup and shutdown.
(2) Includes data through March 31, 2018.

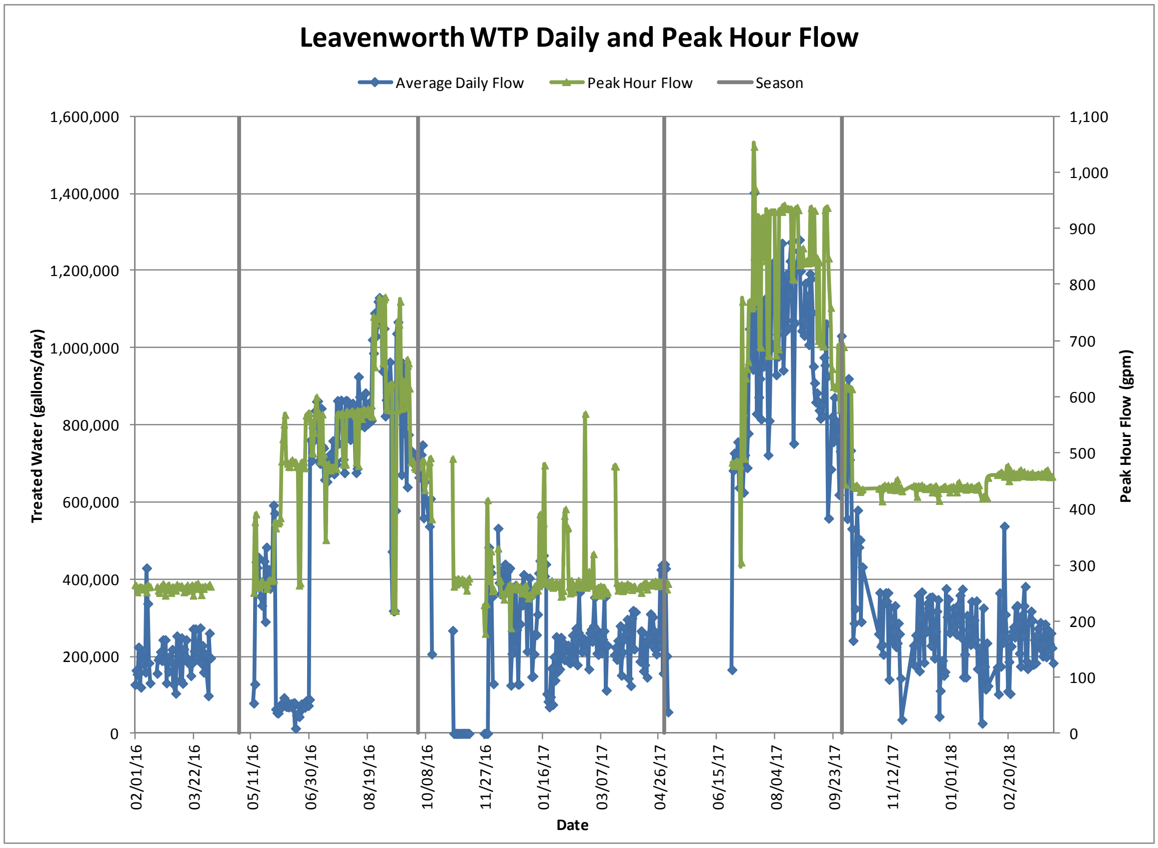

FIGURE 1

Daily and Peak Hour Flows

From the data, the following trends were identified:

- Average daily flow and peak hour flow are higher in the warmer, summer months.

  This correlates with higher irrigation use and increased use from tourism.

- Summer months show higher variability (range from minimum to maximum) in average daily flow and peak hour flow.

- Both average daily flow and peak hour flow increased slightly from 2016 to 2017.

  This increase may be due to factors such as weather, visitation, soil stability, or other climactic factors and may not be indicative of a long-term trend. Fires, warmer air temperatures, population growth, and tourism may also have contributed to this increase.

- Summer peak hour flows are more highly variable than winter peak hour flows.

  This is expected and is most likely due to tourism and irrigation use during the warm, summer months.

- Winter 2017 did not show the sporadic significant increases in peak hour flows seen in winter 2016.

In speaking with operations staff, there were no significant concerns regarding the achievable average daily flow or peak hour flow. The operations staff did have some concerns about not being able to filter raw water at or near the WTP's maximum design capacity of 3,100 gpm (as listed in the *Leavenworth WTP Operation and Maintenance Manual*, Volume I, December 1981); however, this limitation is not likely a result of raw water quality parameters but instead is a result of backwash efficiency, available backwash storage volume, and operational parameters at the WTP. The listed maximum capacity of the WTP is a design value based on the initial media depths, thicknesses, and parameters which have changed since the construction of the plant. As such, the maximum design capacity of the WTP may have increased or decreased along with these performed changes.

Media Filter Backwash

Filter backwash volume is summarized in Table 3 and plotted on Figure 2. These values represent the estimated volume of water used to backwash all four media filters at the WTP. Filters are backwashed based on their filtered water turbidity readings and as needed for operations staff workload. Under normal operation, the filters are backwashed once per day or once every 2 days. As the backwash drain or supply piping is not equipped with a flow meter, the values listed in Table 3 below are calculated based on the flow through the WTP and the backwash sequence duration.

