CHAPTER 2
HISTORICAL PLANT PERFORMANCE

Introduction

Historic operating data for the Grants Pass WTP are reviewed and analyzed in this chapter. The purpose of this data review is to evaluate the existing WTP processes for capacity, operational efficiency, and regulatory compliance. Data collected and reviewed from 2004 to 2011, the period after completion of the 2004 WTPFP, included: plant flow and production information; selected raw, finished and distribution system water quality parameters; basin performance; chemical usage data; and overall filter performance indicators. As highlighted in Chapter 1, a number of recommended improvements in the 2004 WTPFP have been completed at the plant and have had a beneficial impact on plant performance.

Water Treatment Plant Production

The Grants Pass WTP measures and records raw and finished water flows through the plant on a daily basis. Raw water flow is measured using a differential pressure type (Venturi) flow meter located on the influent line prior to chemical addition. Finished water flow is measured using a Venturi flow meter located on the WTP effluent line just downstream of the HSPS. Filter backwash flow is measured in the backwash supply line. FTW flows are discharged upstream of the filter effluent flow meters, and therefore have not been historically measured or recorded since the installation of the FTW line in 1997. The duration of FTW after filters are backwashed usually only lasts for a few minutes and has limited impact on overall plant flow and performance.

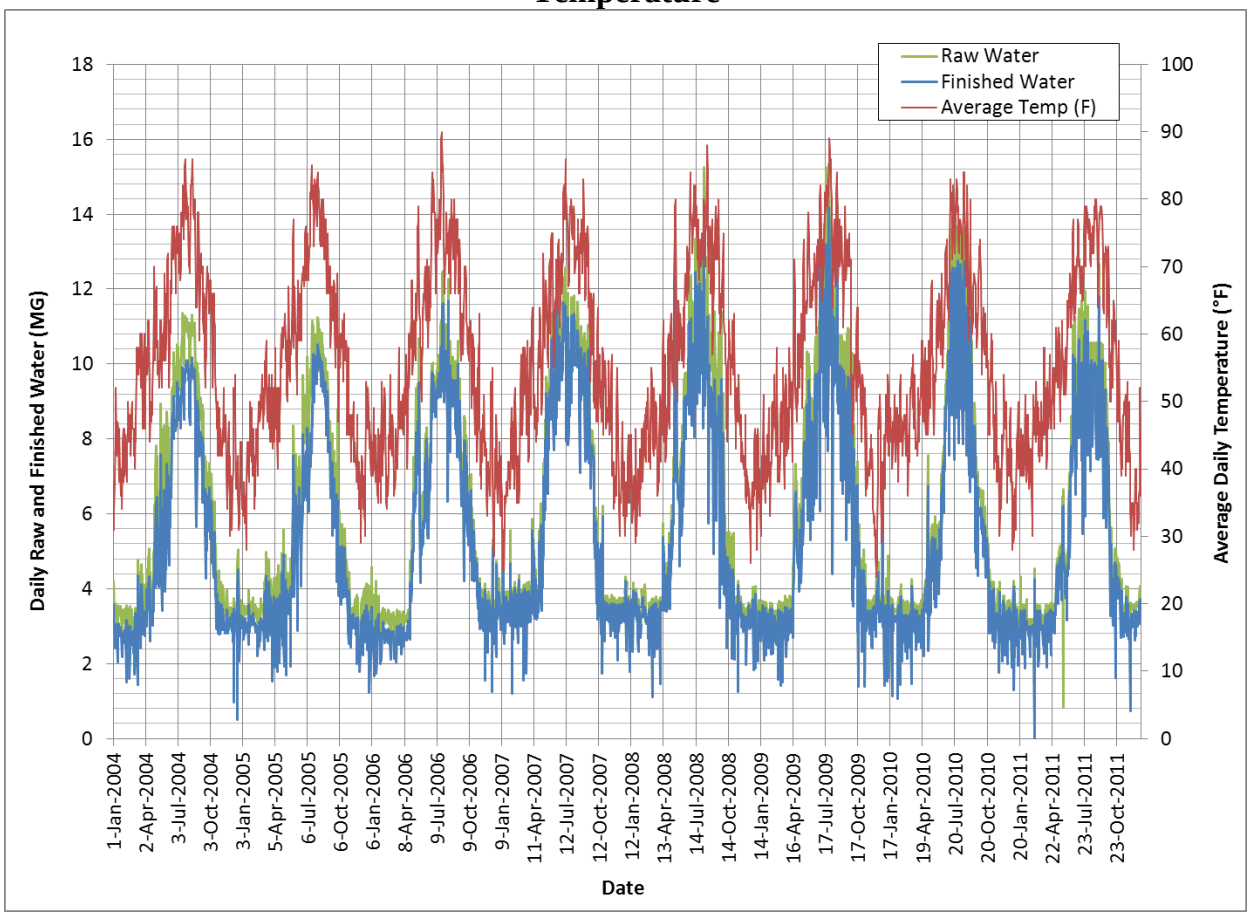
The 2004 WTPFP noted an increase of approximately 3 percent of recorded values for raw and finished water flow rates between 2001 and 2002, attributing the increase to installation of the new SCADA system. The plant staff was of the opinion that the old signal converters may have inadvertently dampened the flow signal, causing the measured flow rate to be as much as 10 percent less than the actual flow rate. There was an observed steady increase in annual average production as measured by the WTP effluent plant flow from 1999 to 2003. The trend of increased production has generally continued from 2004 to 2011.

Figure 2-1 presents the historic average daily raw water volume and finished water production from January 2004 to December 2011. Table 2-1 presents a summary of the plant production data including: annual average flow, average peak and off-season flow, minimum and maximum monthly average flows, maximum weekly average flows, and peak day flows. The City has been experiencing increasing water demands over the past decade. Average day production increased approximately 2 percent per year from 2004 to 2009. Demand in 2010 and 2011 decreased to 2004 levels, but this may have been due to mild summers and a depressed economy, and it is not anticipated that this trend will continue. The peak day production in 2012 of 13.6 mgd occurred on August 8. The summer of 2012 was drier and

warmer compared to the summers of 2010 and 2011. Figure 2-1 highlights that 2010 and 2011 did not experience the peaks in water temperature that prior years have experienced.

A maximum day production from the Grants Pass WTP of 14.2 mgd was observed on July 28, 2009. The highest average maximum monthly production of 10.5 mgd was observed in July 2010. Figure 2-2 displays the maximum daily operating rate of the plant from 2004 to 2011. Increasing demands can most likely be attributed to steady growth in the service area.

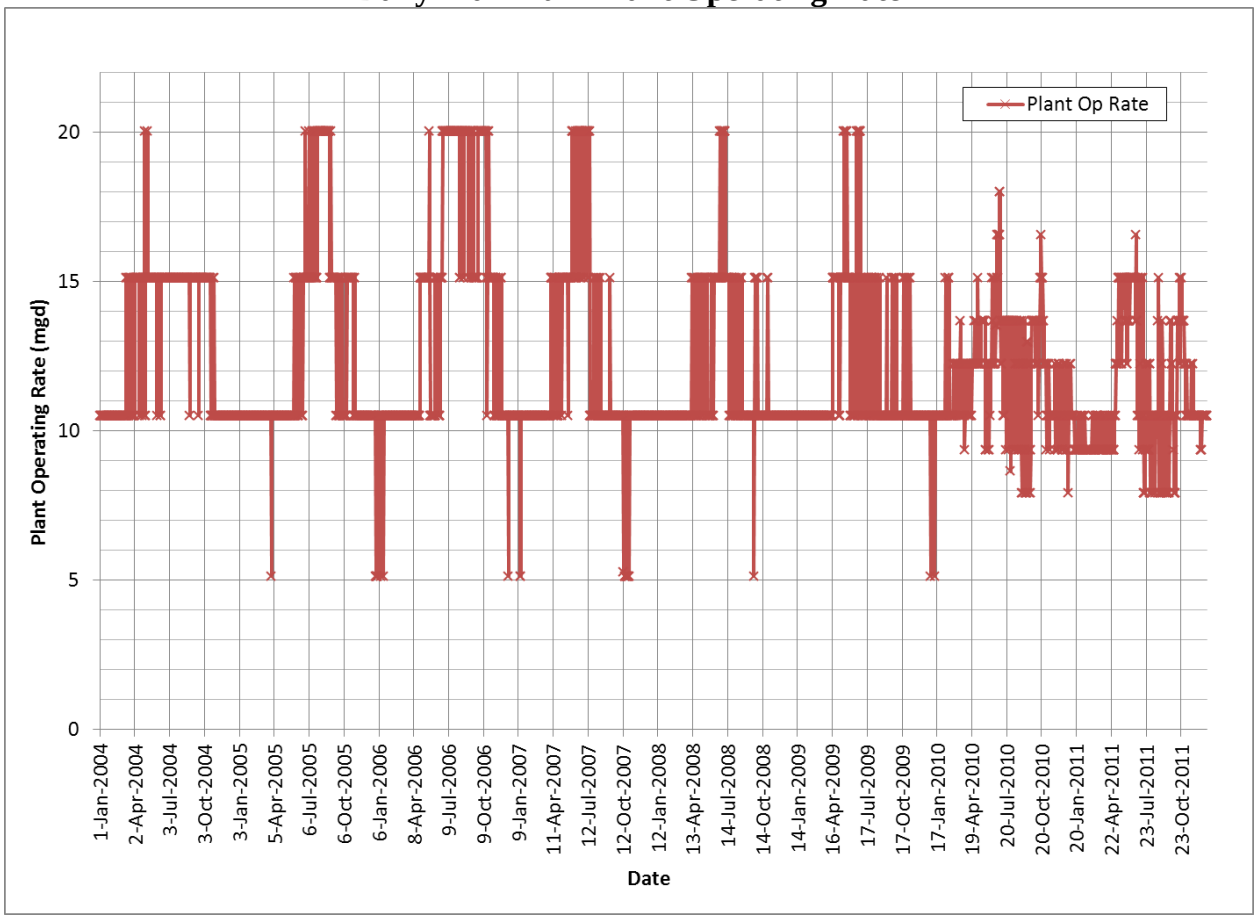
Figure 2-1
Historical Raw Water Intake and Finished Water Production and Average Daily Water Temperature



The flow data presented in Table 2-1 was used to develop peaking factors that are useful in water supply planning. The primary peaking factor is the ratio of peak day flow to annual average flow; this value ranged between 2.0 occurring in 2004 and 2007 to 2.5 occurring in 2009. Another important peaking factor is the ratio of peak month flow to annual average flow. For Grants Pass, this value ranged from 1.7 in 2007 to 2.0 in 2010. These values are consistent with those used for demand forecasting in the City's most-recent Water Distribution System Master Plan, where peaking factors of 2.2 and 1.8 were used for the peak day and peak month flows, respectively. This is in agreement with other recent studies on systems in the Pacific Northwest where maximum day peaking factors typically varied

from approximately 2.0 to 2.5. The peaking factors for the City system are consistent with these regional numbers.