TABLE 3

Media Filter Backwash Summary

Year	Average Volume (gal)	Minimum Volume (gal)	Maximum Volume (gal)
Winter			
2016	—	—	—
2017	55,753	21,000	134,000
2018	57,521	53,000	104,000
Summer			
2016	55,215	46,000	97,000
2017	57,962	41,000	70,000

(1) Data tabulated from files provided by the City.

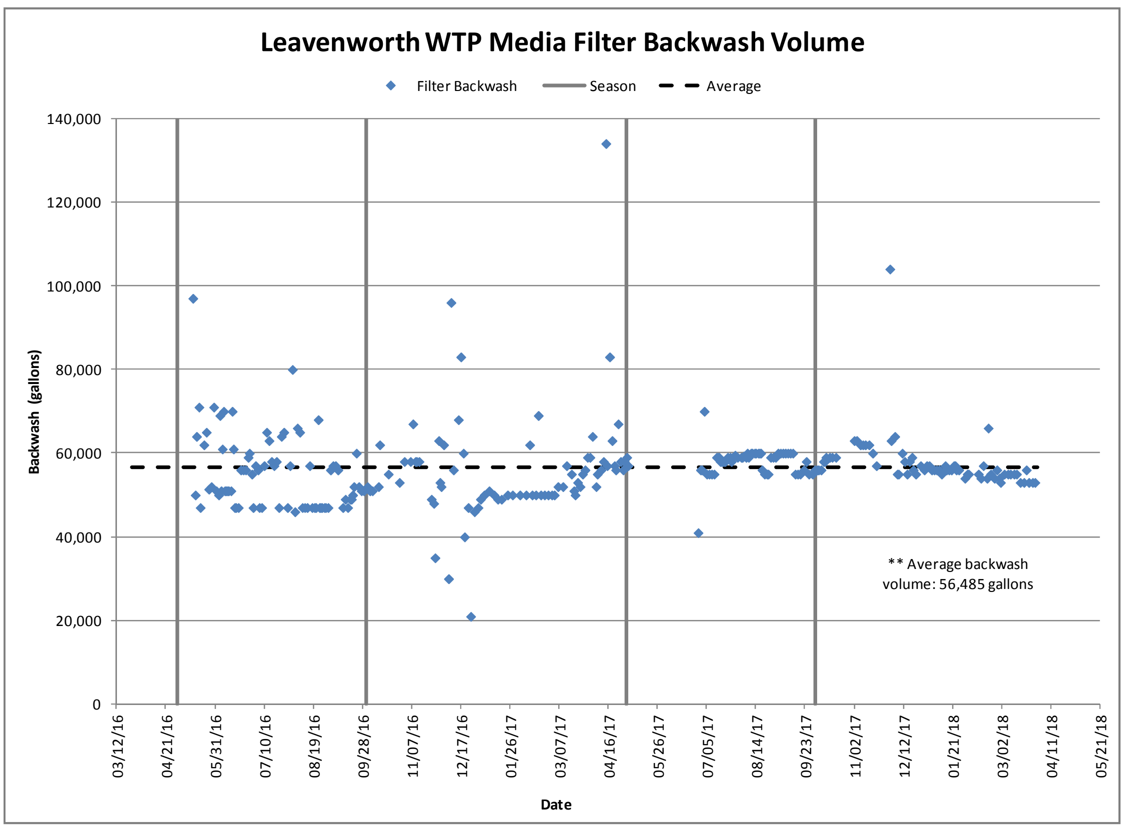

FIGURE 2

Media Filter Backwash Volume

An analysis of these data suggest that backwash volumes have remained consistent (55,000 to 57,000 gallons per day) between 2016 and 2018. The many outlying data points seen on Figure 2 are likely due to flow spikes measured during the initial stages of a backwash cycle. The design backwash flow rate listed by the filter system manufacturer (Infilco) is 10 to 14 gpm/sf. Using the average backwash volume of 56,485 gallons (for four filter cells) from Figure 2, a total filter area of 476 sf (119 sf per filter cell) and a backwash cycle time of 9.5 minutes (surface wash, backwash, and combo backwash), the estimated backwash flow rate is 12.5 gpm/sf, which is within the range of design flows provided by the filter manufacturer.

Discussions with the operations staff suggest that although the backwash flow rate is within the design range, backwashing seems to be less effective than in prior years. This is evident in that the filter takes longer during filter-to-waste periods after backwash to return to operating conditions (turbidity of less than 0.05), and that a visual observation of the backwash cycle does not seem to remove a significant volume of trapped particles. Furthermore, the existing surface wash nozzles may be corroded to such a degree that they are essentially ineffective. Staff also suggest that the existing backwash basin may not have sufficient volume to adequately store backwash wastewater from the backwash of all four filters. Two potential methods for improving filter particle removal during backwash are to lengthen the time of backwashing and to increase the backwash flow rate. Both of these alternatives would increase the volume of water consumed during a backwash cycle. However, the existing backwash storage basin does not appear to have the capacity to accept this additional volume. Operations staff also suggest that filter run times – or the time between backwash cycles – is decreasing, which suggests that backwash cycles are not effectively removing particles trapped on the filter media. While lengthening the backwash cycle may help remove additional particles, the primary method to increase the effectiveness of each backwash cycle is to increase the backwash flow rate to approximately 14 gpm/sf – which is the maximum design flow rate recommended by the filter manufacturer. Even if the backwash flow rate is maximized, backwash cycle timing would need to be optimized in order to maximize the filter's particle removal efficiency.

Temperature

Raw water temperature is summarized in Table 4 and plotted on Figure 3. Data were collected from the raw water pH probe which simultaneously measures both the pH and the temperature of the incoming water.

TABLE 4

Raw Water Temperature Summary

Year	Average (°F)	Minimum (°F)	Maximum (°F)
Winter			
2016	38.5	33.8	44.4
2017	37.9	32.4	49.1
2018	40.3	33.8	51.8
Summer			
2016	52.0	41.9	61.0
2017	59.2	42.8	64.4

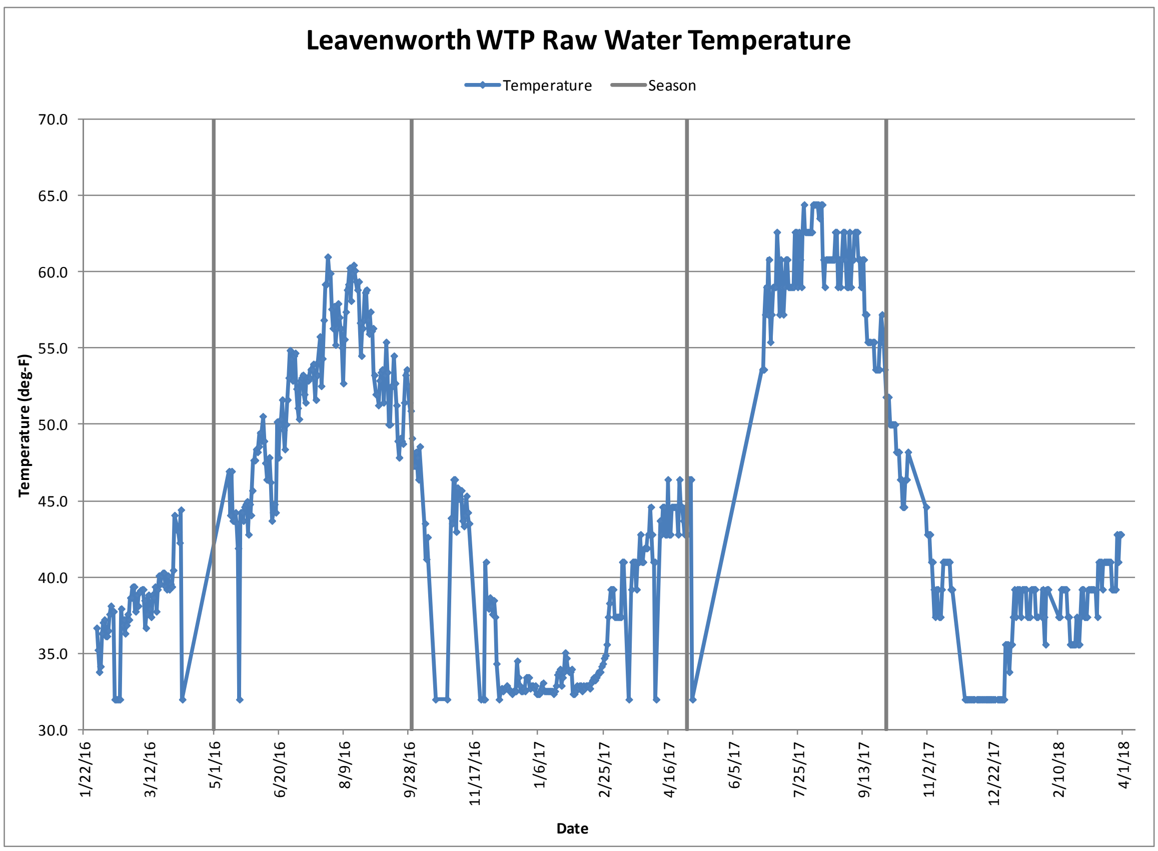

FIGURE 3

Raw Water Temperature

Raw water temperature varies seasonally between 32 and 64 degrees Fahrenheit from winter to summer. There does appear to be a slight increase in wintertime average and maximum temperatures between 2016 and 2018; however, this may be due to other climatic influences such as air temperature and timing of snowmelt, etc., and may not be indicative of a long-term trend.

The primary impacts of temperature on water treatment are coagulant efficiency and CT requirements. Many studies conducted both by research institutions as well as coagulant manufacturers have shown that coagulation/flocculation is less effective as temperature decreases. An increase in temperature can have a positive effect on coagulation/flocculation; however, there is a limit to the positive effects caused by temperature. It is not likely that the small increase seen from 2016 to 2017 will have a negative impact on coagulation/flocculation of the raw water, and contrarily, this small increase may result in increased coagulation/flocculation efficiency. The colder water temperatures measured in the winter months are likely to reduce the effectiveness of coagulation of the raw water particles; however, the WTP operations staff currently performs jar tests on a quarterly basis which allows them to optimize the coagulant dosage and maximize particle settling and removal.