Figure 2-2
Daily Maximum Plant Operating Rate



Typical Operations

The WTP operates in a daily start-and-stop mode for most of the year to minimize labor costs. The plant currently has 5 FTEs and uses seasonal employees when needed for a total of 6.0 to 6.5 FTEs on an annual basis. During the winter months, the plant is able to meet demands by typically running at 10.5 mgd for 8 hours per day. During the spring and fall, the plant historically ran at 10.5 mgd or 15.1 mgd for 8 to 12 hours per day. During the summer, the plant has run at the15.1 mgd or 20 mgd flow rate for 12 to 16 hours per day. The plant switched to 24 hour per day summer operations starting in 2007 at reduced flow rates. After the raw water pumps were equipped with VFDs in 2010, the plant has had more operational flexibility with respect to flow rates.

Table 2-1
Water Treatment Plant Production Summary[1]

Year		Flow (mgd)							
		2004	2005	2006	2007	2008	2009	2010	2011
Annual Average		5.0	4.8	5.3	5.8	5.5	5.6	5.2	5.0
Peak Season Average[2]		8.1	7.6	8.4	9.4	9.0	9.1	8.6	8.3
Off-Season Average[3]		3.4	3.3	3.7	4.0	3.8	3.8	3.4	3.3
Minimum Monthly Average	**Month**	Feb	Dec	Jan	Nov	Mar	Jan	Dec	Mar
	Flow	2.6	2.7	2.7	3.3	3.1	2.9	3.0	2.9
Maximum Monthly Average	**Month**	Jul	Aug	Jul	Jul	Jul	Jul	Jul	Aug
	Flow	9.3	9.6	9.6	10.1	10.	10.3	10.5	9.4
Maximum Weekly Average	**Week**	8/12-8/18	8/5-8/11	7/22-7/28	7/1-7/7	7/15-7/21	7/29-8/4	8/12-8/18	9/2-9/8
	Flow	9.9	10.0	10.2	11.1	10.8	11.2	11.5	9.5
Maximum Daily	**Date**	8/12	8/5	8/10	6/15	8/6	7/28	7/28	9/3
	Flow	10.2	10.5	11.7	11.9	13.9	14.2	12.8	11.8

Notes
1. Values as reported from plant effluent meter
2. Peak season average from June to September
3. Off-season average from January to May and October to December
4. From 1999 to 2003: Average day demand of 4.7 mgd, peak day demand of 10.5 mgd

Raw Water Quality

Five raw water quality parameters were analyzed as part of this review:

- turbidity,
- temperature,
- pH,
- alkalinity, and
- TOC.

These parameters are typically of most importance when evaluating a treatment plant's overall performance. A discussion of each of these parameters is presented as part of this section.

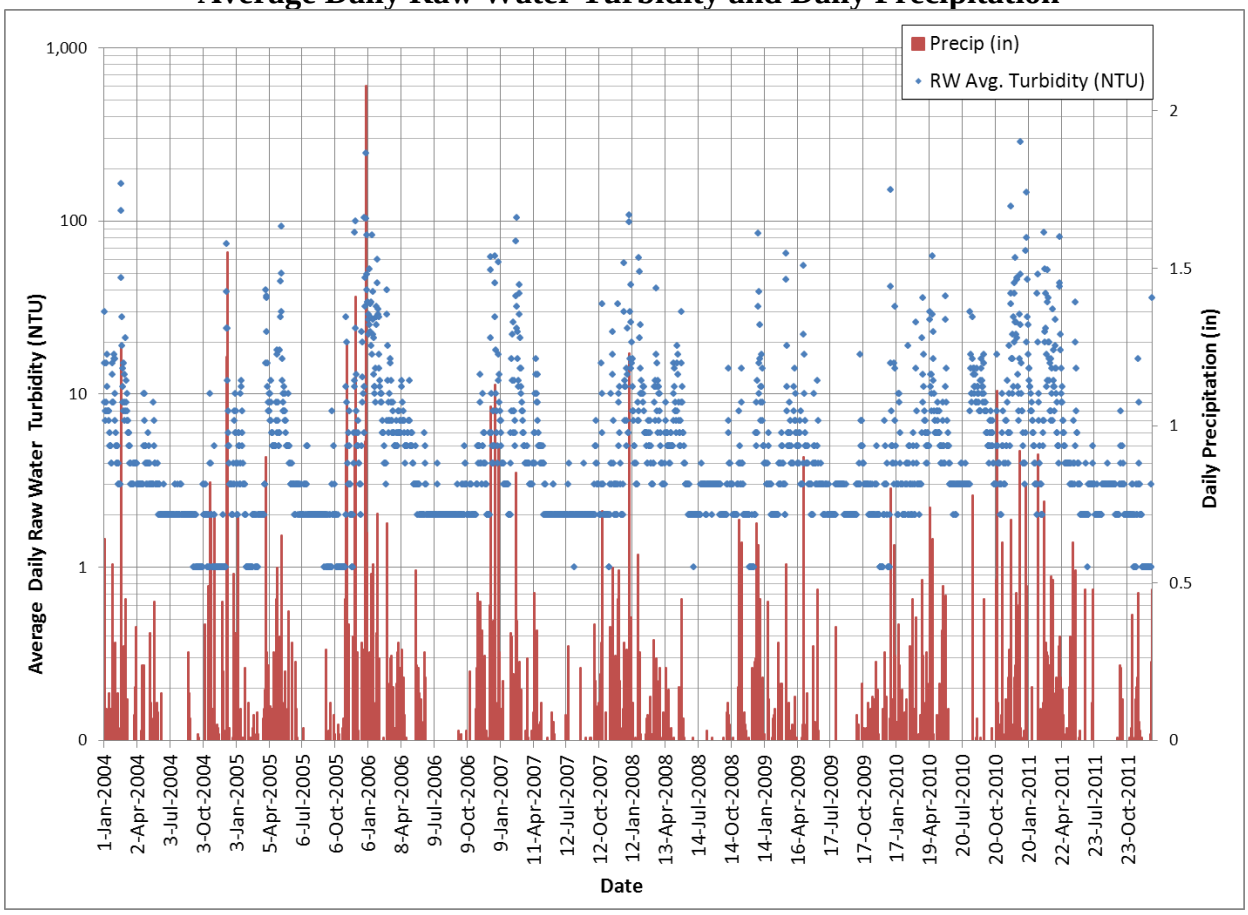
Turbidity

Turbidity is a measure of light penetration through a water sample and is indicative of the amount of particulate matter in the sample. It is measured in nephelometric turbidity units, or NTUs. Water with lower turbidity is typically easier to treat and usually requires lower chemical doses for optimum coagulation and filtration. High turbidity levels can reduce the

effectiveness of disinfection treatment processes and can provide a medium for the growth of microorganisms.

The raw water turbidity from the Rogue River has historically been low and moderately variable during the majority of the year. Increases in raw water turbidity generally correspond to high rainfall events. Figure 2-3 presents the average daily raw water turbidity, as well as the observed daily precipitation, between January 2004 and December 2011. The lowest turbidity periods occur during the warmer, drier months and the highest turbidity periods occur during the wet weather months.

Figure 2-3
Average Daily Raw Water Turbidity and Daily Precipitation



Average turbidities were generally less than 6 NTU from May to October; minimum turbidities were as low as 1.0 NTU during these months. Between November and April, turbidities typically averaged 9 NTU, with average maximums approaching 200 NTU. The highest average day raw water turbidity was reached in December 2010 when a daily average turbidity value of 286 NTU was observed in the raw water. A daily maximum turbidity spike of 787 NTU was observed in December 2005.

During the past few years, the WTP has experienced less predictable turbidity trends and the turbidity values have been more variable than they were in the past twenty years. This is attributed to the removal of the Gold Ray Dam, located on the Rogue River upstream of the WTP raw water intake, which began in the summer of 2010. Especially notable was the coffer dam failure in August 2010 that caused a breach in the dam. The plant experienced turbidity spikes of over 100 NTU; the August average turbidity is usually around 3 NTU. Since dam removal, the plant staff has noticed an increase of sediment accumulation on the base of the raw water intake screens, and has had to modify cleaning operations. The volume of solids that collect in the sedimentation basins has also increased, resulting in higher volumes of solids that needed to be handled and dewatered at the plant. The effects of the dam removal are not expected to be long-term, but it is currently unknown what effects the dam removal will have on turbidity and plant operations in the future.

Temperature

The temperature of raw water impacts water treatment by affecting the rate of chemical reactions, including disinfection and the formation of disinfection byproducts, floc formation and settling, and filter performance. As the temperature of the raw water increases, chemical doses generally decrease for floc formation, settling, filtration, and disinfection. An increase in optimal filter backwash rates results from an increase in water temperature due to the decreased viscosity of the warmer water.

Figure 2-4 shows that the maximum daily temperature of the raw water entering the WTP varies by season. From 2004 to 2011, winter temperatures averaged approximately 43.7 °F (6.5 °C) and summer temperatures averaged approximately 63.6 °F (17.6 °C). The lowest observed temperature in the time period was 33.3 °F (0.7 °C) on December 9, 2009. The highest observed temperature in the time period was 70.0 °F (21.1 °C), occurring on July 22, 23, and 24, 2004. Temperatures of 69.7 °F (20.9 °C) were also observed on July 24 and 25, 2010.

Raw Water pH

The acidic or basic nature of water is measured by pH and can be indicative of the water's corrosiveness. A pH of 7.0 represents neutral conditions, and pH values greater than 7.0 are generally considered less corrosive. Lower pH values usually indicate corrosiveness, which can lead to leaching of toxic metals into the water system and potential degradation of conveyance facilities. In water treatment, pH is also important because of its impacts on coagulation performance and chemical disinfection. A pH in the range of 6.0 to 7.0 is considered optimum for aluminum sulfate (alum) coagulation, and lower pH values are often desirable to enhance the removal of dissolved organic carbon. Lower pH values are often desirable for enhanced disinfection with chlorine. The formation of DBPs such as THMs and haloacetic acids is affected by the pH of the water during and following chlorination.

In plants lacking the ability to adjust pH at several points throughout the treatment process, corrosion control targets typically govern the pH, with perhaps some sacrifice in coagulation

and disinfection performance. The addition of certain water treatment chemicals alters the pH. Aluminum sulfate depresses the pH, while NaOCl increases the pH.

Figure 2-4
Maximum Daily Raw Water Temperature

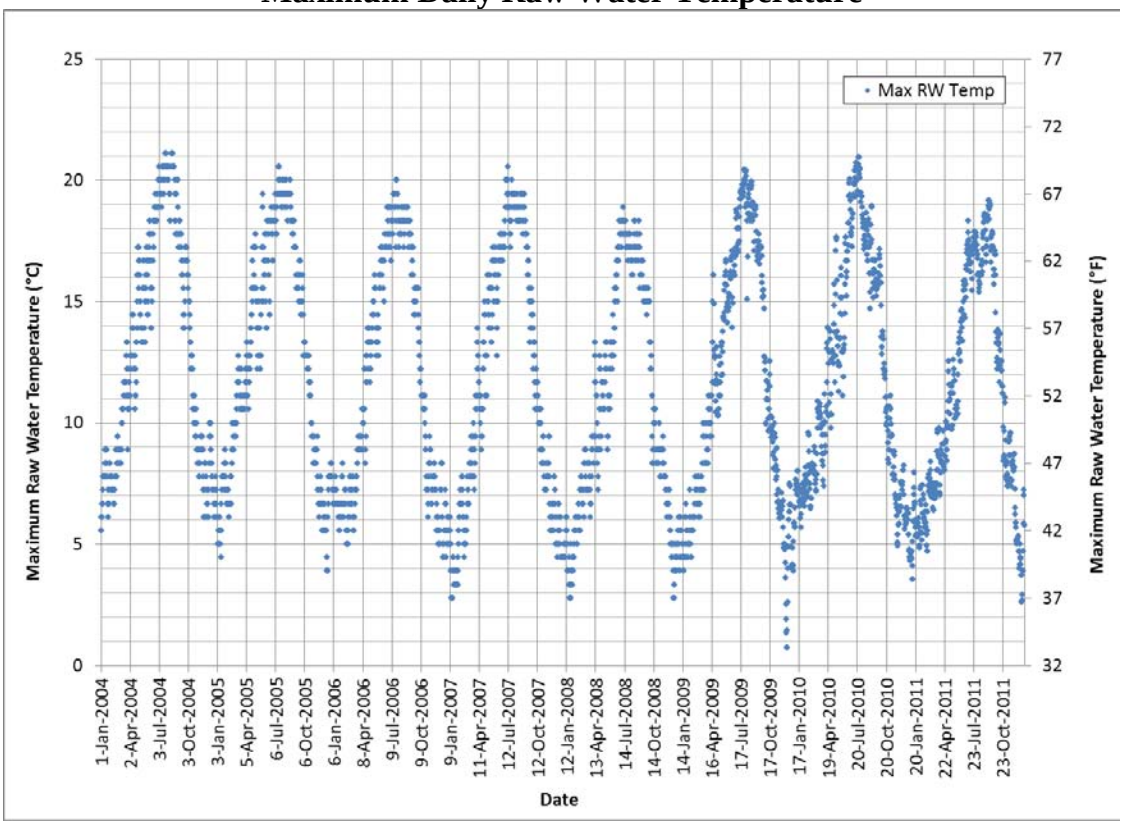


Figure 2-5 presents the historical raw water pH values recorded at the WTP between January 2004 and December 2011. As shown in Figure 2-5, the pH of the raw water from the river typically varies between 7.4 and 8.3 throughout the year, with average values between 7.6 and 8.0. Historically, pH peaks a few times each calendar year with the most pronounced peak occurring in mid-spring and a secondary peak occurring in the early fall, probably corresponding to algal activity in the river. Historic minimums occur in the winter months due to higher precipitation. The lowest observed raw water pH was 7.3 in December 2006. The highest observed pH was 8.6 in March 2005. Raw water pH can also be affected by algae throughout the summer, with diurnal variations between 7.5 and 8.5.

Figure 2-6 shows the historical finished water pH values recorded at the WTP between January 2004 and December 2011. Finished water pH has increased from 2007 to 2011 due to the reduction of alum usage and use of a new primary coagulant. The reduction in alum

Figure 2-5
Average Daily Raw Water pH

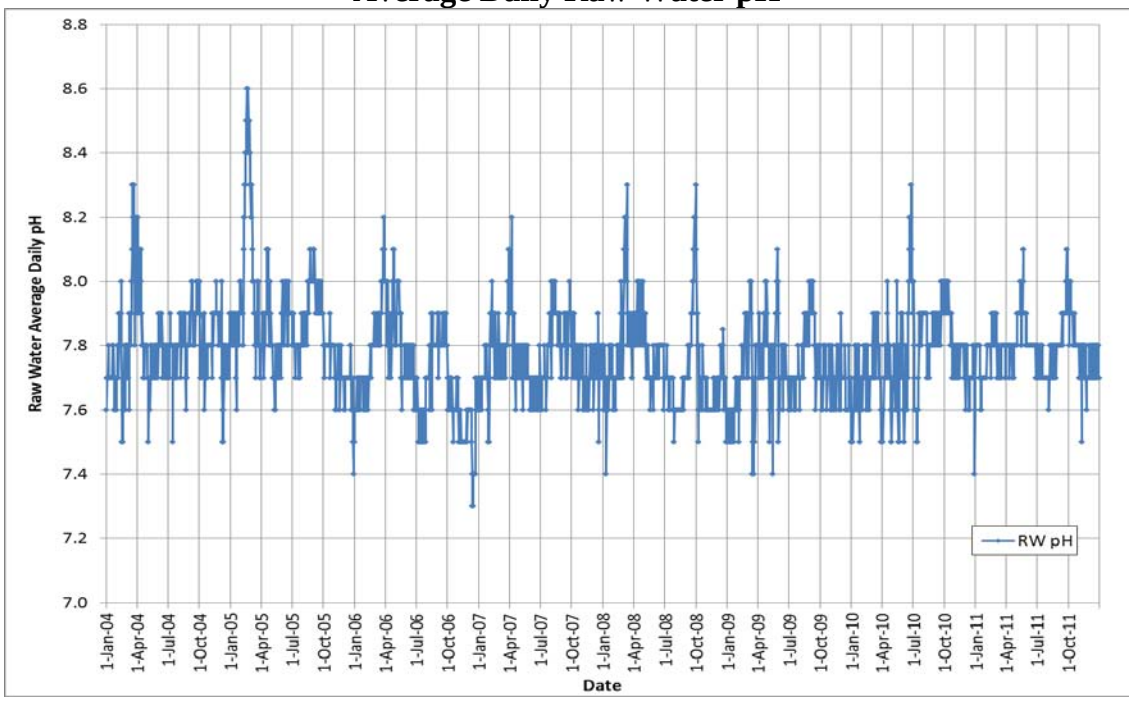
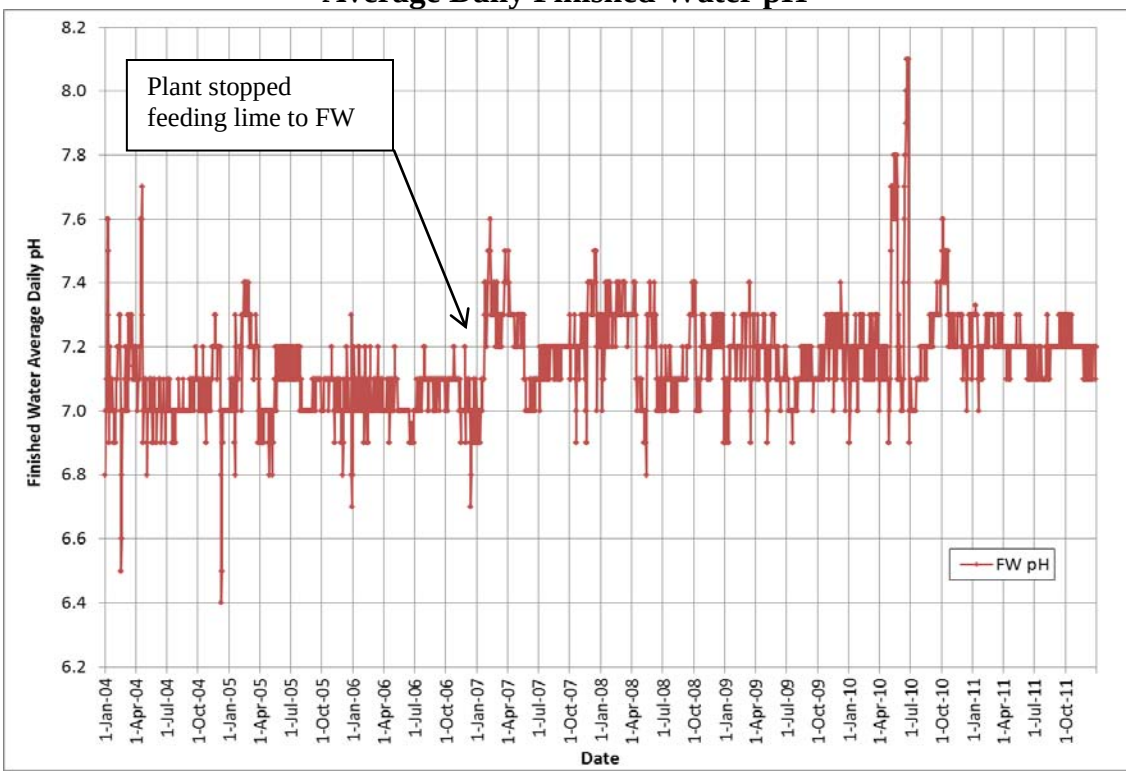


Figure 2-6
Average Daily Finished Water pH



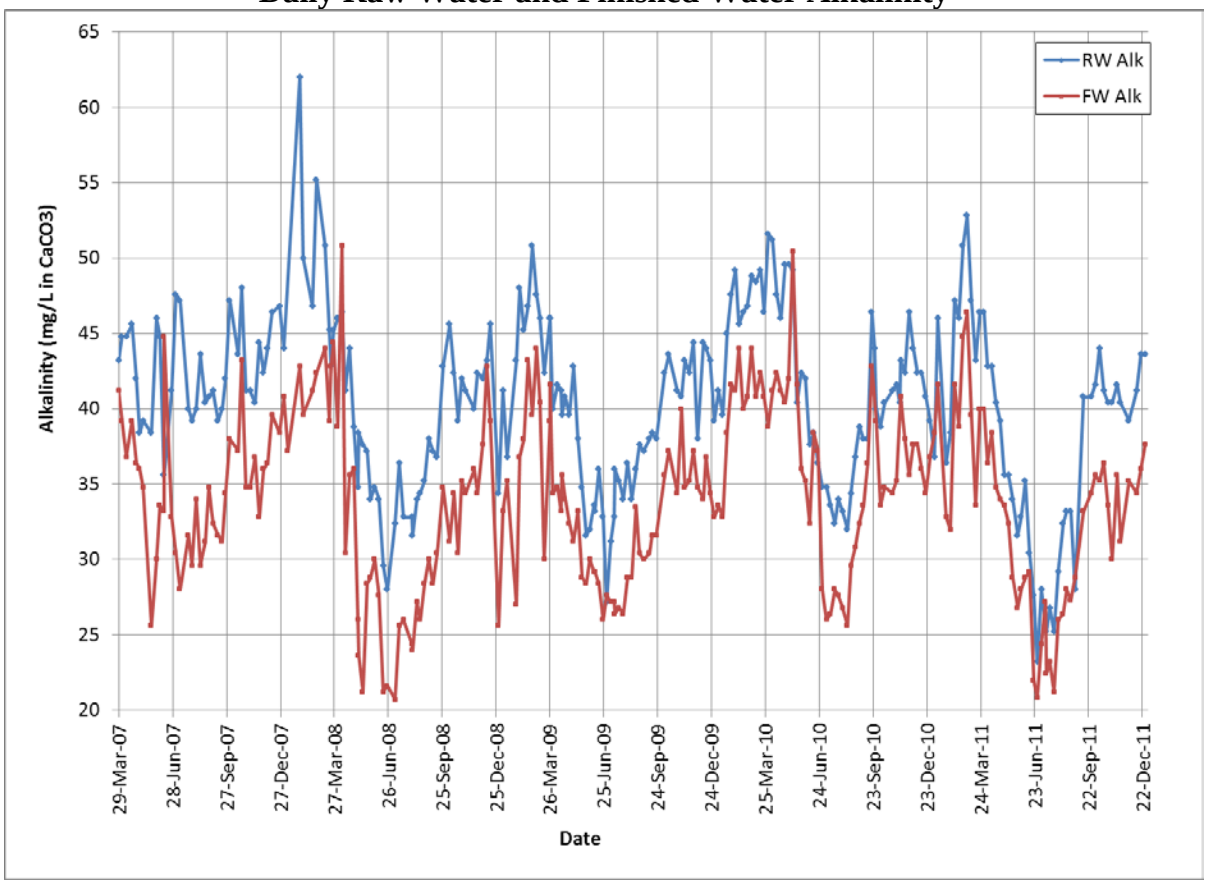
usage influenced the staff's decision to remove the lime system since post-filter pH adjustment is no longer practiced.