Water temperature can also impact the level of CT the WTP must provide. CT is a measure of the level of disinfection and is a combination of contact time and chlorine residual. As water temperature decreases, additional CT is required. A tracer study completed at the WTP in 2017 by Gray & Osborne indicated that the WTP provides ample CT for its finished water and a small change in raw water temperature will not significantly affect required operations at the WTP.

Turbidity

Raw and finished water turbidity are summarized in Table 5 and plotted on Figure 4. Raw water turbidity to the WTP fluctuates seasonally and is largely influenced by an influx of snowmelt in the spring (late May to early June) and rainstorms in the fall (late October to early November). Overall, the raw water turbidity is low, and for all periods outside of the spring snowmelt should not negatively impact WTP filtration effectiveness. Turbidity for both the raw and finished water are measured using on-site instrumentation.

TABLE 5

Raw Water and Finished Water Turbidity Summary

Year	Raw Water			Finished Water		
	Average (NTU)	Minimum (NTU)	Maximum (NTU)	Average (NTU)	Minimum (NTU)	Maximum [1] (NTU)
Winter						
2016	0.40	0.18	0.74	0.04	0.02	0.10
2017	0.24	0.09	1.00	0.04	0.02	0.15 [2]
2018	1.52	0.10	7.33	0.04	0.02	0.10
Summer						
2016	0.35	0.16	1.19	0.04	0.02	0.08
2017	1.49	0.08	22.7 [3]	0.04	0.03	0.07

(1) DOH Performance Standard is 0.1 NTU per WAC 246-290 Part 6.
(2) Value not in violation as more than 95 percent of all values must be below 0.1 NTU.
(3) Value collected immediately prior to WTP shutdown.

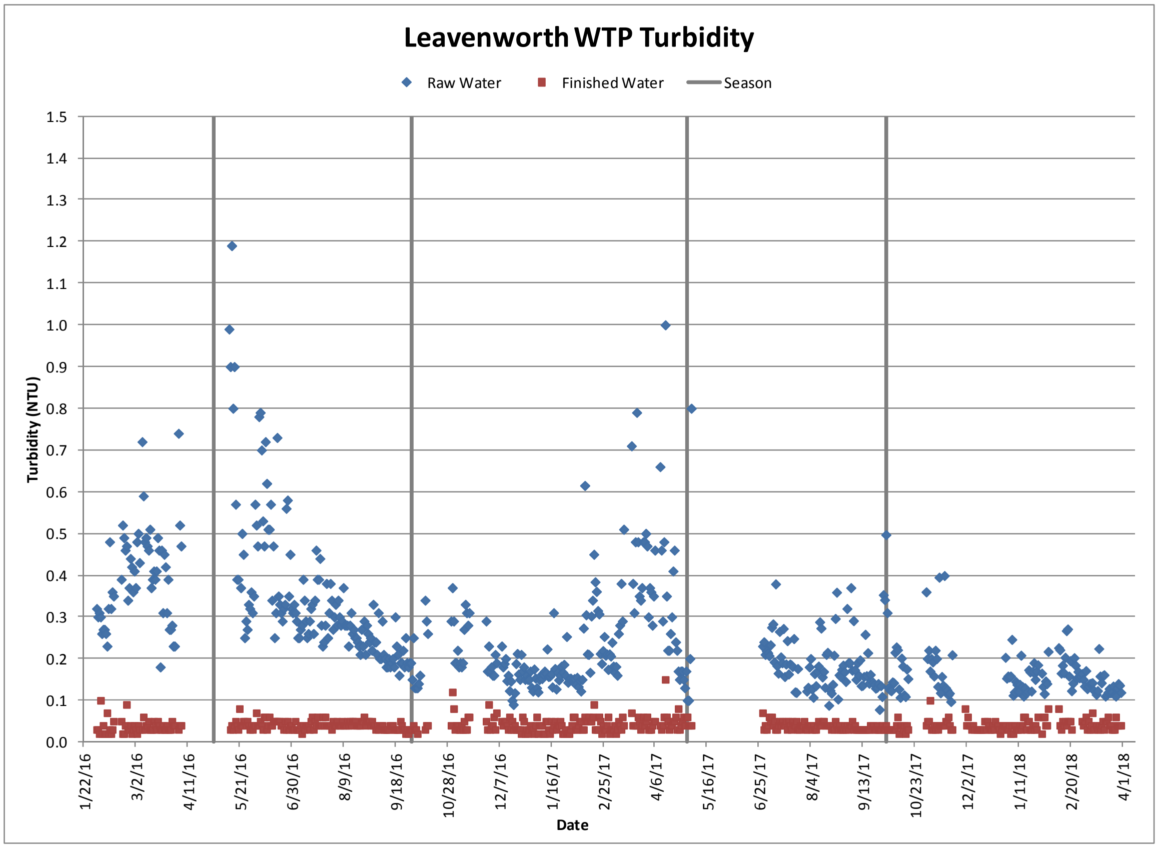

FIGURE 4

Raw Water and Finished Water Turbidity

The raw turbidity varies based on season, local weather conditions, and typically shows a significant increase in spring (May through June) and fall (October through November). As previously mentioned, during these times of high turbidity, the WTP is typically taken offline for annual maintenance. Once raw water turbidity returns to more typical values (less than 2 NTU), the WTP is returned to normal operation. Two significant spikes, in July and December 2017 are not shown on Figure 4 for clarity, but raw water turbidity during these periods was approximately 22 and 6.5 NTU, respectively. These values were collected directly before the plant was temporarily taken offline and do not represent sustained flow at the WTP.