Alkalinity

Alkalinity is important in water treatment because of its impact on pH stability, coagulation performance, and corrosiveness. Alkalinity greater than 20 mg/L as $CaCO_3$ is generally considered adequate for aluminum sulfate coagulation and for improved pH stability in the distribution system. Alkalinity can also impact TOC removal requirements, depending on raw water organic concentrations.

The raw water alkalinity of Rogue River water varies seasonally as depicted in Figure 2-7, and seasonal trends seem to follow pH variability. The raw water alkalinity can be as low as 20 mg/L during winter periods and can be as high as 62 mg/L during the summer. When the alkalinity is low and turbidities are high, higher alum doses are required which can further depress the pH below optimum coagulation conditions. Using a coagulant which does not depress the pH or affect alkalinity during periods when the raw water turbidity is increased has eliminated the need to add an alkali to the raw water. Figure 2-7 also shows that finished water alkalinity is lower than the raw water alkalinity.

Figure 2-7
Daily Raw Water and Finished Water Alkalinity



Organic Content

The natural level of organic matter in the raw water can affect its treatability as well as other parameters, including chlorine demand, DBP formation, and tastes and odors. Organic content can be derived from the natural decay of plant life, as in humic and fulvic acids, or the presence of algae, or in some cases, from human activities. As the concentration of organic matter in the raw water increases, the need for chemicals such as alum and chlorine also typically increases. Since DBPs result from chlorine's reaction with organic matter, higher concentrations of organic matter in raw water usually result in higher levels of DBPs in the distribution system. Elevated algae concentrations can sometimes create difficult treatment conditions and can interfere with coagulation, cause filter clogging, or create nuisance tastes and odors, depending upon the type and concentration of the algae.

Total organic carbon is a general measure of the natural organic matter present in water. This parameter is sometimes used as an indicator of DBP formation potential. Total organic carbon is also important because existing regulations intended to minimize DBP formation require the removal of a fraction of the overall raw water TOC through the treatment process, depending on the raw water TOC concentration and alkalinity.

The Grants Pass WTP staff has been monitoring TOC concentrations in the raw and finished water at least monthly since 2002. Results from 2004 to 2010 are presented in Figure 2-8. The data suggest that the TOC concentrations in the raw water are comparable to other U.S. surface water supplies, typically ranging between 0.5 to 5 mg/L, and slightly higher than other similar Pacific Northwest surface water supplies, which often range between 1.0 to 3.0 mg/L. There were several samples prior to 2008 that were above 2.0 mg/L, the current "trigger" concentration for TOC removal requirements under existing regulations. Since 2008, there have only been four such instances. Further discussion of required TOC removal efficiencies and other regulatory issues associated with TOC are discussed in Chapter 3.

Because TOC analysis is expensive and labor-intensive, the 2004 WTPFP recommended the City consider purchasing a bench-top UV spectrophotometer and incorporating daily UV absorbance monitoring at the WTP as a surrogate measure for TOC. Dissolved and soluble organic carbon absorbs UV light at a wavelength of 254 nm. A spectrophotometer measures the percentage of UV absorbance, a value directly proportional to TOC concentration. Once calibrated, UV_{254} readings can be correlated to TOC concentrations. UV_{254} sampling is a relatively inexpensive and simple alternative to off-site lab analysis of TOC. The plant began recording UV_{254} in July 2004. For comparison, Figure 2-9 displays raw water TOC and UV_{254} readings.

Taste and Odor

The Grants Pass WTP does not typically experience significant taste and odor issues. Typically, WTPs that use the same source water have similar taste and odor characteristics. However, the taste and odor events related to algae that occur at the Medford Water Commission WTP upstream rarely occur at the Grants Pass WTP.

Figure 2-8
Raw Water and Finished Water Total Organic Carbon

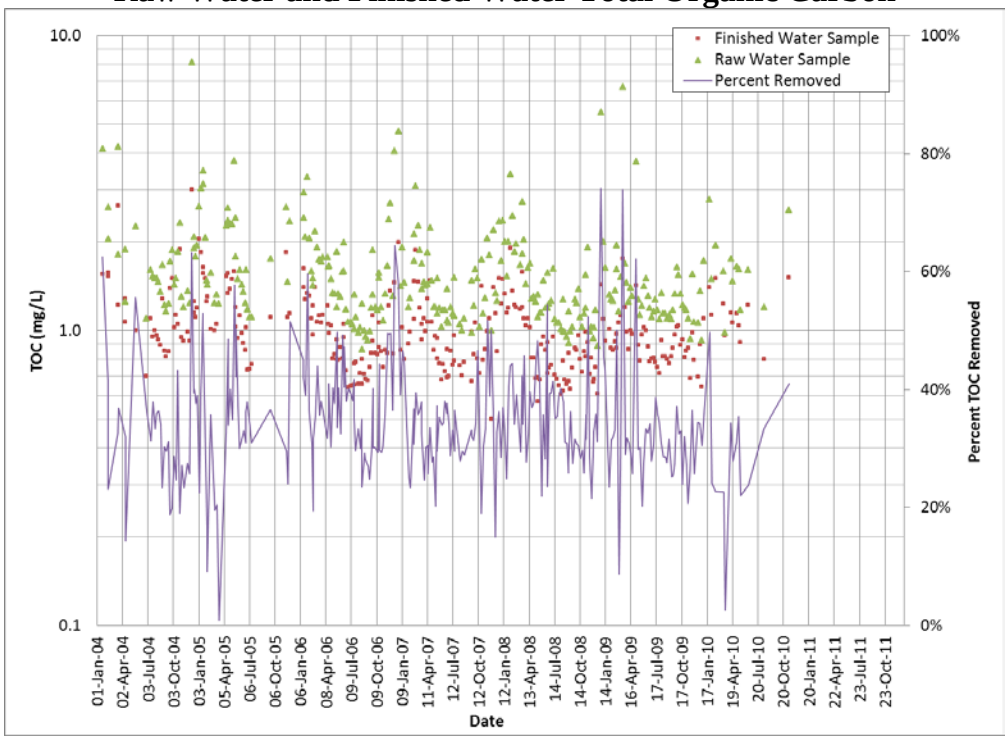
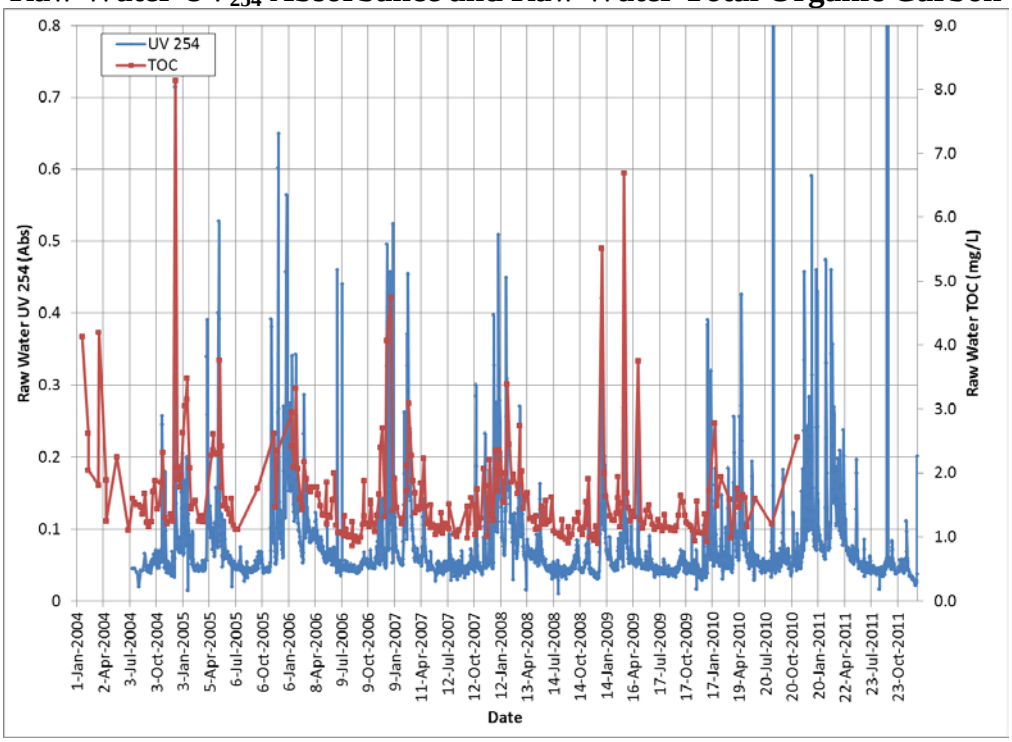


Figure 2-9
Raw Water UV_{254} Absorbance and Raw Water Total Organic Carbon



Chemical Usage

The four major chemicals currently used at the Grants Pass WTP are:

- alum
- ACH,
- filter aid polymer, and
- liquid sodium hypochlorite.

Liquid alum and ACH are used as the coagulants and are fed year-round. The polymer is used to condition the water entering the filters for improved filter performance. Sodium hypochlorite is added to the raw water and finished water as a disinfectant. Hydrated lime and potassium permanganate are chemicals that were used in the past. As noted above, lime use has been discontinued, and potassium permanganate is used infrequently. A brief discussion of each chemical is presented as part of this section.

Aluminum Sulfate

Liquid alum is stored as a 50 percent solution, by weight, and fed via metering pump to the raw water pipeline upstream of the static mixer prior to the flow split to the basins. The addition of alum to the raw water destabilizes negatively charged suspended particles, thereby allowing the formation of insoluble floc particles via coagulation and flocculation, and their subsequent removal via clarification and filtration.