From the data, the following trends were identified:

- Sudden increases in turbidity typically occur in early May to June during spring runoff from snowmelt and again in October from heavy fall rains.
- The maximum measured spring turbidity in 2017 was less than the same value in 2016.
- Finished water turbidity is very consistent and meets the performance standard listed in WAC 246-290.

In general, the turbidity of raw water received at the WTP is very low for a surface water source. It is not uncommon for surface water sources to have sustained raw turbidities greater than 10 NTU and for the applied turbidity – the turbidity of raw water post coagulation/flocculation – to be between 1 and 6 NTU. Figure 4 shows that raw water turbidity for Icicle Creek is less than 0.5 NTU for a vast majority of the year, which suggests that the creek represents a very clear, clean surface water source. As such, the WTP appears to be performing in accordance with WAC 246-290 and no immediate modifications are necessary with regard to finished water turbidity. The raw water turbidity is well within typical ranges for surface water sources and applied turbidity to the filters is within the capabilities of the existing filter media. Furthermore, the historical raw water turbidity would not preclude the City from investigating any particular method of filtration.

Discussions with WTP operations staff indicate that although the WTP appears capable of successfully filtering water with turbidities upward of 22.5 NTU – as seen in the spring and fall – the effectiveness of filter backwash cycles may not be sufficient to return the filters to normal operation in a reasonable time frame. Furthermore, the existing backwash basin does not appear to have the storage capacity required to accommodate the more frequent backwashing required for highly turbid raw water. The existing backwash basin appears to only have sufficient capacity to store 50,000 to 60,000 gallons of backwash water. Historically, this is the volume of water used for each backwash cycle, which usually occurs daily. However, during periods of high raw water turbidity a volume of 100,000 to 120,000 gallons (two backwash cycles) or more may be needed.

pH

Raw water and finished water pH are summarized in Table 6 and plotted on Figure 5. Data are collected as part of the WTP's normal monitoring parameters and are measured using on-site instrumentation.

TABLE 6

Raw Water and Finished Water pH Summary

Year	Raw Water			Finished Water		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Winter						
2016	6.97	6.55	7.25	6.86	6.47	7.19
2017	7.20	6.37	7.68	7.10	6.21	7.56
2018	7.21	6.6	7.50	7.00	6.31	7.41
Summer						
2016	6.96	6.29	7.54	6.89	6.2	7.62
2017	7.15	6.70	7.48	7.06	6.58	7.32