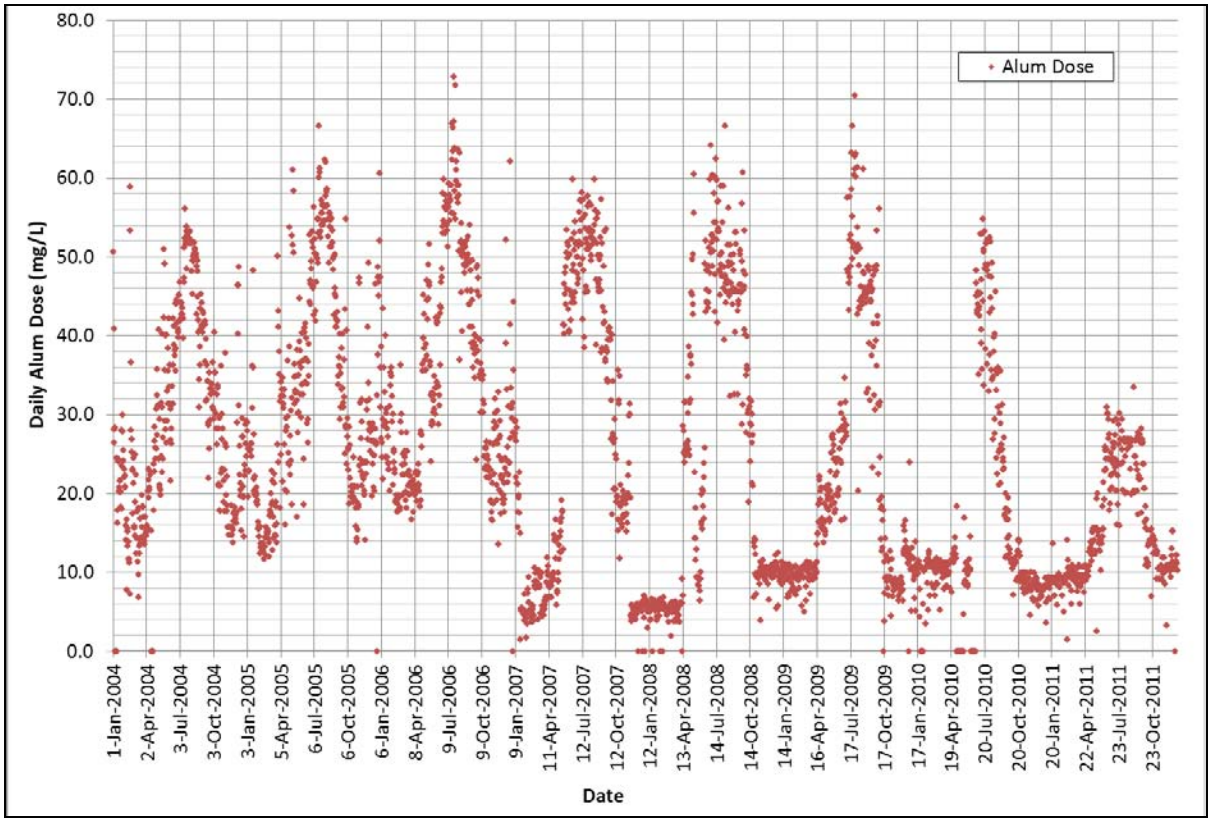
Figure 2-10 shows the annual trends in alum usage between January 2004 and December 2011. The required alum dose varies throughout the year. From 2004 to 2006, when alum was the sole coagulant used, the typical off-peak season alum doses averaged 27 mg/L as dry alum while peak season alum doses averaged 21 to 22 mg/L as dry alum. The highest alum doses have typically been above 60 mg/L as dry alum during fall and winter because of high turbidity events. The plant used an average of 200 tons of alum per year from 2004 to 2006. In response to the 2004 WTPFP, the plant staff began experimenting with different coagulants (ACH and PACl) and started using these other coagulants with alum intermittently from 2007 to 2008. Starting in the fall of 2009, the plant began feeding alum and ACH concurrently. In all cases, use of an additional coagulant has been able to reduce alum dosages and multiple benefits have been observed including less pH depression and lower solids production rates. In addition, the plant was able to stop feeding lime for pH adjustment. Filter performance may also be enhanced by the current coagulation process as the floc formed is generally stronger and has a higher shear resistance within filter media. Alum usage from 2010 and 2011 averaged 93 tons per year.

Other Coagulants

ACH and PACl are generic terms used to describe different formulations of proprietary coagulants that are derivatives of the general base molecular formula of an aluminum

chlorohydrate molecule. These proprietary formulations vary in strength, pH, basicity, freezing point, and specific gravity. ACH and PACl offer many benefits to optimizing coagulation strategies. They do not depress pH like alum and, as a result, reduce the need of an alkali addition to adjust the pH.

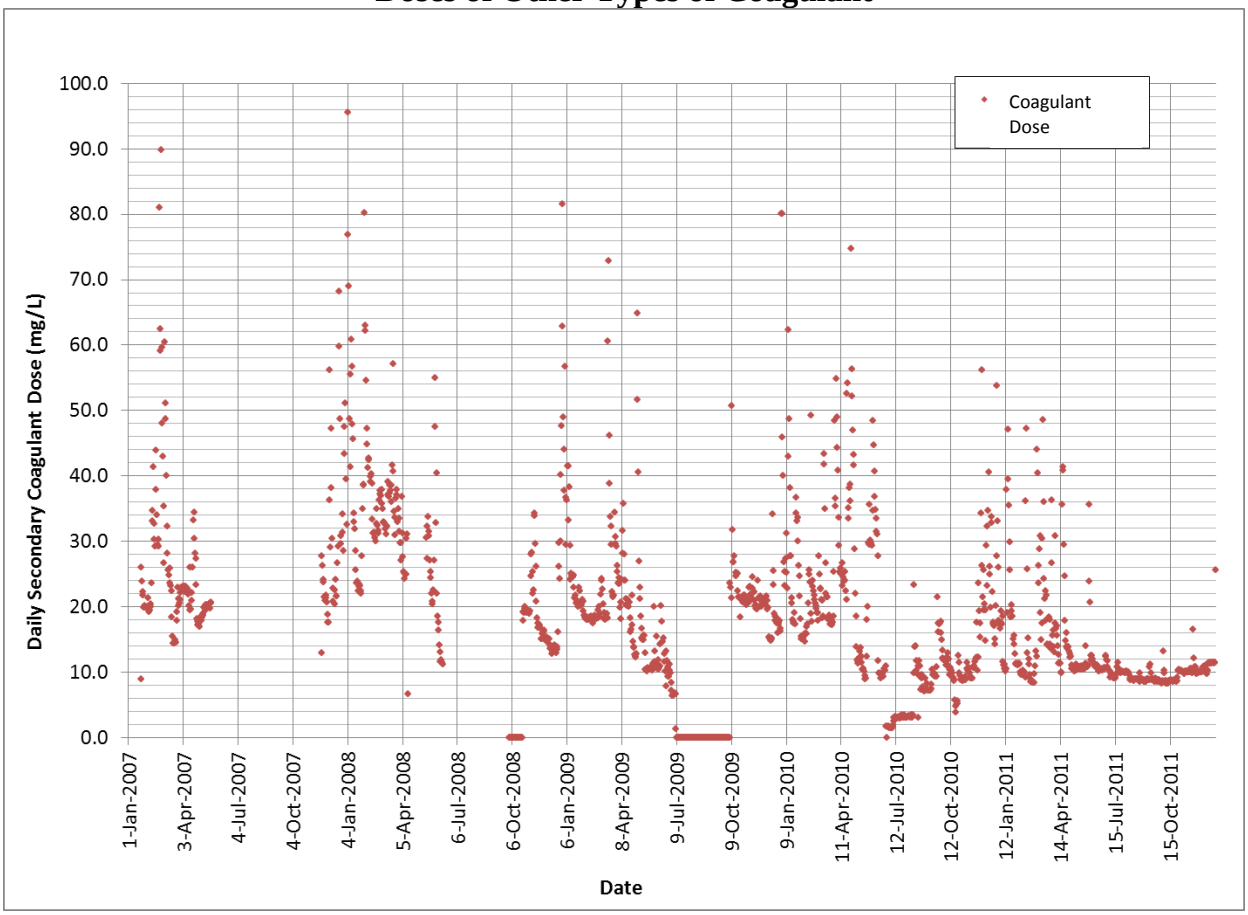
Figure 2-10
Alum Doses



From 2007 to 2008, the plant tested Pass-C, a PACl derivative, in conjunction with alum during different seasons. Except for one week in January 2010 when the plant tested NIAD I-5, another PACl derivative, as the sole coagulant, the plant began feeding an additional coagulant with alum during daily operations in the fall of 2008. In May 2010, the plant switched from Pass-C to T-Floc B-135, a derivative of ACH. Since that time, the plant has transitioned from using alum as its primary coagulant to ACH as its primary coagulant. Alum is now used as a supplementary coagulant.

Use of ACH as a primary coagulant has reduced alum usage at the City's WTP. Because of this, a tank which was formerly used to store alum is now used to store ACH in bulk. A separate metering pump doses ACH to the injection location. Figure 2-11 shows doses of coagulants other than alum from 2007 to 2011.