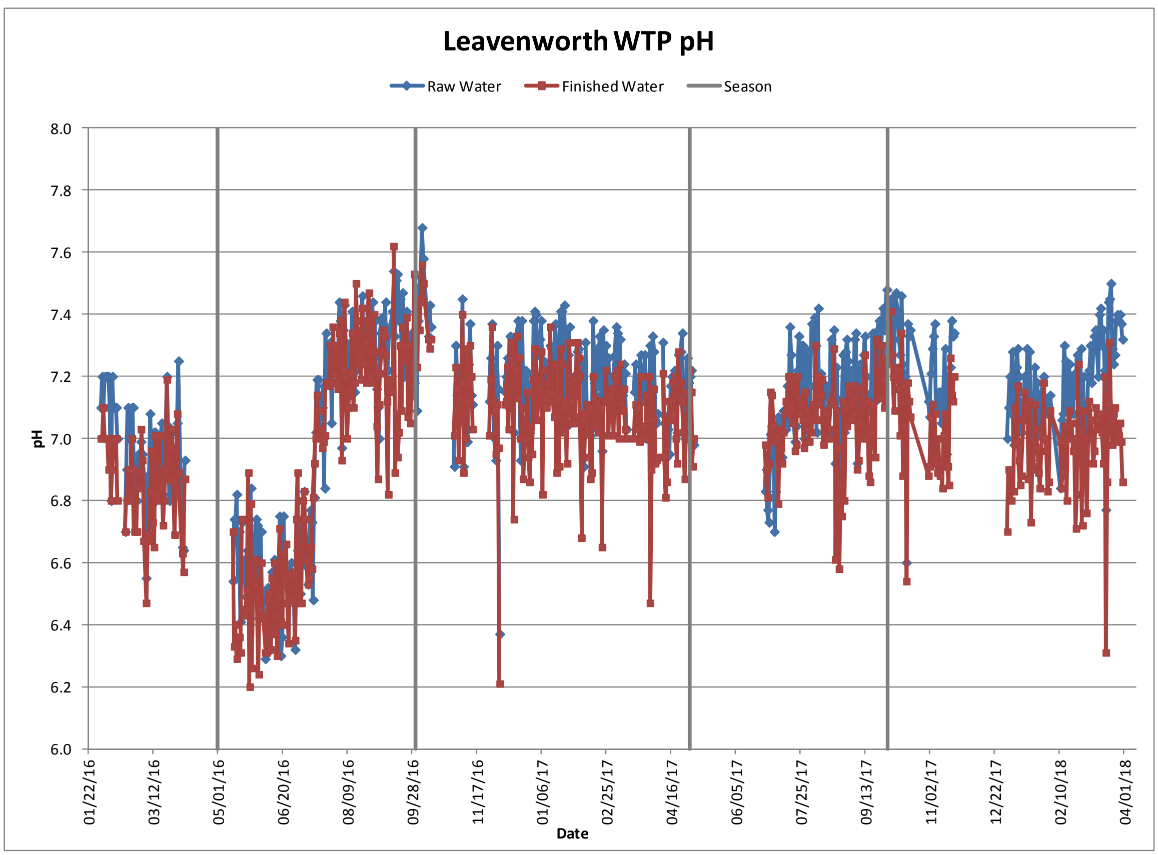

FIGURE 5

Raw Water and Finished Water pH

The typical pH of the raw water fluctuates between 6.9 and 7.2, while the final pH of the finished water ranges from 6.8 to 7.1. Historically, the pH of the finished water is always slightly lower than that of the raw water. This difference may be in part due to the addition of alum or other coagulants, which are known to depress pH relative to the raw water.

Also, there is a significant drop in the pH of both raw and treated water during summer 2016 and there appears to be a slight divergence between the raw and final pH developing in February 2018. The sudden increase in pH in May 2016 is unclear, but may be due to recalibration of the instrumentation, change in sampling technique, or some other operational parameter. It is unlikely that the sudden increase is due to a change in the water quality of Icicle Creek. The divergence that is seen between January 2017 and March 2018 may also be due to drift of the instrumentation, deterioration of standards, sampling techniques, or some other operational parameter. It is unlikely that there is a steady decrease in pH for water from Icicle Creek.

The City should continue to monitor raw and finished water pH to identify long-term trends in this parameter. It is also critical to maintain all instrumentation calibrations and to perform regular cleanings and calibration checks for this equipment. If additional pH values are available, for instance from the City's groundwater sources, it may be interesting and useful to compare these values to the WTP raw/finished water pH to identify trends and to validate the data collected at the WTP.

The pH for Icicle Creek source is within the design range for all methods of filtration and does not pose a significant concern with regard to long-term treatment effectiveness at this point in time.

Alkalinity

Historical raw and finished water alkalinity is summarized in Table 7 and plotted on Figure 6. Data are collected as part of the WTP's normal monitoring parameters. Values are measured at the WTP using standard methods and commercially procured reagents.

TABLE 7

Raw Water and Finished Water Alkalinity Summary

Year	Raw Water			Finished Water		
	Average (mg/L as $CaCO_3$)	Minimum (mg/L as $CaCO_3$)	Maximum (mg/L as $CaCO_3$)	Average (mg/L as $CaCO_3$)	Minimum (mg/L as $CaCO_3$)	Maximum (mg/L as $CaCO_3$)
Winter						
2016	25.0	19.0	29.0	23.2	20.0	28.0
2017	25.8	18.3	33.1	23.9	17.7	29.8
2018	24.9	16.7	30.0	22.6	16.6	28.9
Summer						
2016	19.5	12.0	27.5	18.9	12.0	26.7
2017	21.1	14.0	29.3	20.1	13.7	27.1

(1) Data tabulated from City WTP standard monitoring data files.

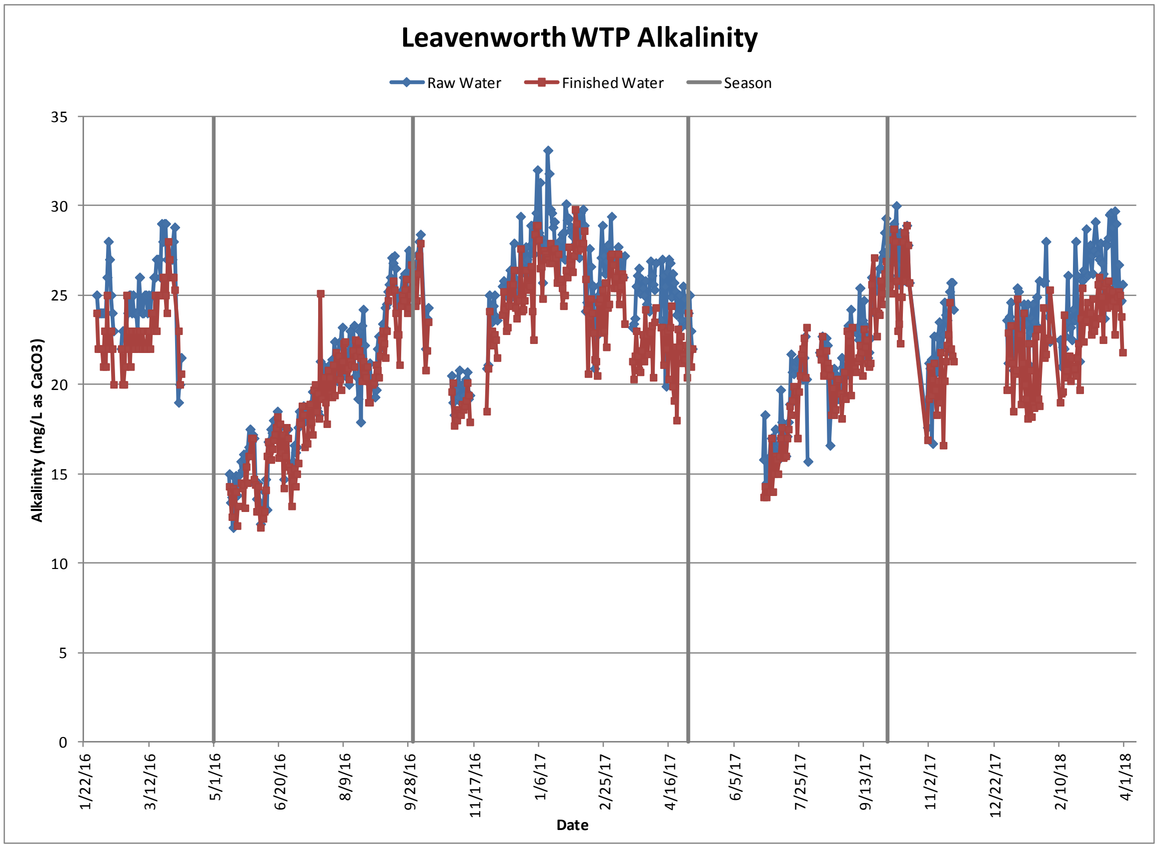

FIGURE 6

Historical Raw and Finished Water Alkalinity

The alkalinity for both raw and treated water varies seasonally with lower values in the spring increasing to higher values in the winter. Alkalinity is generally higher in the raw water than the finished water, likely due to the addition of coagulant. Similar to the pH, there is a drop in both raw and treated alkalinity during spring/summer 2016.

The seemingly cyclical trend in raw water and finished water alkalinity may be due to recalibration of instrumentation or some other operational parameter, but may also be due to changes in the water quality of Icicle Creek. It may also be possible that the additional flux of water from snowmelt during the late winter and early spring months acts to dilute the natural alkalinity of Icicle Creek. As Icicle Creek flows decrease during summer and fall, a similar level of alkalinity in the water would result in a higher concentration – which is shown on Figure 6. Additional data would be necessary to identify this cycling as a trend or an aberration based on only two seasons of data. The City should continue to monitor alkalinity and maintain the measuring devices in good working order to ensure accurate results. Calibration checks from secondary chemicals as well as commercial laboratories may also be useful information. Given this apparent seasonal variation, the WTP should continue to conduct quarterly jar testing in order to optimize coagulant dose rates with alkalinities seen in Icicle Creek.

The range of alkalinities measured between 2016 and 2018 are within the typical range for surface water sources and do not represent a significant issue for water treatment at the WTP.

SUMMARY AND CONCLUSIONS

Based on the water quality data analyzed, the following conclusions were reached:

- Average daily flow and peak hour flow vary seasonally.

  This variation is likely due to warm summer temperatures and increased tourism population during these months.

- Temperature varies seasonally.

  This is a natural occurrence and is due to seasonal air temperatures and the influx of snowmelt in spring.

- Summer months show higher variability (range from minimum to maximum) in treated water volume and peak hour flow.

- Volume of backwash water used to clean the filters has remained fairly consistent.

  WTP capacity may be limited by backwash storage capacity. The existing backwash storage basin does not have the necessary storage volume for multiple backwash sequences, which may be required to successfully treat raw water with higher turbidity seen during spring and fall runoff/rainy periods.

- Finished water turbidity is very consistent.

  The WTP consistently produces water that meets or exceeds the standards listed in WAC 246-290.

- During post-shutdown periods in 2016 and 2017, both pH and alkalinity appear to decrease.

  This may be due to instrumentation, recalibration of equipment, or other operational parameters. It may also be due to the natural seasonal cycling of flows within Icicle Creek that dilute the alkalinity concentrations during periods of high flow.

Table 8 provides a summary of all water quality parameters tabulated within this memorandum. Table 8 also lists typical values for Pacific Northwest surface water source samples which show water quality parameters from Icicle Creek are not unique within Washington and that the creek represents a relatively high-quality source of water. Furthermore, none of the water quality parameters analyzed in this memorandum represent a significant concern for continued treatment at the City's WTP.

TABLE 8

Water Quality Summary and Comparison

Parameter	Typical Surface Water Source	Icicle Creek
Treated Water (gpd)	—	—
Peak Hour Flow (gpm)	—	—
Filter Backwash (gal)	—	—
Raw Water Turbidity (NTU)	0.2–50	0.5
Finished Water Turbidity (NTU)	<0.1	<0.1
Raw Water Temperature (°F)	32–70	32–64
Raw Water pH	6.0–7.8	7.0–7.4
Finished Water pH	6.6–7.4	6.8–7.4
Raw Water Alkalinity (mg/L as $CaCO_3$)	15–70	20–30
Finished Water Alkalinity (mg/L as $CaCO_3$)	15–70	17–27

(1) Data selected from USGS Surface Water Quality Report.