Figure 2-11
Doses of Other Types of Coagulant



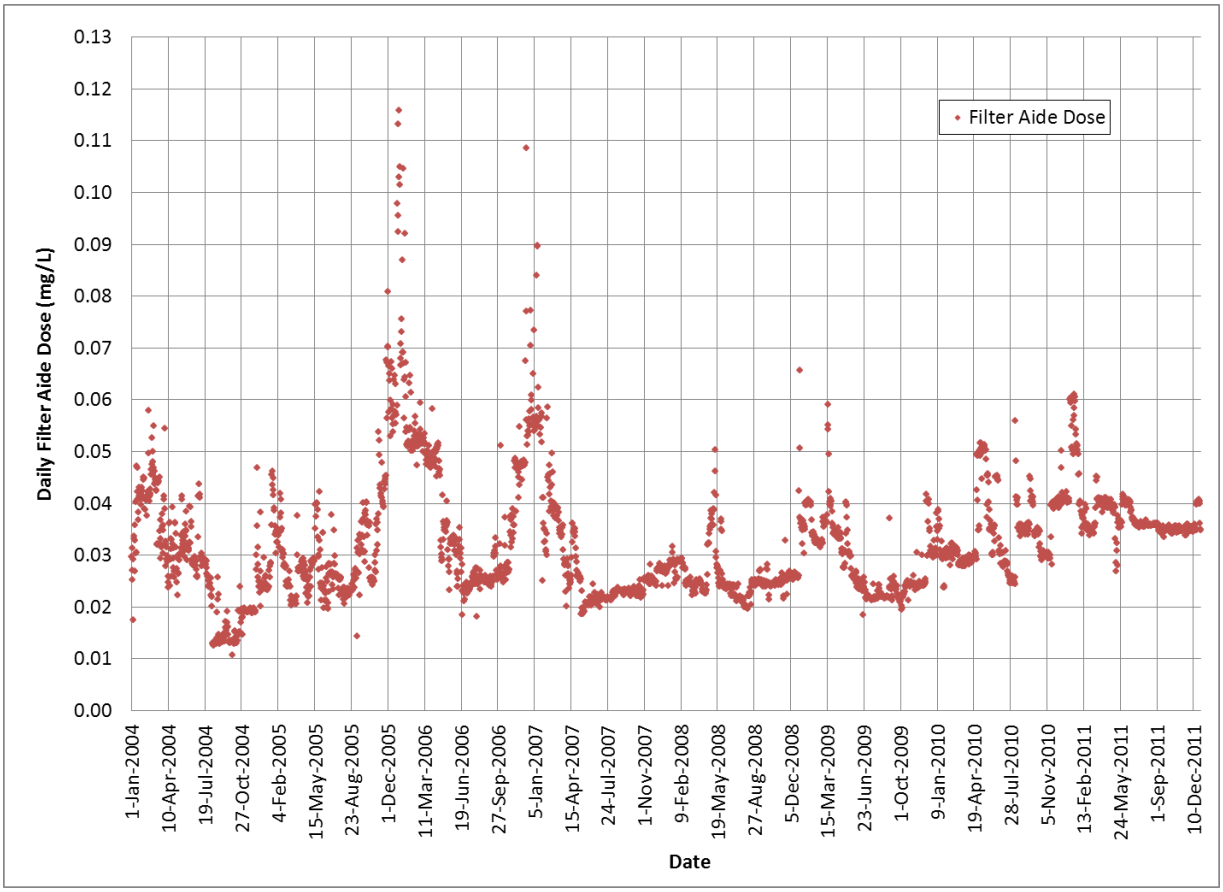
Polymer Filter Aid

The Grants Pass WTP currently uses a low-molecular-weight polymer as a filter aid. The dry polymer is mixed and aged with water, then fed via metering pump and carrier water to the filter influent. Flows are split eight ways to each filter using rotameters. Filter aid polymer is used continuously throughout the year and total daily usage is monitored and recorded. The polymer's role in improving overall turbidity removal at the Grants Pass WTP is important. When introduced to the settled water, the polymer helps make the alum floc that leaves the sedimentation basins "stickier." This property helps the filters retain the floc better and minimizes turbidity "breakthrough." If the filter aid were not added, the filtered water turbidity would be higher and filter run lengths would be significantly shorter due to premature breakthrough. This would require more frequent backwashing.

Figure 2-12 presents the historic average daily filter aid polymer dosages from 2004 to 2011. Filter aid polymer dosages tend to increase in the winter when water temperatures are low and decrease in the summer and early fall when the water is warmer. The average daily polymer dose was 0.027 mg/L during the summer, increasing to approximately 0.040 mg/L

in the winter and as high as 0.12 mg/L during winter's most challenging raw water conditions.

Figure 2-12
Filter Aid Doses



Lime

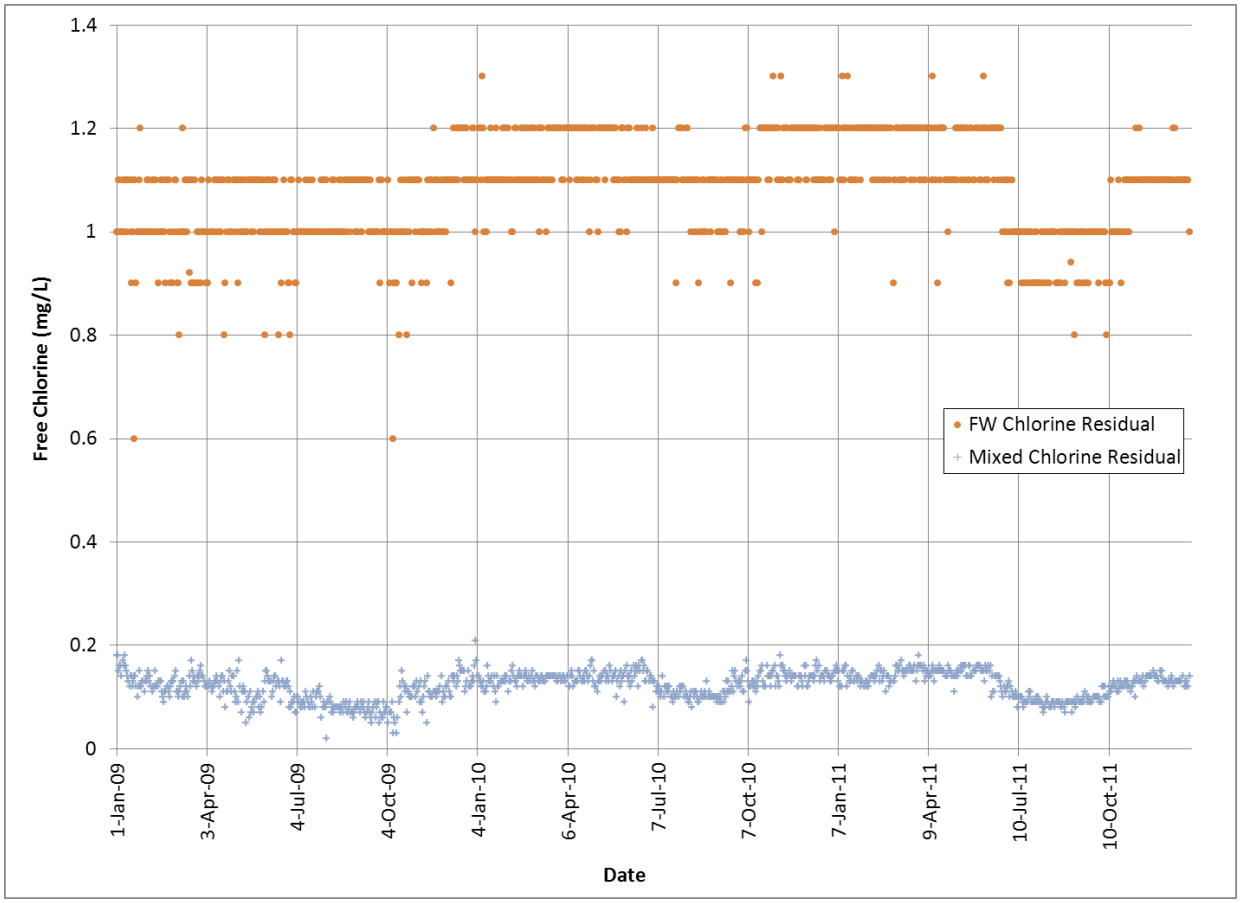
Lime was historically used to raise the pH by restoring alkalinity consumed through the coagulation process when alum was the sole coagulant. Plant staff maintains a target finished water pH of 7.2 for corrosion control. Since the plant has changed the coagulation approach and now uses ACH in addition to alum, the alum dose has decreased. The pH depression caused by alum has been to the point where lime is no longer needed to maintain proper finished water pH for corrosion control.

Sodium Hypochlorite

Hypochlorite is added to the raw water to assist in coagulation, control biological growth through the sedimentation basins, and for disinfection purposes. The target chlorine residual exiting the sedimentation basin is approximately 0.2 mg/L to ensure a measurable residual is maintained throughout the basins and to ensure disinfection compliance. The plant has reduced the pre-chlorination dose over the past few years to minimize DBP formation.

Chlorine addition to the finished water is intended for disinfection purposes and is added to maintain a chlorine residual in the distribution system. Chlorine is "boosted" throughout the distribution system (up to three times for some parts of the system) for residual maintenance. Figure 2-13 shows the free-chlorine residual in the treated raw water following chemical addition and rapid mixing by the 36-inch diameter static mixer. Pre-chlorination doses have typically ranged from 0.2 mg/L to 1.4 mg/L, although this range represents changes in operational strategy as well as fluctuations caused by normal operation. The figure also shows the free chlorine residual in the finished water effluent following post-chlorination. Finished water chlorine residuals are generally maintained between 0.9 mg/L and 1.3 mg/L with an average of approximately 1.1 mg/L.

Figure 2-13
Mixed and Finished Water Free Chlorine Residuals



Liquid sodium hypochlorite is stored at 12.5 percent solution in three 2,300-gallon fiberglass tanks located on-site. The hypochlorite system was installed in 2001 to replace the original gas chlorine injection system.

Additional Chemicals

In addition to the primary treatment chemicals used daily at the Grants Pass WTP, the plant also has the ability to dose $KMnO_4$ for taste and odor control. The use of potassium permanganate is rare. It was last used over a four-day period in December 2010 to January 2011 in response to a taste and odor event. Originally, the plant was designed to use PAC as an additional taste and odor control process, but PAC was rarely, if ever, used. The PAC slurry tank was converted to a solids mixing and conditioning tank and PAC can no longer be fed.

The WTP uses other miscellaneous chemicals for operational purposes. A long-chain polymer is applied to sedimentation basin residual solids during cleaning activities to aid in dewatering. Calcium thiosulfate is used to dechlorinate filter maintenance water and is also dosed to water for the intake structure wash system.

Plant Performance Data

The WTP staff keeps daily records of plant performance data that were used to assist in the evaluation of overall plant performance. This section summarizes the historic operating performance of the treatment processes including the sedimentation basins and filters.

Coagulation

The Rogue River water quality presents some treatment challenges at the WTP resulting from seasonal and diurnal variations in pH, seasonally variable turbidity, and temperature, as well as occasional taste and odor events. Excepting taste and odor, this variable raw water quality can significantly impact coagulation performance at the plant. Historically, these challenges were met by using a relatively high dosage of alum. This strategy resulted in high solids production and depressed pH which corresponded to an increase in pH adjustment chemical usage and cost and decreased overall plant efficiencies. The 2004 WTP Facility Plan suggested the use of a different coagulant to offset these deficiencies. Now that the plant is using ACH as a primary coagulant, overall alum usage has decreased by half. As a result, the plant operates at higher efficiencies and the use of a pH adjustment chemical is no longer necessary.

Clarification

The City's WTP relies on three sedimentation basins for clarification prior to filtration; no formal flocculation is provided in the basins. Basin 1 was constructed as part of the original plant; basins 2 and 3 were incorporated into the plant during the various plant expansions. The design of the basins are different and effluent water quality differs between the basins as a result.

The basins are each drained and cleaned at least twice per year. Prior to 2007, cleaning was restricted to off-peak seasons, as the plant required the full capacity to meet summer

demands. Now that the plant is operating 24 hours per day during the summer, each basin operates at a lower flow rate and it is possible to take a basin out of service for cleaning while still meeting peak season demands. As solids accumulate in the basins, the detention time decreases, which reduces the solids removal and disinfection performance of the basins.

The State currently rates the plant as "complete conventional," but the lack of formal flocculation and higher-than-desired surface loading rates of the basins could result in a future de-rating to a direct filtration plant. This would present significant challenges to providing disinfection during periods of high demands.

Typical Operations and Flow Control

Raw water flow is split into two pipes downstream of the static mixer; the first pipe leads to a slow mix basin for basins 1 and 2, the second leads to basin 3. Each pipe has a butterfly valve for flow control. A butterfly valve located at the influent to the slow mix basin can be used to control flow, but it is normally left open. The pipes and valves were designed to split the plant flow proportionally to each basin based on the basin's settling area. The proportions of flow reaching each basin are approximately 36 percent, 24 percent, and 40 percent of plant flow to basin 1, 2, and 3, respectively. Short-circuiting has caused flows through basin 3 to be reduced. The valves controlling the flows to each basin were set based on a plant flow of 20 mgd and the percentage of flow to each basin varies at lower plant flow rates unless the valves are manually adjusted.

Clarified water flows from the sedimentation basins to the filter influent channel. In general, filters 1, 2, and 3 are fed by basin 1; filters 4 and 5 are fed by basin 2; and filters 6, 7, and 8 are fed by basin 3. The clarified water trough is continuous between the filters and is intended to distribute the water evenly to the filters associated with each sedimentation basin. Because basin 3 is farther from basins 1 and 2 and has a longer pipe connection, the amount of water mixing and sharing between basins 1 and 2 and basin 3 may be somewhat restricted.

Sedimentation Basin Geometry

An optimal sedimentation basin is rectangular with a minimum length-to-width ratio of 4:1, a minimum length-to-depth ratio of 1:15 and a sufficient volume to keep mean flow velocity under 3.5 ft/min. Optimal basins provide approximately 20 to 30 minutes of flocculation and 90 to 120 minutes of sedimentation, or a total of 120 to 150 minutes of detention time. Baffles are useful to ensure good flow distribution and prevent short-circuiting. None of the three basins meet these optimal parameters.

Basins 1 and 2 are rectangular basins. Water enters at the south ends of the basins. Laminar flow conditions are improved in basin 1 by two baffle walls: one at the inlet, the second approximately half way along the length of the basins. Basin effluent collects in launders located on the north ends of the basins.

Basin 3 is the newest basin in the plant, built in 1983. Water enters this square basin via a central vertical pipe that discharges through ports located from 3 to 5.5 ft below the water surface. The water then flows under a circular baffle that extends from just above the water surface to 8 ft below. Water exits from the basin into one continuous square launder. Water from this square launder collects in a common trough that flows to the filter influent trough. Because its square shape and radial flow, basin 3 is vulnerable to short-circuiting. Despite the large volume of the tank, the path length from the inlet to the outlet is relatively short.

Based on these criteria, it is expected that basins 1 and 2 will be more efficient with solids removal than basin 3. Stable flow is difficult to maintain in basin 3 because its cross-sectional area is large in comparison to the cross-sectional area of flow. There are no automated solids removal mechanisms installed inside any of the basins, although provisions for future upgrades were included in the design of basin 3.

Sedimentation Basin Performance

Overall, the sedimentation basins provide satisfactory water for filtration during most of the year, as evident by filtered water turbidities. All basins experience challenges with regard to short-circuiting, high solids loading resulting from relatively high coagulant dosages, sub-optimal flocculation, and seasonal turbidity spikes. The basins are not equipped with any type of automated solids removal system. As solids accumulate in the basin, the effective volume of the basin is reduced which compromises flow characteristics and overall performance in the basin until the solids are removed. Without having continuous residual solids removal in the basins, basin cleaning events create large, “slug” doses of solids that present operational challenges. Basin 3 is especially vulnerable to short-circuiting or not clarifying as efficiently as basin 1 and basin 2, as indicated by filters 6, 7, and 8 needing more frequent backwashing. Plant staff observations and operating data support that the filters fed by basin 3 are backwashed approximately 25 percent more often than the rest of the filters.

Filtration

The plant has eight dual-media gravity filters of varying sizes and shapes, depending on the time of construction. Filters 1, 2, and 3, also called the East Filters, were constructed in 1931 as part of the original construction. filters 4 and 5, called the West Filters, were constructed as part of the 1950 plant expansion. Filters 6, 7, and 8, were added as part of the 1983 expansion project.

All of the filters which were constructed at the same time have the same individual surface areas, but the surface areas of filters in other groups are different. It is uncommon for a WTP to have variable filter shapes because demands on the filter support systems common to all filters (i.e. backwash pump, surface wash pump, washwater conveyance system, etc.) will vary according to the different filter surface areas.

The original filter design used mixed media with gravel support. Based on recommendations made in the 2004 WTPFP, the filters were modified in 2005 to use a deeper dual media with new underdrains that do not use gravel support. The current dual media design includes 20 inches of 1.0-mm anthracite over 10-inches of 0.5-mm sand. This new dual media has resulted in longer filter run times between backwashes and has improved overall plant production efficiency while continuing to produce low filtered water turbidities.

Typical Operations

The filters are operated by rate-of-flow control. Butterfly valves on individual filter effluent pipes modulate to maintain a specific filtration rate. Overall filter flow is adjusted to maintain a constant water level in the filter influent channel. Filter aid is dosed at the influent to each filter. The filters share common backwash pumps equipped with VFDs to provide variable flow rates depending on filter size and water temperature. Until an additional backwash pump was installed in 2012, there was no back-up supply for backwash water.

Turbidity

Each filter at the Grants Pass WTP is equipped with a turbidimeter to measure the turbidity of the individual filter effluent. Another turbidimeter is located in the filter gallery to measure the plant's combined filter effluent (CFE) turbidity. Data from each of these instruments is used for regulatory reporting. Figure 2-14 presents a summary of daily maximum combined filtered water turbidities between 2004 and 2011, taken from the plant's regulatory summary sheets reported monthly to the OHA. As shown in the figure, the maximum daily turbidity has always been less than 0.70 NTU, and is usually less than 0.10 NTU. Figure 2-15 presents a statistical summary of maximum daily combined filter effluent turbidities between 2004 and 2011 . From the figure, the plant has produced water with a turbidity of 0.05 NTU or less 95 percent of the time. The plant has normally performed well with respect to meeting the desired turbidity goal for optimal particulate removal.

Individual filtered water turbidities have also been recorded since 2004. These measurements are used to monitor filter performance and help decide when a filter needs to be backwashed. They are also used to determine when a filter-to-waste cycle should be stopped following a backwash.

All eight filters have produced filtered water turbidities under 0.15 NTU for at least 95 percent of the time. In general, all filters are performing well with regard to overall particulate removal.

Figure 2-14
CFE Turbidity Values

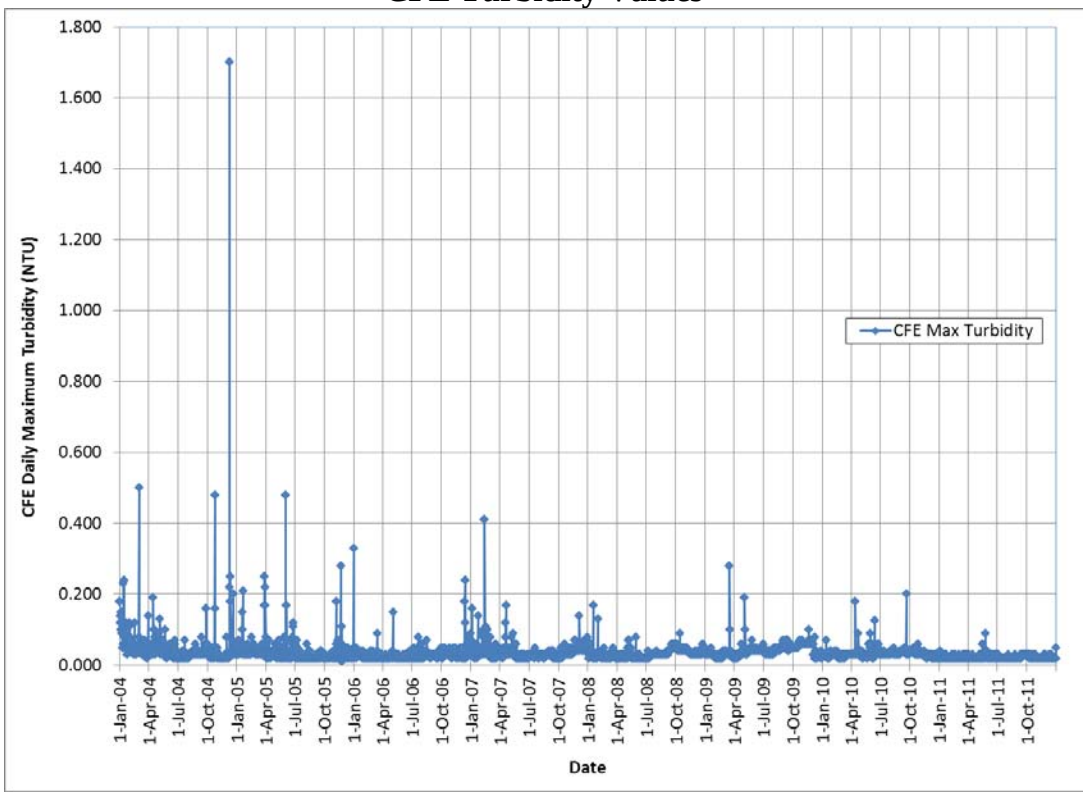
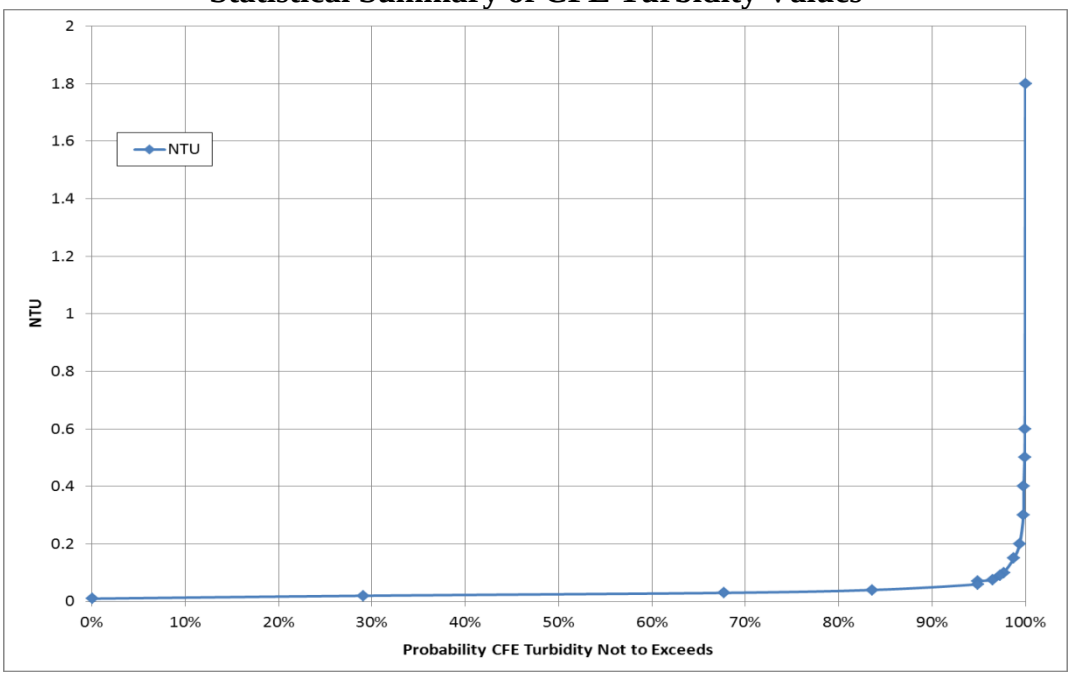