RECOMMENDATIONS

Given the data and conclusions presented above, the efficiency and/or performance of the WTP does not appear to be limited by water quality parameters such as pH, turbidity, temperature, or alkalinity. Furthermore, the WTP consistently meets or exceeds the performance standards listed in WAC 246-290 for water treatment facilities. As such, new treatment technology is not required in order to treat raw water from Icicle Creek.

The WTP does appear to be limited in backwash storage capacity. To successfully remove higher particulate loads experienced during spring and fall rain events which bring high-turbidity raw water to the WTP, additional filter backwashing may be necessary. However, the existing WTP backwash basin does not appear to have the storage and/or handling capacity for the additional volume that would result from additional backwashing. As such, the City should investigate alternatives to develop and/or construct additional backwash storage capacity at the existing WTP. This additional capacity would allow the WTP to store, treat, and discharge a higher volume of backwash water each day, which would increase its ability to successfully treat highly turbid water during spring and fall rain events. With the ability to store and handle additional backwash water, the WTP may be able to increase the daily production as well as eliminate the current extended periods of offline maintenance. In addition to providing additional storage, the WTP should replace a majority of the backwash basin supply pipe, which is in poor condition, and install a flow meter in order to accurately track water used for backwashing. This will also allow the WTP to track the volume of water discharged back to Icicle Creek.

Additionally, we recommend that the City continue to track the water quality parameters summarized above as well as any other parameter of particular interest to establish long-term trends in water quality. These trends could also be used to optimize specific treatment processes or chemicals that the City may wish to utilize in the future. Furthermore, the historical raw water quality parameters summarized as part of this memorandum would not preclude the City from pursuing any specific type of treatment equipment for future modifications/expansions to the treatment process.

Concurrent with this water quality analysis, Gray & Osborne completed an assessment of the City's WTP facilities (*Leavenworth WTP Assessment Report*, Gray & Osborne, Inc., 2018). This WTP Assessment Report offers additional insights on the condition of the existing facilities and provides additional recommendations on how the City might modify, improve, or optimize performance of the treatment process and/or equipment at the WTP.

APPENDIX D

EXPANDED ALTERNATIVES
SUMMARY ANALYSIS TABLE

City of Leavenworth

WTP Assessment and Recommendation Report – WTP Treatment Alternatives Summary Table

Alternative No.	Description	Target Capacity (gpm)	Estimated Project Cost	Advantages	Disadvantages	Additional Consideration	Other Potential Cost Impacts (not included Estimated Project Cost)
1	Status Quo	950	$927,000	• low capital cost • low operational complexity	• low filter capacity • continued deterioration of filter equipment	• minimum to keep the WTP functioning	
2A	Upgrade Existing Equipment	1,400	$2,326,000	• low capital cost • operational familiarity • utilize existing equipment	• cost of ongoing maintenance • continued deterioration of filter equipment • must avoid spring/fall high turbidity		• May need to upgrade distribution system piping for increased flows
2B	Upgrade Existing Equipment	2,800	$4,001,000	• low capital cost • higher filtration capacity • operational familiarity • utilize existing equipment	• additional optimization testing required • uncertain final filter capacity • must avoid spring/fall high turbidity	• CAC for coagulation/flocculation	• Need to upgrade distribution system piping for increased flows
3A	New Rapid Rate Filtration Equipment	1,400	$6,069,000	• operational familiarity • can be used year-round	• loss of work/storage space • building expansion required	• New building	• May need to upgrade distribution system piping for increased flows
3B	New Rapid Rate Filtration Equipment	2,800	$7,137,000	• higher filtration capacity • operational familiarity • can be used year-round	• high capital cost • building expansion required • loss of work/storage space	• New building	• Need to upgrade distribution system piping for increased flows
4A	New Membrane Filtration Equipment	1,400	$7,653,000	• utilize existing filter cells • can be used year-round	• high capital cost • high operational cost • increased operational complexity	• Reuse building • Additional pumping	• May need to upgrade distribution system piping for increased flows
4B	New Membrane Filtration Equipment	2,800	$9,873,000	• higher filtration capacity • utilize existing filter cells • can be used year-round	• high capital cost • high operational cost • increased operational complexity	• Reuse building • Additional pumping	• Need to upgrade distribution system piping for increased flows
5	New WTP Facility	3,600	$10,541,000	• higher filtration capacity • utilize new technology and equipment • can be used year-round	• highest capital cost • would require new site, permitting		• Need to upgrade distribution system piping for increased flows
6	Additional groundwater wells	4,650	$3,468,000	• low capital cost • reduced operational cost • reduced staffing requirements • low operational complexity	• decreased source redundancy • must pump to serve upper Icicle Creek Road • difficulty in transferring water rights	• New well at alternate location • New booster station	• Replace or upgrade distribution system piping to maintain service/fireflow to existing customers on Icicle/East Leavenworth • Should not require improvements to intake screen and piping