Figure 2-15
Statistical Summary of CFE Turbidity Values



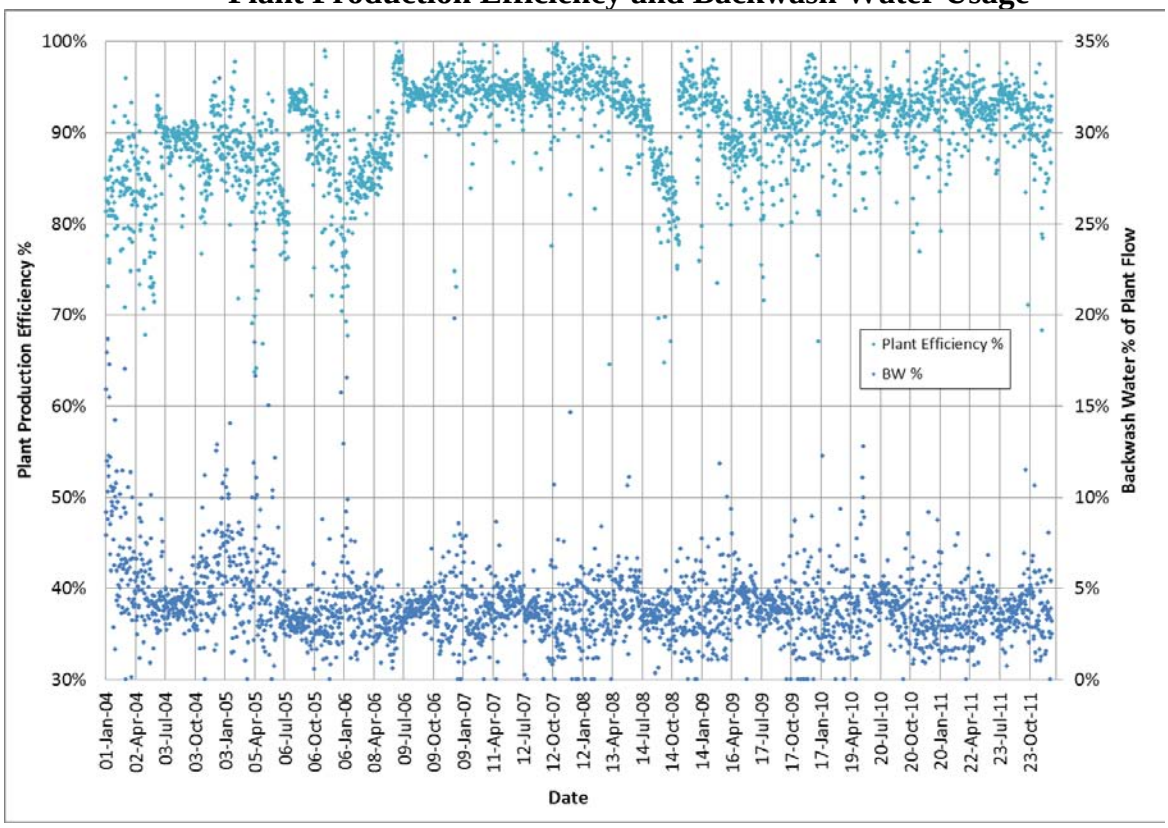
Filter Production Efficiencies

For a new surface water treatment plant, a typical suggested minimum overall efficiency is 97 percent. The City's WTP efficiency does not consistently meet this goal. The 2004 WTPFP identified a number of improvements that could be made to the filtration process to improve production efficiencies. As a result, the City has made the following upgrades:

- Filter media replacement and optimization
- Filter underdrain improvements
- Optimized filter backwash procedure and Unit Filter Run Volume optimization
- Addition of a second backwash pump to help provide backwash operational reliability

Figure 2-16 shows how plant efficiency has increased since 2004 and that the amount of backwash water used as a percent of plant flow has decreased. Prior to 2006, plant production efficiencies were in the range of 80 to 90 percent, while from 2006 onward plant efficiencies are observed to be consistently 85 to 95 percent. If basin 3 turbidities could be reduced, filters 6, 7, and 8 may require less frequent backwashing, resulting in increased plant efficiency.

Figure 2-16
Plant Production Efficiency and Backwash Water Usage



Operations and Maintenance

Historical operations and maintenance costs for the WTP since 2004 are presented in Table 2-2. Plant operations and maintenance costs are typically classified as either fixed or variable. The fixed costs remain fairly constant except for minor variations that are within typical budgeting allowances. The greatest fixed cost for a WTP is usually labor and administrative support. Variable costs are based on the annual volume of water being treated and pumped, and can also be affected by variations in raw water quality which can change chemical and solids handling requirements. The greatest variable costs for a WTP include power for pumping raw and treated water, chemicals, and solids handling and disposal. The operations and maintenance costs for the WTP have increased significantly since the 2004 WTPFP was completed for the following reasons:

- Changes in plant operating strategy including operating for longer periods each day at lower flow rates to improve plant production efficiency
- Increases in power costs
- Increases in chemical costs
- Incorporation of a solids handling program (geobag dewatering system) beginning in 2005
- Maintenance and repair related to the fish screens and screen cleaning system
- Additional plant staff and administrative support and re-structuring of the Public Works Department accounting methods

The unit production cost of treating water, shown in Table 2-2, is currently approximately $632/MG. Given the plant's current condition, this is a relatively low cost compared to similar utilities in the Pacific Northwest.

Summary

The Grants Pass WTP has supplied water to meet the City's water demands using a daily start-and-stop operating approach in the past. The recent historic peak day plant production was 14.2 mgd in July 2009 and is well below the nominal plant capacity of 20 mgd. Generally speaking, water demands have increased approximately 2 percent per year over the last decade.

The plant has performed well with regard to finished water quality and has met the regulatory requirements for filtered water turbidity. Plant production efficiencies have greatly improved since the 2004 WTPFP, averaging over 92 percent for the past five years compared to an average of about 87 percent prior. A minimum plant production efficiency of 97 percent should still be considered the long-term goal.

By switching from alum as a primary coagulant to ACH as a primary coagulant, alum usage has decreased and lime addition is no longer needed. It may be possible that coagulation chemistry between alum and ACH or PACl can be further optimized to reduce solids

production or reduce chemical addition at the plant, or both. An optimal coagulation strategy will balance plant efficiency with coagulation chemical costs, disinfection requirements, pH adjustment requirements, and residual solids production.

Table 2-2
Summary of Annual Water Treatment Plant Operations and Maintenance Costs[1]

	FY[2] 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Support Services									
Personnel	156,036	236,523	186,944	213,190	247,205	277,102	270,541	282,022	277,896
Operating Supplies	15,866	19,537	9,681	10,515	14,253	27,395	11,591	25,960	18,804
Contract Services	32,157	90,459	98,191	100,155	107,054	121,510	109,758	125,677	117,264
Capital Outlay	1,243	7,370	6,582	10,054	2,405	4,035	10,412	7,782	2,164
Sub-Total	*205,302*	*353,889*	*301,398*	*333,914*	*370,917*	*430,043*	*402,301*	*441,441*	*416,127*
Process									
Personnel	119,341	108,884	117,960	119,222	145,379	145,289	135,748	135,722	152,277
Operating Supplies	90,094	84,764	116,723	134,710	147,763	153,991	179,473	145,418	172,886
Contract Services	173,973	162,840	168,535	191,893	176,491	192,053	193,487	200,797	202,270
Capital Outlay	0	7,099	5,119	16,551	10,418	2,410	5,420	3,413	0
Sub-Total	*383,408*	*363,587*	*408,337*	*462,376*	*480,051*	*493,743*	*514,127*	*485,351*	*527,433*
Maintenance									
Personnel	36,613	64,256	61,188	60,758	102,155	98,076	125,817	137,101	133,999
Operating Supplies	44,421	21,152	27,197	32,744	33,402	30,492	26,727	26,877	31,815
Contract Services	26,137	24,541	22,603	40,971	43,874	53,874	70,302	41,354	19,449
Capital Outlay	10,576	0	0	5,532	1,590	4,241	0	7,735	0
Sub-Total	*117,747*	*109,948*	*110,988*	*140,004*	*181,021*	*186,683*	*222,846*	*213,067*	*185,263*
Pump Stations									
Personnel	8,485	3,967	16,686	23,989	15,787	22,630	27,795	33,598	39,667
Operating Supplies	12,159	15,159	21,259	22,000	20,651	6,855	12,341	18,660	16,150
Contract Services	78,331	81,387	77,448	98,106	88,769	99,206	107,464	129,153	115,897
Capital Outlay	5,781	292	0	1,260	0	0	0	0	0
Sub-Total	*104,756*	*100,804*	*115,393*	*145,354*	*125,207*	*128,691*	*147,599*	*181,410*	*171,714*
Solids Handling									
Personnel	143	12,416	16,915	40,095	11,831	32,734	22,652	12,838	17,908
Operating Supplies	1,364	24,111	32,895	39,229	18,617	37,382	28,761	32,187	34,245
Contract Services	2,811	11,328	30,127	15,642	18,936	17,341	29,077	38,872	30,597
Capital Outlay	0	0	801	0	0	0	0	0	0
Sub-Total	*4,319*	*47,855*	*80,738*	*94,966*	*49,384*	*87,458*	*80,490*	*83,897*	*82,749*
Total Annual Cost	**$815,532**	**$976,083**	**$1,016,855**	**$1,176,614**	**$1,206,580**	**$1,326,618**	**$1,367,363**	**$1,405,166**	**$1,432,162**
Total Annual Cost of Treatment[3]	**$698,957**	**$860,810**	**$888,959**	**$999,123**	**$1,066,960**	**$1,187,241**	**$1,203,932**	**$1,204,826**	**$1,209,408**
ADD (MGD)	**4.92**	**4.84**	**4.95**	**5.81**	**5.62**	**5.40**	**5.26**	**5.15**	**5.24**
Unit Treatment Cost ($/MG)	**$390**	**$487**	**$492**	**$471**	**$521**	**$602**	**$627**	**$641**	**$632**

Notes
1. All costs are in respective fiscal year dollars.
2. Fiscal year represented by the year at the end of the reporting period; e.g. FY 2004 represents July 2003 through June 2004.
3. Total Annual Cost of Treatment excludes Pump Station line items and all Capital Outlay costs.

Overall, the sedimentation basins provide satisfactory clarified water for filtration, as well as adequate contact time for disinfection during most of the year. All basins experience challenges with regard to short-circuiting, moderate solids loading, sub-optimal flocculation, and seasonal turbidity spikes. The basins are not equipped with any type of automated solids removal system. As solids accumulate in the basin, the effective volume of the basin is reduced, compromising flow characteristics and overall performance in the basin.

The filters have provided finished water with acceptable turbidity levels. Filtration efficiency has been improved by recent upgrades to the filters. Overall efficiency is consistently between 85 and 95 percent. Additional improvements to clarification could potentially result in increased efficiency.

As water demands continue to increase, the annual plant operating strategy may also need to be adjusted. Longer operating periods during the spring and fall months may be required. Due to occasional challenges in meeting disinfection requirements, mostly during winter cold water conditions, it may be necessary to operate the plant at lower flow rates and extend the hours of operation. Plant staffing assignments may need to be adjusted to accommodate this. These potential staffing adjustments need to be considered by the City when developing future operations budgets.

The WTP operating costs have increased by approximately 50 percent since 2004 for a variety of reasons. When considering future capacity expansions, the operating costs need to be evaluated carefully in addition to capital costs.